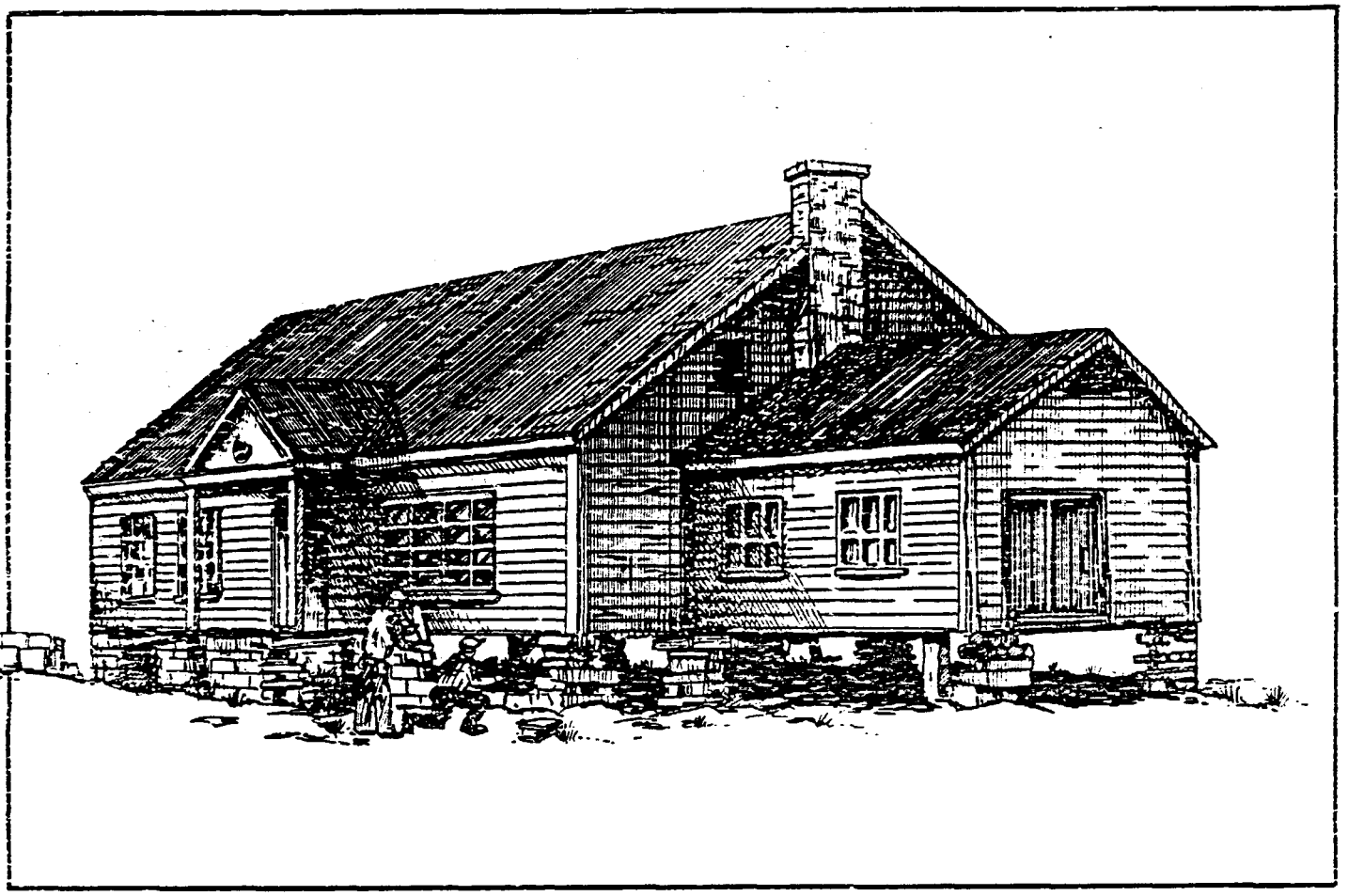
Floodplain Management:
The Experiences of Three Kentucky Communities



Commonwealth of Kentucky
Natural Resources and Environmental Protection Cabinet
Department for Environmental Protection
Division of Water

PREFACE

Since 1975, Kentucky has had six Presidentially Declared Natural Disasters caused by flooding. Nearly $45 million has been expended in Public Assistance and Individual and Family Grant programs. And still, several communities located in flood-prone areas throughout the Commonwealth have not yet developed flood management strategies. Too many times such strategies have only been considered after the flood damage has occured.

The three case studies in this report serve as examples of how communities in Kentucky can take the initiative to develop and implement flood management programs. Each case study focuses on the communities past problems, their solutions, and how they have financed these solutions. By planning ahead, they have reduced or eliminated the possibility or recurrence of extensive flood damage.

This report was prepared by the Natural Resources and Environmental Protection Cabinet, Division of Water, through a cooperative agreement with the Federal Emergency Management Agency (FEMA). The Division of Water offers its appreciation to the following people for their assistance in researching and preparing this report:

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Among Division of Water staff, Gene Harmon and Debbie Collinsworth have had primary responsibility for preparing the study.

NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
DIVISION OF WATER
FLOODPLAIN MANAGEMENT SECTION
FRANKFORT, KENTUCKY 40601

September, 1983

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INTRODUCTION

For many communities in Kentucky, flooding is a life threatening hazard and a source of property damage during periods of moderate to heavy rainfall. Therefore, it is imperative that these communities take every possible step to reduce or eliminate the flood hazards affecting them.

There are several ways communities can reduce flood damages. These measures can be grouped into three categories: (1) modification of floodways, (2) flood damage susceptibility reduction, and (3) flooding impact reduction.

Floodway modification measures keep flood waters away from populated areas by (1) decreasing runoff, (2) increasing channel capacity, or (3) containing, redirecting or storing floodwaters. Typical measures include dams and reservoirs, levees and floodwalls, channel alterations, diversions, and land treatment. These measures are classified as structural, while the remaining two categories above are classified as nonstructural.

Susceptibility to flood damage can be reduced by keeping people and development out of flood hazard areas or by making a development more resistant to flood damage. Typical measures include floodplain regulations, (i.e. zoning, subdivision regulations, and building codes), policies designed to discourage the development and redevelopment of flood-prone areas, warning and preparedness plans, and floodproofing.

Finally, the impact of floods can be reduced by providing assistance to those affected by a major flood. Such assistance becomes available when periods of extreme rainfall create unusual floods. Typical assistance includes basic food and shelter, as well as low-interest loans made available during flood disasters and flood insurance claims that cover the cost of damages.

In the past, the most commonly used methods for reducing flood damage have been floodway improvements or control structures. The implementation of structural measures alone, however, has proven to be ineffective at reducing flood loss over a long term. The major emphasis today is on nonstructural flood damage reduction measures.

This report examines how three Kentucky communities - Barbourville, Benton, and Bowling Green-Warren County used nonstructural measures to reduce flood damages.

BARBOURVILLE

BACKGROUND

Barbourville has one of the most comprehensive floodplain management programs in the State of Kentucky.

It has a population of approximately 3,500 people, and is located in Knox County in southeastern Kentucky, about forty miles northwest of the Cumberland Gap. The City was founded in 1800 at the confluence of two streams--Richland Creek and the Cumberland River.

The Cumberland River is the largest of the two streams affecting Barbourville, having a total drainage area of 17,914 square miles. It slopes an average of 1.5 feet per mile at Barbourville and has an average channel width of 225 feet, and an average floodplain width of 1600 feet. In contrast, Richland Creek has a drainage area of only 74.1 square miles. The creek slopes an average of 3.5 feet per mile near Barbourville with an average channel width of 100 feet.

Most of Barbourville's floods have occurred in winter and early spring. Floods from the Cumberland River usually last three to four days. During significant precipitation events the Cumberland has been recorded to rise greater than one foot per hour at Barbourville.

To help reduce the threat of flooding, the Barbourville Local Protection Project was initiated. Completed in 1959, this project consists of 3.5 miles of levee constructed by the Nashville District of the Corps of Engineers. The levee provides protection equal to the flood of January 1946, plus three feet of freeboard. Approximately seventy percent of Barbourville's population resides within the protected area. About fifty percent of the city's total acreage, much of it in commercial use, is protected by the levee. The remaining acreage consists of residences, schools, a hospital, Union College, and undeveloped land. The total assessed value of real estate in Barbourville is approximately $23 million, with an additional $6.5 million in tangible personal property.

Current estimates show the levee will protect Barbourville to about the 95-year flood occurrence. The flood of April, 1977, came to the top of the wall. The 100-year flood would slightly overtop the wall and the Standard Project Flood (the largest flood projected to ever occur) would overtop the wall by approximately eight feet.

Barbourville's history of flooding during the early seventies prompted the City to begin two programs to prepare citizens for potentially destructive flood events. The first program was the development of a Flood Emergency Evacuation Plan and the second program was the Apple Grove Flood Mitigation Program. Both the plan and the mitigation program are non-structural measures to reduce flood damage.

FLOOD EMERGENCY EVACUATION PLAN

Planning and Development

The stimulus for preparing Barbourville's Flood Emergency Evacuation Plan was due to a number of significant floods in the 1970s. In fact, of the ten largest floods prior to 1976, five occurred in the early 1970's. City officials recognized that an overtopping of the levee would be catastrophic.

In response to these concerns, Barbourville contacted the Nashville District of the Corps of Engineers (COE) for assistance in developing a flood emergency evacuation plan. It was determined that the Corps should be the lead planning agency. The Nashville COE began by reviewing available documents relating to Barbourville's unique problem. The COE also established guidelines, performed the necessary studies, and prepared a program plan. The Nashville COE selected the consulting firm of Crouch and Adams, Inc., to assist in this endeavor.

An early task of the COE subcontractor was to identify the groups involved in preparing the Flood Emergency Evacuation Plan. The success of the plan depended on the extent public and private agencies contributed to the formulation of the plan and participated in its execution. The contractor identified the following persons and agencies as being essential to the success of the project:

PRIMARY PARTICIPANTS

City of Barbourville

Mayor
Manager, Water and Electric Company
Fire Chief
Chief of Police
City Attorney
Superintendent of Schools

Knox County

County Judge Executive
Superintendent of Schools
Director, Health Department
Sheriff
Knox County Rescue Squad

Kentucky

State Police
Kentucky National Guard
Director & Assistant Director,
Division of Disaster &
Emergency Services (DES)

American National Red Cross

Local Chapter Representative
Director, Disaster Services, Louisville

Federal Agencies

United States Department of Army,
Corps of Engineers, Nashville District

SUPPORTING PARTICIPANTS

Union College
Local Radio and Newspapers
Knox County General Hospital
L & N Railroad
Continental Telephone Company
Kentucky Utilities Company
Cumberland Valley Rural Electric Cooperative Corporation
Cumberland Valley Area Development District
Barbourville Chamber of Commerce
Boone Manor Nursing Home
Radio Amateur Civil Emergency Service for Kentucky
City of Corbin

Several preliminary discussions with other participants were held to discuss the details of Barbourville's plan, including the locations of primary and alternative Emergency Operating Centers (EOC), the identification of shelter areas, the appointments to the EOC staff, and an inventory of available equipment, supplies and persons who could assist in an emergency.

The first draft of the evacuation plan was completed in June, 1976. A review meeting was held after this draft, and the final plan was completed shortly thereafter. The plan was fully adopted as the result of several actions which included:

(1) passage of a city ordinance which provided the legal framework to implement the plan, including authority of designated personnel;

(2) adoption of a resolution by the Knox County Fiscal Court to cooperate and to make facilities and equipment available during flood emergencies;

(3) a mutual aid agreement signed between the cities of Barbourville and Corbin;

(4) approval of the evacuation plan by the Red Cross;

(5) approval of the use of Knox County school facilities; and

(6) assurances from a Corbin nursing home and hospital that they would accept patients from Barbourville in the event of an evacuation.

To help implement the evacuation plan, the actions identified below were taken.

(1) An Emergency Operating Center (EOC) staffed by ten positions was established. Local leadership for plan implementation was provided by trained volunteers of the EOC staff. Standard operating procedures were established for each member of the EOC. Staff were responsible for monitoring flood conditions, maintaining communications with the public and other agencies, determining river conditions that would initiate a four level flood warning response system, issuing bulletins and instructions, and ordering any actual evacuation which might be necessary.

(2) Barbourville provided the following three levels of education for each household: (a) information on the nature and extent of the flood hazard, (b) instructions on shelter locations and evacuation procedures, and (c) warning instructions. Barbourville designated evacuation routes and shelters by dividing the city into three conveniently numbered and color-coded zones. Each household was notified by an informational letter identifying their evacuation zone, their evacuation routes, and the location of shelter areas. (See Figures 2, 3 and 4). Additionally, each vehicle was tagged with a color-coded decal, which corresponded to the

marks painted on telephone poles within each particular zone. During an evacuation, vehicles simply would follow their color-code to the designated shelter. Contingencies were also made for evacuating the sick and elderly, and prisoners in the local jail.

(3) Barbourville instituted four levels of warning corresponding to various river conditions, as described below.

(a) Level I - precautionary alert to public officials and evacuation participants to watch the river, to review their responsibilities and duties, and to prepare for a higher state of readiness. A Level I warning is issued when a river stage of 20 feet has been reached.

(b) Level II - initial steps to prepare for evacuating the area behind the levee. Schools are closed, EOC is activated, and state officials are notified. The public is told to stay tuned into radio and television stations for status reports. Level II warning is issued at a river stage of 27 feet.

(c) Level III - start to evacuate, such as closing factories and businesses. Additionally, the levee patrol is activated, sandbags are readied, and the EOC is staffed. A Level III warning is reached at a river stage of 32 feet or greater in combination with a rate of rise of one foot per hour or greater, or when the river stage reaches 37 feet regardless of rate of rise. Voluntary evacuation is encouraged and families are asked to prepare for evacuating by assembling personal effects and securing houses and/or business.

(d) Level IV - declare a State of Emergency. Families are ordered to evacuate. A Level IV warning occurs when: (1) a 38 foot river stage has a 1.5 foot per hour rate of rise. (2) a 40 foot stage has a 1.0 foot per hour rate of rise. (3) a 42 foot stage has a 0.5 foot per hour rate of rise; or (4) a 44 foot stage exists. When a Level IV

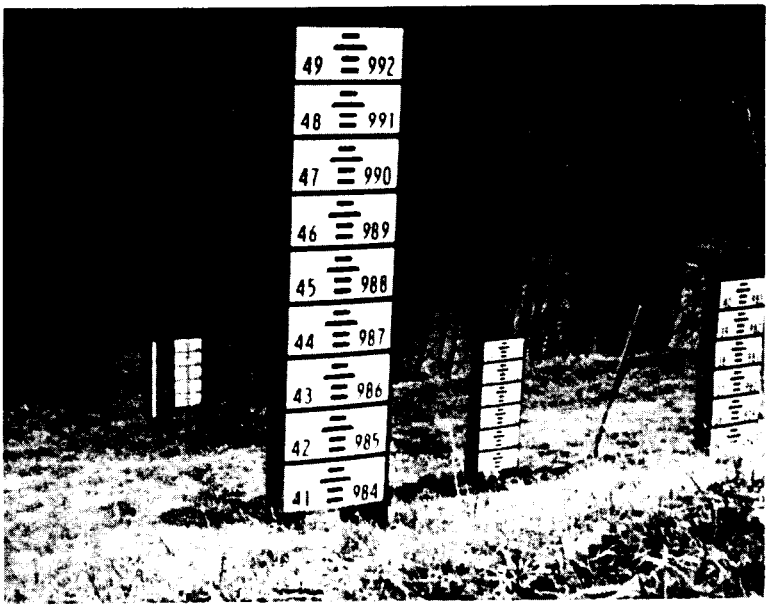

Figure 1. Barbourville Floodgage on Side of the Levee

City of Barbourville

OFFICE OF THE TREASURER

BARBOURVILLE, KY. 40906

June 15, 1976

Dear Barbourville Resident;

Please keep this letter and map as long as your home is inside the main part of Barbourville that is protected from floods each winter by a flood levee. The floodwall is in excellent condition and will protect us from floods as big or bigger than we have ever had in the past. But it is possible that some day a flood could be extremely large, and come over the top of the levee. Therefore, we have put together an evacuation plan that would help everyone to leave Barbourville before any water reached the top of the levee.

You will find enclosed with this letter and map a list of information to prepare you now, so that if we are ever forced to leave Barbourville by a flood you will know what to do and where to go.

Remember, keep these papers in a safe place. I would encourage you to look over the list and map at least once a year. During the first rise in the river each fall would be a good time.

Very Truly yours,

Jack Ketcham

Honorable Jack Ketcham
Mayor
City of Barbourville

JK/djm
ENCLOSURE

City of Barbourville

OFFICE OF THE TREASURER BARBOURVILLE, KY. 40906

EVACUATION LIST

1. Find on the map which one of the three sections (Red, Green, or Brown) your home is located in. Follow the marked roads from your section to 25E. Learn this route. The National Guard will help direct traffic during an actual evacuation.

2. When the time to evacuate is declared by the blowing of the Fire Siren many times, you will need to take some personal items with you (clothes, tooth brush, etc), but only items that you can take in your vehicle on a one trip basis will be allowed. No return trips. After once you leave town, you must continue out of the area in order not to block the people behind you.

3. If you do not have a ride, listen to the radio to see where the nearest school bus is located to pick you up.

4. If you do not have a ride and are sick or bedfast, you will have to call the City Police. Help to move the sick will be provided.

5. The Red Cross will help by Providing Shelther and food a Lynn Camp, Gray, and Boone Height Schools. But, if you can get to your relatives in a near-by town (Corbin, London, etc), I would recommend that you go there.

Figure 4 - Chart A

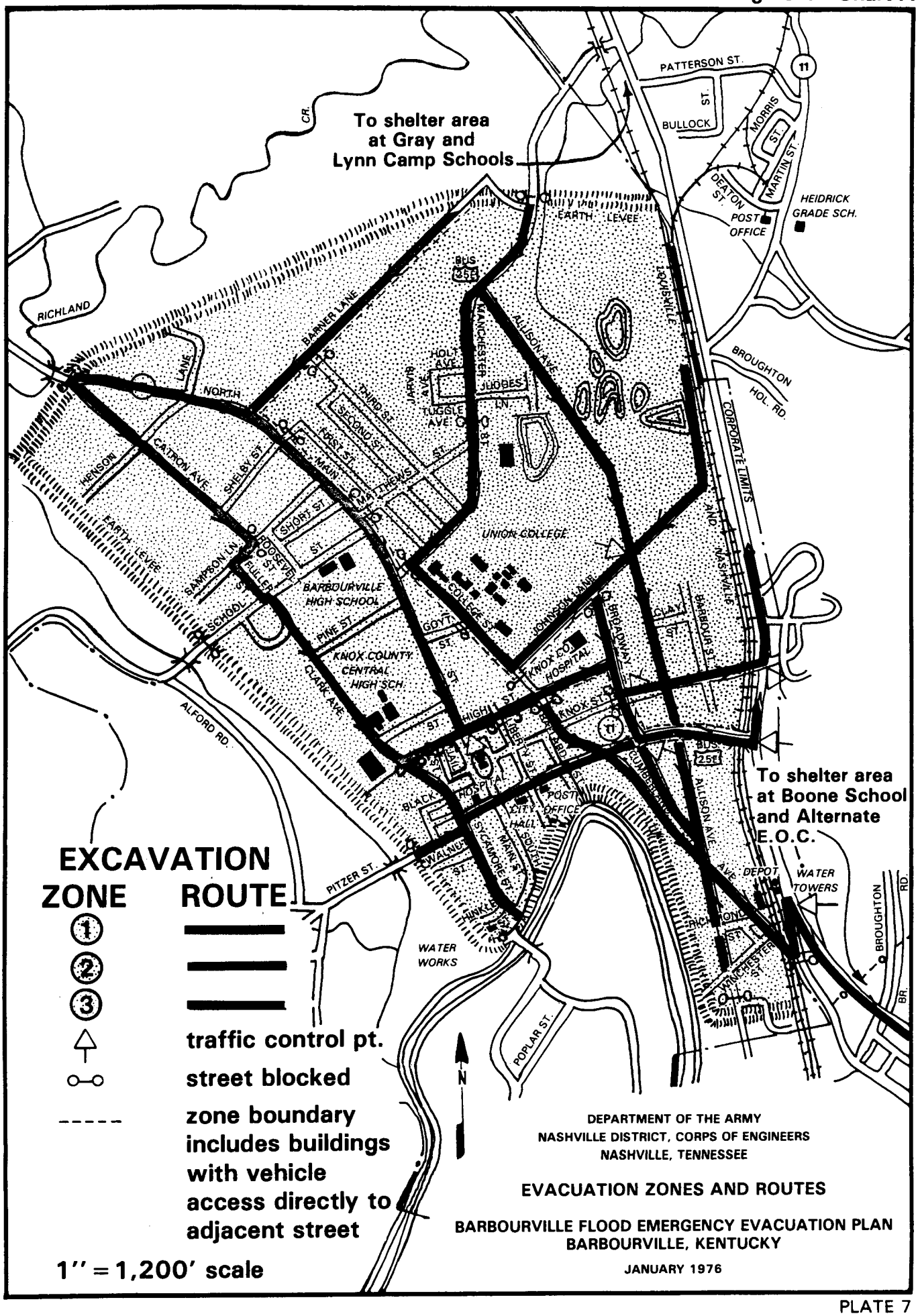

PLATE 7

IMPORTANT — KEEP MAP AND EXCAVATION LIST IN SAFE PLACE

warning is issued, evacuation of the sick and infirmed begins first, followed by the evacuation of the remaining of the population. Additionally, the levee is watched closely so that weak points can be reinforced with sandbags. When the study was completed in 1976, it was estimated that Level III had been reached ten times in the past, while Level IV had never been reached.

Implementation

In April, 1977, only a few months after plan completion, Barbourville was forced to implement the evacuation plan.

Heavy rain started on Sunday, April 3, 1977. By Sunday night, the City realized potential flood conditions were developing and initiated communications with the National Weather Service. Early Monday morning City officials closed the rain gates on the floodwall. Reports were continuously received during the day indicating Harlan (upstream from Barbourville) was in serious flood trouble. Monday night the main floodgate was closed and the evacuation committee was called to order.

By 6 a.m. on Tuesday morning, the committee realized there was a good probability of the levee being overtopped, which lead to a decision to alert the public. At 7 a.m., a Level III warning was issued by radio notifying residents of the possible need to evacuate. The residents were instructed to keep their evacuation information in hand. Those persons with places to go were urged to leave.

By 11:30 a.m., the committee decided to issue a Level IV warning. All people were ordered to evacuate, and the city was closed. The Corps of Engineers estimated that the wall would be overtopped by one to two feet. In an attempt to prevent flooding of the city, more than 400 volunteers began sandbagging the floodwall. Sandbagging continued until about 3:00 a.m. on Wednesday, when the flood peaked. All total, 11,000 sandbags of the 20,000 stored by Barbourville were used. Later that afternoon, the residents of Barbourvile were allowed to return to their homes.

The actual implementation of Barbourville's evacuation plan proved that the plan worked. Minor modifications were later added to provide additional labor for sandbagging and to provide food and shelter for volunteers.

Cost

The cost of developing Barbourville's Flood Evacuation Plan was approximately $12,000. The Nashville District of the Corps of Engineers and the City of Barbourville shared the cost. The initial cost of implementing the plan was approximately $4,000 for such items as safety and communications equipment, the Emergency Operating Center, and training exercises. The annual cost of implementing the plan was estimated to be $1,000, primarily to maintain equipment and supplies.

The flood evacuation plan for Barbourville has proven to be very successful. Several factors are responsible for this success, including the uniqueness of the community (the wall provides advance evacuation time), public awareness of the flood problem, and the presence of a strong chief operating officer.

However, this flood evacuation plan does not include procedures for residents outside the protected area. Their threat is substantially different. Barbourville has also attempted to reduce the hazards for these residents through alternate communication and assistance programs.

APPLE GROVE FLOOD MITIGATION PROGRAM

Background

The Apple Grove neighborhood is located in the south end of Barbourville. The entire neighborhood is outside the protection of the floodwall. In fact, this neighborhood is isolated from the Barbourville road system when Barbourville's floodgates are closed. Previous flooding has resulted in the deterioration of many of the structures in this neighborhood.

To help correct these problems, the city applied for and received a Housing and Urban Development (HUD) Community Development Block Grant. Consideration was initially given to the relocation of all families out of the floodplain. However, HUD was not in favor of this plan because it would destroy the neighborhood unit. Final approval was given for the elevation of sixteen structures and the rehabilitation of sixty-five structures. The property acquired under this program were to be resold with restrictions concerning future development.

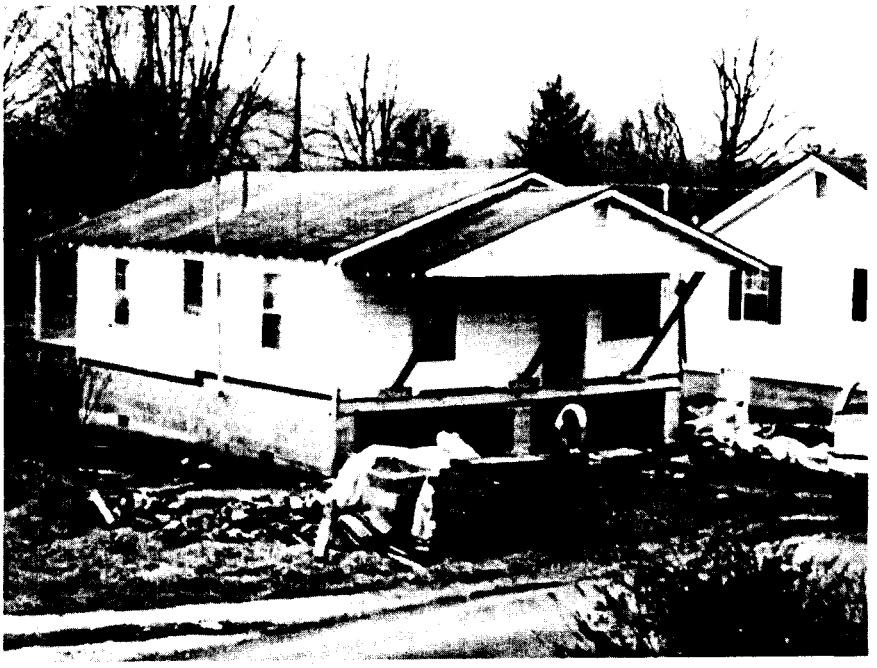

Figure 5. Elevation of a House in the Apple Grove Neighborhood of Barbourville

Cost

This project will cost approximately $2 million over a three year period. All funds will come from the HUD Community Development Block Grant Program.

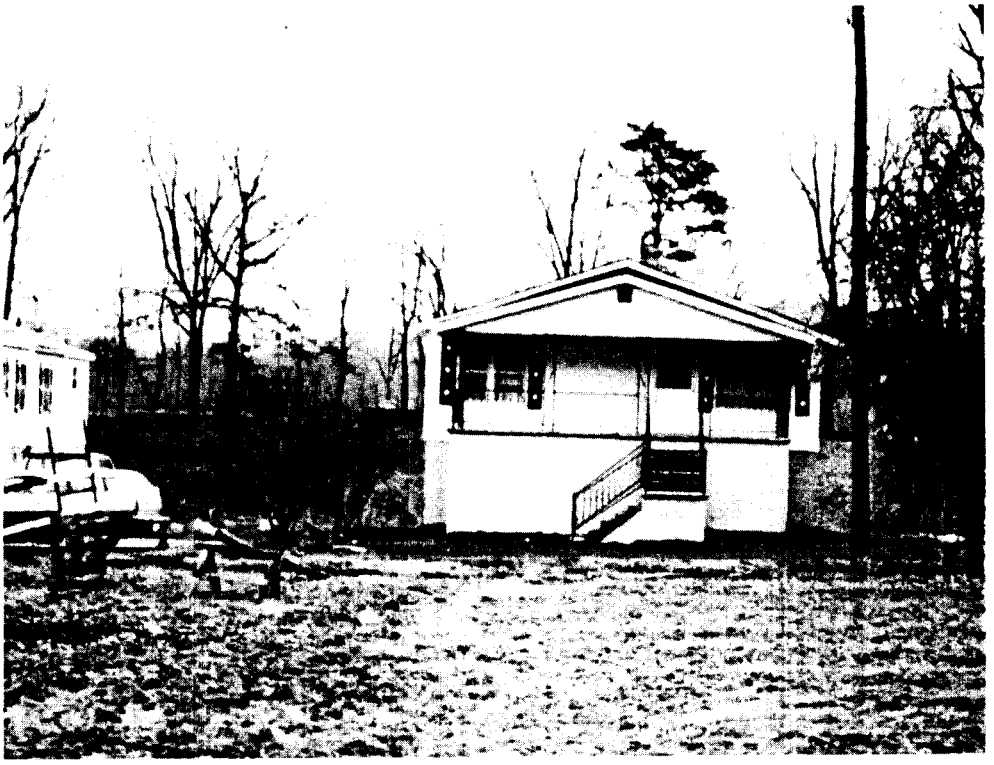

Figure 6. Elevated House in the Apple Grove Neighborhood of Barbourville

REFERENCES

"A Report on Flood Emergency Evacuation for Barbourville, Kentucky", Prepared by the City of Barbourville, Kentucky, September 1976.

"Update of Flood Emergency Evacuation Plan for Barbourville Kentucky", Prepared by the City of Barbourville, August 1979.

"Flood Emergency Evacuation Opertions Manual--Barbourville, Kentucky", Prepared by the City of Barbourville, August 1979.

"Application for Federal Assistance for the Apple Grove Flood Mitigation Program", Prepared by the City of Barbourville, August 1981.

For further information contact:

Randell Young, General Manager, Barbourville Water and Electric Company, or

Mary Skeens, Director, Barbourville Community Development Agency.

BENTON

BACKGROUND

Benton, the county seat of Marshall County, is located in western Kentucky adjacent to Kentucky Lake. With a population of 3,600, Benton is in an upland area that lies south and west of the Clarks River between river miles 22.0 and 24.0. The Clarks River has a drainage area of approximately 227 square miles. Most of Benton is built on uplands and sloping hillsides, but development has extended across the floodplain to the left bank of the Clarks River. Several commercial establishments and residences are located in the Clarks River floodplain with some residential developments located in tributary floodplains.

Town Creek and tributaries, with a drainage area of 2.86 square miles, drain the southern and eastern portions of Benton. Town Creek has been plagued by intense summer storms with major floods occuring in 1937, 1951, 1952, 1957, and 1964. The major flood problems associated with Town Creek in recent years occurrred in the Longview Subdivision.

The Longview Subdivision consisted of twenty-six (26) homes (approximately 121 people) built in 1971 under a Housing and Urban Development (HUD) Section 235 subsidy program for elderly and low income families. All 26 homes were built within the 100-year floodplain of Town Creek. On the average, eight of these homes flood once or twice a year with two to three feet of water. During March of 1975, several of the homes were flooded causing considerable damage. One home had three feet of water, others had only one to eighteen inches. Flooding decreased property values from the $24,000-26,000 range in 1972 to $15,000 following the 1975 flood. One home remained vacant for two years following the flood. In addition to these economic problems, there were also substantial safety issues. Whenever Longview flooded, several families had to be evacuated. Many of the residents were elderly and evacuation was not an easy task.

After flooding occurred in 1975, the residents of Longview, fearing for their safety and the loss of property, petitioned the officials of Benton for help. HUD was unable to assist the city, and a lawsuit against the bankrupt developer was unsuccessful.

After listening to the residents and becoming fearful of the safety aspects, the City of Benton committed itself to solving the problem. City officials contacted many state and federal agencies asking for assistance in studying and solving the problem of Longview Subdivision.

The Tennessee Valley Authority (TVA) took an interest in the project and began working closely with the city. Using funds from TVA, the consulting engineering firm of Florence and Hutcherson, Inc., was employed to study Town Creek and alternatives for reducing flood damages. This study was ultimately the basis of the Longview Subdivision Relocation Project.

LONGVIEW SUBDIVISION RELOCATION PROJECT

Planning and Development

The study identified five alternative methods of reducing flood damage in the Longview Subdivision. They were:

(1) dredging 2,000 feet of Town Creek, including deepening and widening the channel in the flood-prone area;

(2) constructing a levee along both sides of Town Creek with a pump station to reduce interior drainage problems caused by the levee;

(3) raising the homes in Longview to an elevation above the 100-year flood level;

(4) constructing a dam and reservoir upstream from Longview; or

(5) relocating the homes to a safer location, including the construction of new streets and utilities.

Each of these alternatives were evaluated with respect to monetary costs, environmental impacts, effectiveness in reducing flood damage, and public acceptability. Estimates for construction costs ranged from $61,000 for the dam to $270,500 for the relocation.

With respect to environmental impacts, each of the major channel construction alternatives was considered to have some problems. The dredging proposal in alternative one was considered infeasible due to the large volume of dredging required. The levee construction of alternative two would entail considerable earthwork and would have a poor aesthetic impact on the area. Finally, the proposed upstream dam in alternative four was considered to have a negative impact on land use trends in the area of the proposed reservoir.

In terms of effectiveness, the study concluded that the the dam would not be effective due to the lack of a site in close proximity to the Longview Subdivision. Raising homes above the 100 year flood level without relocation would only partially reduce flood damages, and would require evacuation during significant floods. Dredging would not reduce flooding enough to sufficiently affect the damages and would require continued maintenance. Finally, the levee would create an interior drainage problem necessitating the installation of a pump station. Again, continued maintenance would be required for the pump station, mowing, and other activities.

Each alternative was evaluated according to public acceptability, which varied from one alternative to the next. In general, the impact on the environment and adjacent property owners made dredging unacceptable. Due to aesthetics, the levee alternative was also not supported. Raising homes would still not alleviate the problem, so this option was clearly ruled out. Last, public oppposition to acquiring private land for constructing a dam rendered this option unacceptable.

Table 1--Ranking of Alternative Proposals

	ALTERNATIVES				
	1	2	3	4	5
Monetary Costs	4	2	3	1	5
Environmental Effects	4	5	2	3	1
Effectiveness in Reducing Flood Damages	3	2	4	5	1
Public Acceptability	5	4	2	3	1
TOTALS	16	13	11	12	8
Composite Ranking	5	4	2	3	1

All five alternatives were ranked on the basis of each category above. Based on this ranking (Table 1) it was decided that alternative five was the most feasible. Although a few residents would initially oppose the move, the study concluded that the long term benefits outweighed the initial inconveniences. The study further suggested that the land making-up Longview Subdivision be developed into a park after the relocation of residences.

Implementation

TVA became the lead implementing agency for this project. They met with the city council and the residents of Longview. Each alternative was discussed and the recommendations of the study were endorsed. TVA agreed to fund part of the project. The Natural Resources and Environmental Protection Cabinet, Division of Water, also agreed to provide funds through the Community Flood Damage Abatement Program (CFDAP). The initial cost was projected to be $430,000, with approximately half provided by the TVA and the other half by the CFDAP.

The City began the search for possible relocation sites. A committee of five Longview Subdivision residents was appointed to help. It was decided that the entire neighborhood would be moved together, with the new neighborhood arrangement as close as possible to the original neighborhood. In October 1980, the city purchased 18.7 acres, a half mile away, for $85,000.

The next two years were spent solving the multitude of problems related to relocation. This included accepting bids and awarding contracts for the development of the new site. Site preparation, which involved excavation, grading, and the installation of utilities, took over a year to complete.

After the site was ready, the city accepted bids for the actual relocation. This entailed pouring new foundations and moving the houses. Also included were reconnections of sanitary sewer and potable water lines, construction of new porches, concrete walks and driveways, and other related items. Due to the uniqueness of this relocation project, bids for relocation varied greatly (by as much as $100,000).

Still, not all of the problems were solved. The original plan called for all 26 families to move. However, two families decided not to move, placing the entire project in jeopardy. Later, all the parties involved decided that two families were not substantial enough to stop the project.

Finally, after years of planning and months of work, the groundbreaking ceremony took place on September 8, 1982. The first house was moved on that date. The remaining twenty-three houses were relocated in less than thirty days.

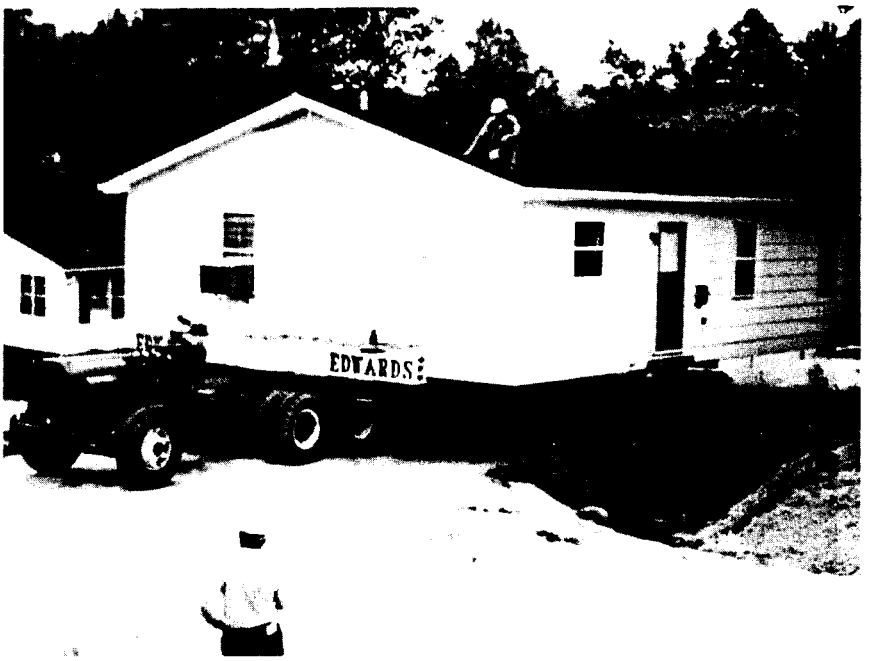

Figure 7. Relocating House in Benton (Photo Courtesy of TVA)

Cost

The original estimate for this project was $430,000. However, the final cost figure was $778,990, broken down as follows:

$350,000 - Tennessee Valley Authority

$338,990 - Natural Resources and Environmental Protection Cabinet, Division of Water (Community Flood Damage Abatement Program)

$ 85,000 - Benton (Purchase of Land); and

$ 5,000 - Regional and Community Action Program.

CONCLUSION

Benton has demonstrated again what can happen when a community wants to solve flooding problems. According to Gayle Frye, the Benton Project Coordinator, this project was successful because a concerned mayor and city council worked hard to eliminate a recurring problem facing their community. Ms. Frye recommends that any community considering such a project work closely with an agency who has already completed a similar relocation and recruit an experienced project officer.

REFERENCES

"Benton Town Creek Flood Damage Reduction Study, Benton, Kentucky". Prepared by Florence & Hutcherson, Inc., August 1978.

For further information, contact Gayle Frye, Mayor's Office, City of Benton.

BACKGROUND

Warren County is located in south central Kentucky approximately fifty miles north of Nashville, Tennessee, and 100 miles southwest of Louisville. The county has an area of 546 square miles and a population of approximately 72,000. Five incorporated areas lie within its boundary. Bowling Green, the state's fifth largest city, is located in the center of the county and has an area of twenty-eight square miles. It has a population of approximately 42,000. The other incorporated areas are Plum Springs, Smiths Grove, Oakland, and Woodburn.

Warren County has unique topographical features created by its karst terrain. Bowling Green is believed to be the largest city in the United States located on a sinkhole plain. Karst topography is characterized by porous fractural limestone, rocky ground, numerous caves and sinkholes, underground streams and a noticeable lack of surface drainage courses. Surface runoff moves underground through cracks, crevices, sinkholes, and dry wells at the bedrock surface, and then through subterranean conduits in the limestone. These conduits funnel runoff via underground streams or groundwater to major surface streams, the Green and Barren Rivers primarily. When surface streams are at flood stage the direction of subsurface flow may stop or reverse itself, causing water in the sinkholes to rise. Sinkholes may also flood when they clog with silt or debris.

With more common topographical features, storm water management measures would direct runoff to channels or streams. In karst areas, however, this is often a physical impossibility. Over half of Warren County, over three-fourths of Bowling Green, and all of Plum Springs, Smiths Grove, Oakland, and Woodburn are dependent upon the capacity of the natural subsurface drainage system to drain storm water. Numerous dry wells, sinkholes, and other natural openings are used to reduce or remove storm water runoff. Warren County has the largest number of Class V injection wells (dry storm water wells) in Kentucky.

Unfortunately, there is no guarantee that dry wells or sinkholes will function. First, the well may not successfully intercept a subterranean cavern and function as designed. Second, sinkholes occasionally collapse requiring reconstruction. Third, improper construction and/or maintenance of outlet structures may result in reduced efficiency and, at times, failure. Finally, the carrying capacity of natural drainage structures (sinkholes) is not fixed over time. There is no obvious correlation between rainfall intensity and the carrying capacity of sinkholes. What is safe today may be flooded tomorrow. These factors result in frequent flooding of karst areas.

The damages resulting from this flooding have greatly intensified in Warren County, and particularly in Bowling Green, because of the high degree of urbanization. Accompanied by rapid economic development and a 35 percent population increase since 1950, the percentage of sealed surfaces has increased. As a result, runoff volumes and flow rates have increased because of reduced infiltration of rainwater into the soil. This economic and population growth also increased pressure to develop land best used as natural drainage areas.

In summary, four factors - uncontrolled development accompanied by inexperienced builders, the lack of an extensive storm sewer network, dependence on the karst system, and the lack of a storm water management program - resulted in considerable localized flooding and subsequent property damage and led to the development of an official water management program.

BOWLING GREEN - WARREN COUNTY STORM WATER MANAGEMENT PROGRAM

Planning and Development

Bowling Green started thinking about its storm water problem as early as 1970. In that year, Bowling Green commissioned a city-wide storm water drainage study which was completed in April 1972 by the consulting firm of Conser and Townsend. The City/County Planning Commission was given the responsibility for the inspection of public improvements within subdivisions in 1974. In 1975 and again in 1976, the city experienced heavy rains and substantial property damage, particularly localized flood damages.

Because flooding affected both the city and the county, the joint city/county planning commission was given the responsibility to solve the storm water problem. The Planning Commission was given three mandates: (1) allow no more storm water damage; (2) utilize the karst system to its best advantage; and (3) do not stop growth. From these mandates was created the Storm Water Management Program. The Storm Water Management Program adopted two basic criteria:

(1) all drainage design would be calculated based on a 100-year storm frequency; and

(2) drainage design would utilize the rational formula and the Highway Department's methods for sizing pipes to determine inflow rates or the amount of back water that might occur.

It quickly became evident that this criteria created immediate problems. Too much land had been set aside for detention of stormwater. The design criteria was reduced to a 50-year storm frequency, but local flooding continued to occur. Because of these problems, Bowling Green - Warren County turned to David L. Daugherty, P.E., and the system he had proposed for Louisville and Jefferson County. Mr. Daugherty's system recognized the uniqueness and was designed for small urban watersheds. In the fall of 1976, Mr. Daugherty presented a three-week seminar to explain his system. Bowling Green - Warren County liked the approach and agreed to a nine-month pilot program utilizing his services as a specialist-on-call. The pilot program proved successful and was expanded to include all subdivision approvals and other developments where storm sewers were not available.

Implementation

The Storm Water Management Program of Bowling Green - Warren County set up five objectives as follows:

(1) prevent loss of life and significant real and personal property damage;

(2) minimize the degree of inconvenience resulting from frequent rainfall events;

(3) ensure that new development of all descriptions shall not impose measurable off-site water-related damages;

(4) ensure that new development of all descriptions be free from on-site water-related damages; and

(5) support the National Flood Insurance Program by protecting property from the results of a hundred-year rainfall event.

Stormwater management in Bowling Green - Warren County is regulated and enforced under three programs. Plans for stormwater management are included in zoning and subdivision regulations enforced by the Planning Commission and through provisions of city and county ordinances. Building codes are utilized by the city and county building departments as a third regulatory mechanism.

The Stormwater Management Program for Bowling Green - Warren County contains all the basic components of an effective control program: design, plans approval, system permitting, construction, facility inspections, operations and maintenance, and research. The first four components serve to assure that the design and construction of stormwater facilities are compatible with zoning and subdivision regulations, building codes, and general county ordinances. Operations and maintenance are obviously required to assure that facilities are properly functioning. The last component, research, provides information necessary to determine overall effectiveness and to fine-tune the system based on new and better information. The following table lists these major components, as well as the entitites responsible for implementation.

Table 2. Components and Responsibilities of the Bowling Green - Warren County Stormwater Management Program

ELEMENT	PRINCIPAL RESPONSIBILITY of:
Design	Landowner or Developer Planning Commission (Advisory capacity)
Plan Review	
Subdivision Approval	Planning Commission
Preliminary Construction Redevelopment	City Building Inspector and Planning Commission
Floodplain Management (zoning)	Planning Commission
Permit Issuance (Administration)	County and City Building Inspectors
Construction	Landowner and in a smaller capacity, the City and County
Construction Inspection	Landowner and in a smaller capacity, the City and County
Operations/Maintenance	Landowner and some by City and County
Research	Planning Commission/Center for KARST Studies/some by city

The design, construction, and operation of a storm water facility or system on privately-owned land is primarily the responsibility of the landowner or developer. The Planning Commission, however, is able to provide advice through a full-time staff person, well-qualified in hydrology and design. On public lands, the City and County Governments are obviously involved in each of the above aspects.

Plans review and approval is the primary responsibility of the Planning Commission and the city and county building inspectors. All storm water plans for new construction (subdivisions or otherwise), as well as redevelopments, are reviewed for completeness and compatibility with various regulations, building codes, and city or county floodplain zoning rules. Restrictions on redevelopments of the older sections of Bowling Green provide an additional opportunity to correct storm water management program. Redevelopments are regulated by the Planning Commission, which allows for the enforcement of building codes to assure proper implementation of storm water management plans. Establishing compliance with flood insurance regulations is also a joint responsibility of the Planning Commission and government building inspectors.

The responsibility of enforcing construction standards and maintenance has not been clearly delegated. No written policy on maintenance requirements of facilities has been adopted. Additionally, no single county or city government agency has been delegated such authority. In cases where maintenance responsibilities are unclear, officials have had difficulties in resolving the issues and repairing structures before another rainfall event.

Nevertheless, many improvements have occurred to reduce flooding in the Bowling Green - Warren County Area. Hydrology research is now being done by the Center for Karst Studies at Western Kentucky University. Additionally, the City of Bowling Green has on several occasions undertaken system-wide drainage analyses of specific urban watersheds. These studies have helped establish substantial improvements in reducing flood damage.

Cost

Figures for the cost of this program are unavailable since it is an ongoing program. Initial funding was obtained from the local government which was aided by a grant from the Natural Resources and Environmental Protection Cabinet, Division of Water, through the Community Flood Damage Abatement Program.

CONCLUSION

The storm water management program for Bowling Green - Warren County has proven effective. In the first seven years of the program, 191 developments (over 3,400 lots) have been reviewed. To date, only fifty lots of those reviewed have had drainage problems.

Bowling Green - Warren County has completed a review of its storm water management program. The review points out several strong points, summarized as follows:

(1) the program has unified city/county cooperation which has one set of standards, one unified review process, and one inspection procedure;

(2) it has fostered better drainage design for beneficial development, while restricting development in floodprone areas;

(3) it provides design assistance and subdivision project review; and

(4) attention has been brought to the need for storm water management.

Likewise, the review pointed out some weaknesses:

(1) the program lacks a maintenance policy for areas under both public and private sector authority;

(2) more support is needed for the implementation of the program;

(3) property owners need to be made aware of, and responsible for floodproofing design criteria; and

(4) a county-wide stormwater management program needs to be established.

Even with these weaknesses, Bowling Green - Warren County officials have been very pleased with their storm water management program. John Matheney, Director of the Planning Commission, has several suggestions, however, to aid communities considering such a program. First, the program should be a joint county and city effort covering a sufficient area to be effective. Second, the program must be staffed by qualified and aggressive people. Third, the responsibilities of various agencies should be clearly defined. Fourth, the program must be locally-based with the solid support of local government(s). Last, maintenance must be recognized as a key issue.

REFERENCES

Remarks Presented at Workshop "Floodplain Management: Concepts for Public Officials," Presented by John Matheney, March 21, 1983.

Review of Storm Water Management Program for Bowling Green and Warren County, Prepared by John Metheney and staff of the City-County Planning Commission.

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SUMMARY

As the previous sections dealing with Barbourville, Benton and Bowling Green - Warren County demonstrate, Kentucky communities can and have taken steps to reduce or eliminate flood damages. These studies show that solving flood problems is not an easy task. It takes dedicated individuals and hard work.

Evident throughout the three case studies were several common themes. First, each community took action as a result of particular flood events. Second, each community took action as a result of citizen interest. Third, and most importantly, each had local officials with a concern and desire to help citizens of their community. The statement provided by John Matheney at Bowling Green - Warren County applies to any type of flood damage reduction program. These programs must have the solid support of the local government(s) involved.

If you have any questions about the presented case studies, please contact the person responsible for each program or contact the:

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