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FLOODPLAIN MANAGEMENT MANUAL FOR LOCAL GOVERNMENT

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Department of Natural Resources
Colorado Water Conservation Board
J. William McDonald, Director

Preface

Loss of lives and damage to property due to floods continue to increase in the United States in spite of an investment of billions of dollars in flood control structures. Colorado's experience echoes this national trend. Since the turn-of-the-century several hundred Coloradoans have been killed by floods, and property damages in excess of $1.6 billion have been incurred.

Flooding has been going on since long before settlement of Colorado. The lands inundated by floodwaters, or the floodplains, have and always will attract settlement. Flood control structures and disaster relief programs were intended to relieve floodplain residents and/or communities near floodplains of the severe financial and emotional impacts of flooding. Today, however, costs of projects and disaster relief are mounting, as is the cost of flooding damages. Lawmakers have begun pursuing programs of mitigation that would make floodplain regulation possible and so provide a range of managment alternatives to floodplain managers and communities in the floodplain.

In 1937, the Colorado General Assembly created the Colorado Water Conservation Board (CWCB) and charged it with, among other things, the responsibility for "the utmost prevention of floods." In 1966, the Legislature passed H.B. 1007 providing for designation of floodplains by the CWCB so that local governments could regulate and control land uses in flood hazard areas under "police powers." In 1974, the Legislature passed H.B. 1041 providing that floodplains are a matter of state interest, and that after a public hearing, a local government may regulate matters of state interest.

In 1968 Congress passed the National Flood Insurance Act providing for flood hazard insurance and amended it in 1969 to include mudslides (mudflows). The Congress strengthened the program by passing the Flood Disaster Protection Act of 1973.

The intent of the 1937, 1966, and 1974 acts of the Colorado General Assembly and the intent of the National Flood Insurance Program (NFIP) was to reduce hazardous occupation of the floodplains and thereby reduce flood damages and disaster relief costs.

The concept of floodplain management stated simply is to achieve the optimal use of the floodplain while reducing flood damages. Implementation of a floodplain management program, however, is not simple in any respect. *A Floodplain Management Manual for Local Governments* was prepared to provide local government officials with basic information on flood-related precedents, procedures, and programs. It is a revision of a document published in June, 1976 by the CWCB titled, *Manual for Local Governments -- Floodplain Management, Flood Control, and Flood Disaster Programs.*

The revised manual is organized into six chapters, a resource section, and a glossary.

The chapters, **Historic Flood Damages and Causes of Floods,**
Legal Aspects of Floodplain Management,
Identification of the Floodplain,
Floodplain Management Alternatives,
Administration of Floodplain Regulations,
Implementing a Floodplain Management Program,

can either be read one after another to obtain a complete picture of the elements involved in a floodplain management program, or they can be read individually if only a portion of the information is needed. A "resources" section was compiled to supplement the text if some of the information is either not exactly what the floodplain manager needed or if there is information that is missing and a floodplain manager needs to pursue it. The reader will find references to the resources section in the text indicated by (R).

The reader will also be directed to a "glossary" of technical or jargon terms for definition when a word appears in the text that is in italics.

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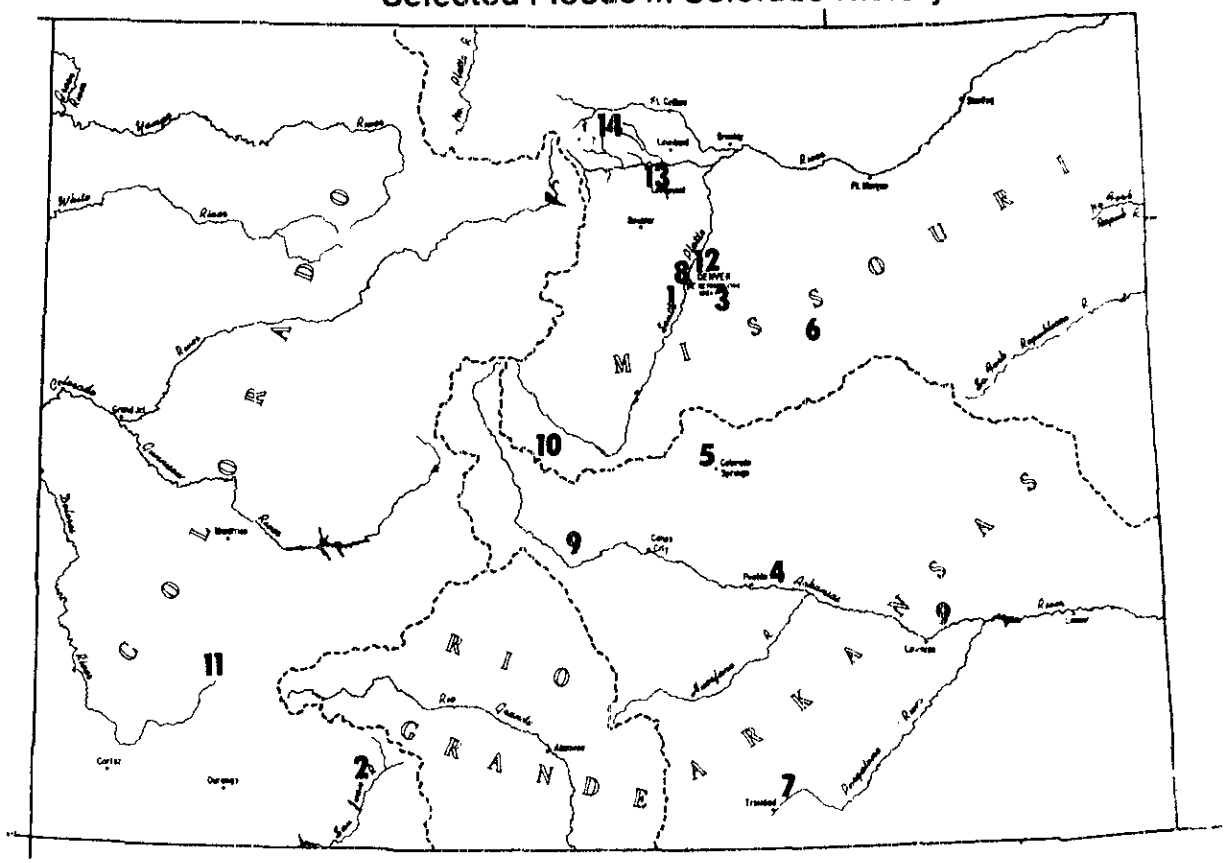
CHAPTER 1
HISTORIC FLOOD DAMAGES AND CAUSES OF FLOODS

Historic Flood Damages

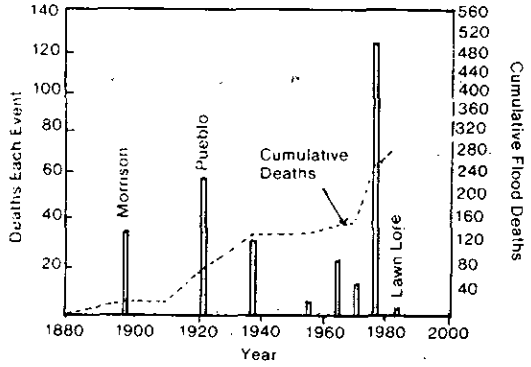
The earliest recorded *floods* in Colorado are reported to have occurred in 1826 in the Arkansas River and Republican River basins. Between 20 and 30 floods of large *magnitude* (in terms of peak *discharge*) occur **somewhere** in the state every year. On the average, every 6 years a major flood killing 22 persons and leaving $114,300,000 in damages (present worth) has occurred. The average annual flood loss in Colorado is almost 4 people per year and $14,000,000 in property damages based on the trend from 1896 to 1976. The President has declared areas in Colorado a major disaster during six of the past 20 years. Most of these disasters were caused by precipitation, but two were caused by dam failure.

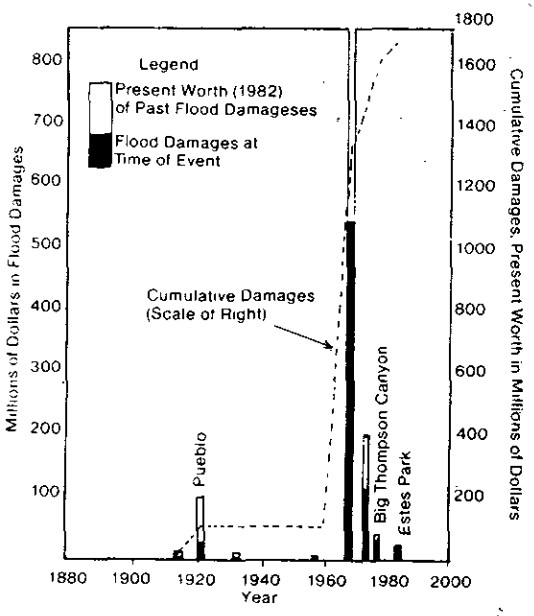
Selected Floods in Colorado History



	Date	Major Stream and Location	Loss of Life	Damages	Damages (Adjusted to 1982 Worth)
[1]July	1836	Bear Creek at Morrison	27	$ ------	$ ------
[2]Oct	1911	San Juan River near Pagosa Spr.	2	100,000	600,000
[3]July	1912	Cherry Creek at Denver	2	1,000,000	6,300,000
[4]June	1921	Arkansas River at Pueblo	78	19,000,000	108,300,000
[5]May	1935	Monument Creek at Colo. Springs	18	1,760,000	8,100,000
[6]May	1935	Kiowa Creek near Kiowa	9	------	------
[7]May	1955	Purgatoire River at Trinidad	2	4,000,000	12,400,000
[8]June	1965	South Platte River at Denver	8	500,000,000	1,150,000,000
[9]June	1965	Arkansas River Basin	16	46,700,000	107,400,000
[10]May	1969	South Platte River Basin	0	5,000,000	------
[11]Sept	1970	Southwest Colorado	0	4,000,000	------
[12]May	1973	South Platte River at Denver	10	121,500,000	206,600,000
[13]July	1976	Big Thompson River in Canyon	139	35,500,000	53,300,000
[14]July	1982	Fall River at Estes Park	3	30,680,000	31,000,000
Total Flood Loss			314	$769,240,000	$1,684,000,000

Deaths from Floods in Colorado





Damages from Floods in Colorado

Recent Presidentially Declared Major Disasters

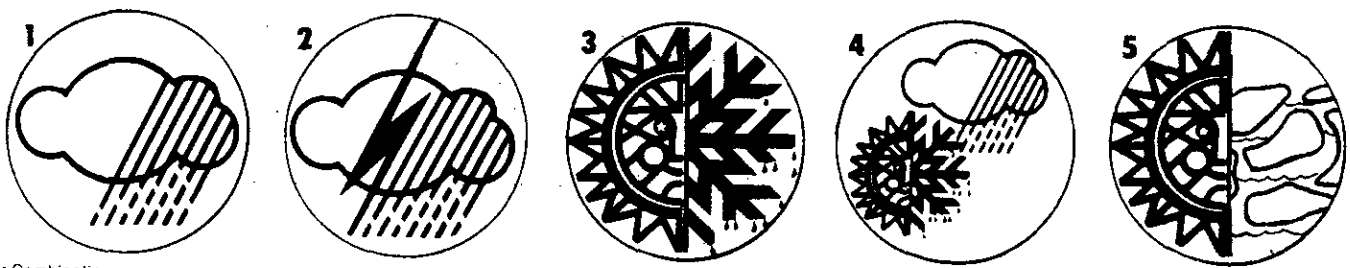
Year	Location	River Basin	Cause
1965	Front Range 33 counties	S. Platte Arkansas	Sustained Rainfall
1969	Front Range 15 counties	S. Platte	Sustained Rainfall
1970	Southwest	Colorado	Sustained Rainfall
1973	(1) Kersey	S. Platte	Dam Failure
	(2) Front Range 13 Counties	S. Platte	Sustained Rainfall
	(3) Southwest 13 Counties	Colorado	Sustained Rainfall
1976	Big Thompson Front Range 2 counties	S. Platte	Flash flooding, heavy rainfall over short duration
1982	Lawn Lake Front Range 1 county	S. Platte	Dam Failure

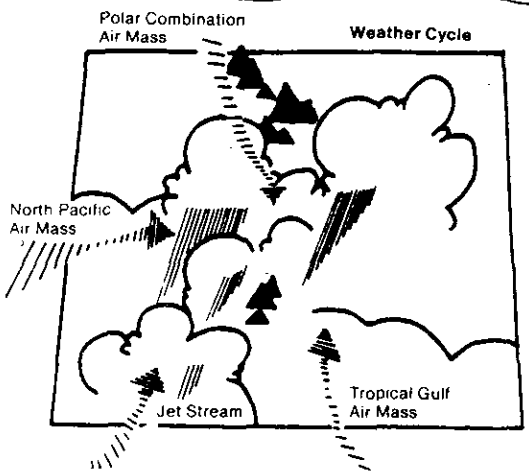
Causes of Floods-

Floods in Colorado occur on *"riverine"* systems which consist of a *basin* or watershed and *channels* ranging from small streams to major rivers, which convey the normal flow of water through the watershed. The area adjacent to the channel is the *floodplain*. A flood is a flow of water greater than the normal carrying capacity of the stream channel. The rate of *rise*, magnitude, *duration*, and *frequency of floods* are a function of specific *physiographic* characteristics of the basin. For example, the rise in water surface elevation is quite rapid on small and steep gradient streams and slow in large and flat sloped streams.

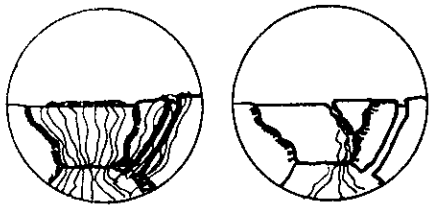
The causes of floods are the accumulation of water from precipitation in a variety of forms or the failure of man-made structures such as *dams* or *levees*. There are some who feel that a heavy snowpack is the chief cause of serious flooding and that once the majority of the snowpack has melted, the state is safe from flooding. Others feel flooding is only a result of isolated thunderstorms in mountain canyons. These notions do not, however, reflect the full variety of causes of flooding related to precipitation which are:

1) rain in a general storm system,
2) rain in a localized intense thunderstorm,
3) melting snow,
4) rain on melting snow,
5) ice jams.





Precipitation in each of Colorado's river basins is related to the seasons and to two major sources of moisture. Summer showers and thunderstorms that occur from June through September are caused by moisture from the Gulf of Mexico or the Pacific Ocean. During the fall, occasional general rainstorms and thunderstorms occur from wet and warm cyclonic air masses which move in from the southern Pacific Ocean. Winter and spring rain and snow storms are generally a result of moist air masses which originate in the cooler northern Pacific Ocean and move inland across the Pacific Northwest.



Floods caused by failure of man-made structures--dams and levees--result from:

1) hydrologic deficiencies,
2) structural deficiencies,
3) improper operation or sabotage.

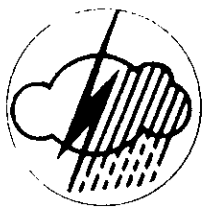
Each of these causes results in floods which have distinct characteristics relative to rate of rise, volume, duration, and flood season.

Precipitation Caused Floods-

General Rain Floods

General rain floods result from moderate to heavy rainfall occurring over a wide geographic area and lasting several days. They are characterized by a slow steady rise in stream depth and a peak flood of long duration. As various minor streams empty into larger and larger channels, the peak discharge on the mainstem channel may progress upstream or downstream (or remain stationary) over a considerable length of river./General rain floods can result in considerably large volumes of water. The general rain flood season is usually from the beginning of May through October. Because the rate of rise is slow and the time available for warning is great, the possibility of saving lives is increased but millions of dollars in valuable public and private property are put at risk.

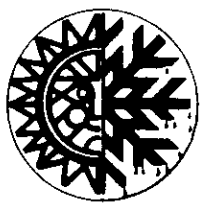
The October 5, 1911 floods in Pagosa Springs and Durango were a result of a general rain system over tributaries of the San Juan River Basin. The June 3, 1921 flood in Pueblo was a result of a general rain system in the Upper Arkansas River Basin. The damaging floods of June 1965 in the Denver-Metro area were a result of heavy to *torrential* rainfall over large portions of the South Platte River basin which nized as a potential source of structural problems due to *liquefaction* of fine-grained material in the embankment of a dam.*



Thunderstorm Floods

Damaging thunderstorm floods are caused by intense rain over basins of relatively small *areal* extent. They are characterized by a sudden rise in stream level, short duration, and a relatively small volume of *runoff*. Because there is little or no warning time, the term "flash flood" is often used to describe thunderstorm type floods. The thunderstorm flood season in Colorado is from the middle of July through October.

The widely publicized Big Thompson Canyon flood disaster of July 31, 1976, was a result of an intense thunderstorm cell which dropped up to 10 inches of rain in a few hours over the basin.



Snowmelt Floods

Snowmelt floods result from the melting of the winter snowpack in the high mountain areas. Snowmelt floods typically begin as spring runoff appears, after the first spring warming trend. If the trend continues up to 8-10 consecutive days, in a basin where the snowpack has a water content more than 150% of average, flooding can develop. The total duration of snowmelt floods is usually over a period of weeks rather than days. They yield a larger total volume of runoff in comparison to other varieties of flood. Peak flows, however, are generally not as high as flows for the others. A single cold day or cold front can interrupt a melting cycle. The rising water will then decline and stabilize until the cycle can begin again. Once snowmelt floods have peaked, the daily decreases are moderate but constant. Snowmelt flooding usually occurs in May, June, and early July.

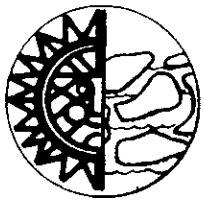
Floods in La Plata County in 1941 and 1949 and those in June, 1983, along the Cache la Poudre River in Fort Collins and Greeley, along Clear Creek and its tributaries in Silver Plume and Georgetown, and along the Arkansas River in Fremont and Chaffee counties, were principally due to melting snow.

Rain on Snow Floods

During the months of May and June and the early part of July there is a potential for flooding due to rain falling after spring snowmelt has already increased runoff. Sometimes such rain is over a small part of a basin and the resulting flood is of short duration and may often go

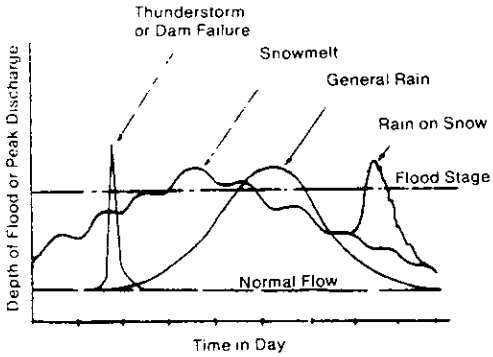
unnoticed in the lower reaches of a large drainage basin. In some cases, however, rainfall may be heavy and widespread enough to noticeably affect peak flows throughout a basin.

Flooding along the Colorado River in Grand Junction in July of 1884, flooding in June of 1965 at higher elevation communities including Georgetown and Frisco, and flooding in June of 1983 along the Gunnison River at Delta and Grand Junction and along the Colorado River at Grand Junction, are examples of flooding from rain on melting snow. The effect of the rainfall in the Colorado River basin in 1983 was felt as far downstream as Mexico.



Ice Jam Floods

Ice jam floods occur when the upper reaches of a stream that has been frozen abruptly begins to melt due to chinook winds. Meanwhile downstream one of two conditions is occuring to promote an ice jam. Either the frozen stream partially melts or temperature inversions cause an unfrozen stream to partially freeze. The upper basin flows move the ice chunks downstream until they become lodged at some *constriction* and form a jam. The jam forces the water to be diverted from the stream channel causing a flood. The ice jams can also break up suddenly causing surges of water as the "reservoir" that was formed behind them is released. Ice jams occur in slow moving streams where prolonged periods of cold weather are experienced. Sometimes the ice jams are dynamited, allowing the backed up water to flow downstream. In 1955, 1962, and 1983 flooding in Rangely resulted from ice jams, as did 1973 flooding in Meeker.

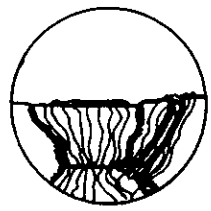


Comparison of Typical Flood Characteristics in Colorado.

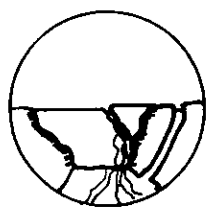
Dam Failure Floods

There are approximately 27,000 dams in the State of Colorado. This includes about 2,249 dams which fall under the review of the Colorado Division of Water Resources (State Engineer) dam safety program, 16,000 small dams for small capacity reservoirs known as "Livestock Water Tanks," and Erosion Control Dams (which are not normally inspected under the dam safety program), potential artificial impoundments created by highway embankments constructed across drainageways, and miscellaneous ponds. A dam has to be at least 10 feet high and the reservoir must have a capacity of at least 50 acre-feet or the reservoir must have a storage capacity of at least 1,000 acre-feet in order to fall under the review of the dam safety program.

Dams and their related appurtenances are inspected to forestall failure due to lack of proper maintenance and repair. Few lives have been lost in floods caused by a dam failure, but property damage has been high. There have been at least 130 known dam failures in Colorado since 1890. Dam failure floods are primarily a result of hydrologic or structural deficiencies. The operation of a reservoir can also influence the safety of the structure.



"Hydrologic deficiency" means one or more of a dam's components do not have the capacity to contain or pass the large volumes of water flowing into the reservoir. The most significant hydrologic deficiency is inadequate spillway capacity causing overtopping of the dam during a large flood. Large waves generated from landslides into a reservoir or the sudden inflow from upstream dam failures are other causes of hydrologic dam failure. Overtopping is especially dangerous for an earthen dam (earthen dams are the most common type of structure in Colorado) because the downrush of water over the crest will erode the dam face and, if it continues long enough, will *breach* the dam embankment and cause the rapid release of the stored water into the downstream floodplain.

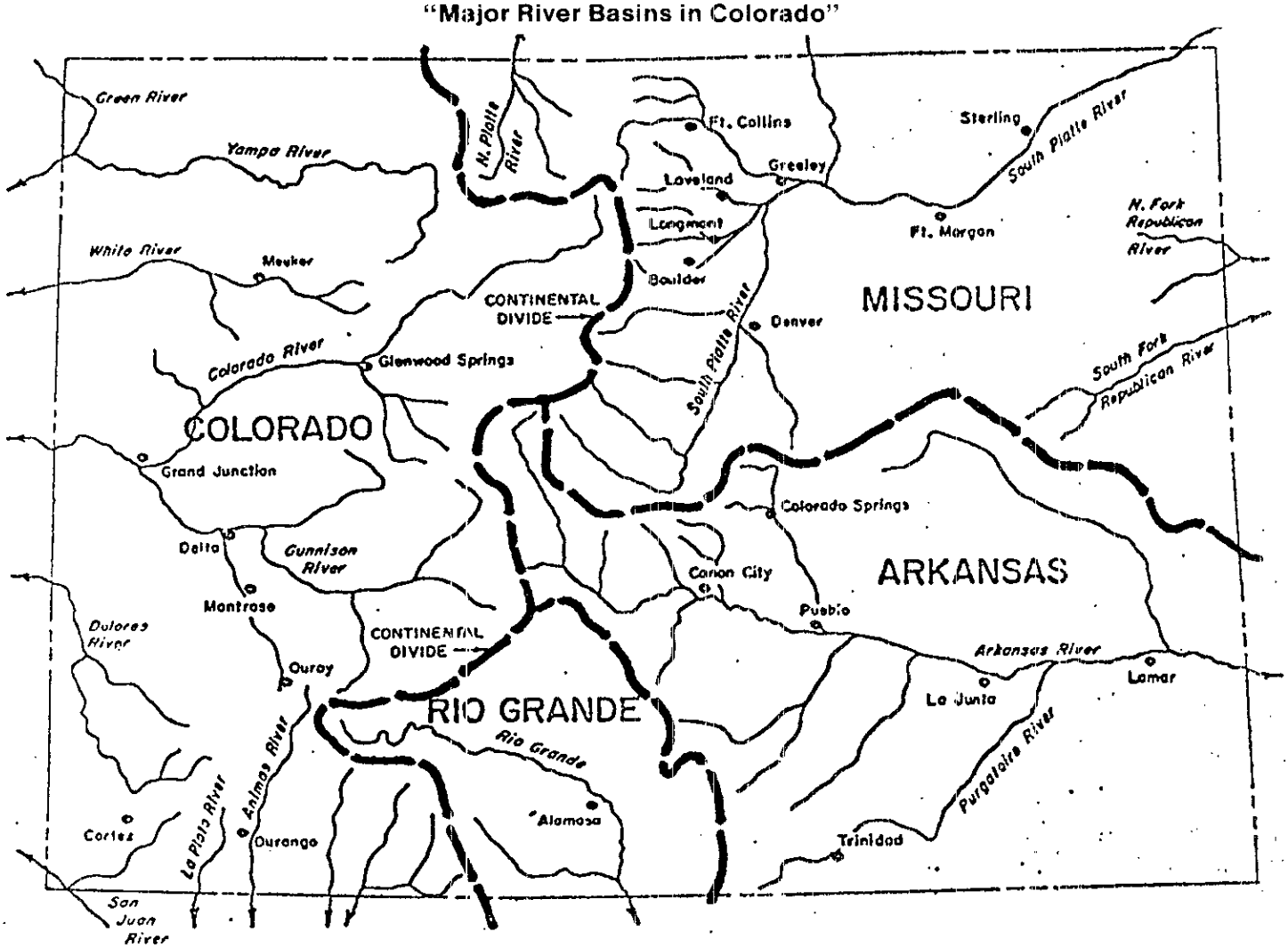


Structural deficiencies include *seepage* through the *embankment. piping* along internal conduits, erosion, cracking, sliding, overturning, or other structural weakness. Old age is often at the root of structural deficiencies. Seismic activity in Colorado has recently been recognized as a potential source of structural problems due to *liquefaction* of fine-grained material in the embankment of a dam. *

The mechanics of a structural failure in an earthen dam, or any other dam, are important to downstream communities because they determine the amount of warning time the community will have and the magnitude of the peak flow that will be experienced. The mechanics depend on the type of dam and the cause and type of failure. By determining what type(s) of dam(s) is(are) upstream of their community, local floodplain administrators can evaluate what type of failure, if any, could occur and what flood characteristics would result. The distance of the dam from the community and the variety of dam monitoring in place will also affect community response to a dam failure.

Most dam failure floods are similar to thunderstorm floods. There is a rapid increase in flows creating a sharp peak, with a somewhat slower decrease in flows following the peak. In June 1965, a flood occurred on Clay Creek in Prowers County from the overtopping (hydrologic failure) of an earthen dam constructed by Colorado Game, Fish, and Parks Commission. (The dam held.) This dam failure flood resulted in an important legal controversy known as the Barr Case. This case was finally decided in 1972 by the Colorado Supreme Court which recognized the concept of *probable maximum flood (PMF)* as a predictable and foreseeable standard for spillway design purposes. Two dam failures in Colorado have resulted in Presidential Major Disaster Declarations. These were the failure of the Lower Latham Reservoir Dam in 1973 and subsequent flooding in the town of Kersey, and the failure of Lawn Lake Dam on July 15, 1982 which caused 3 deaths and $31 million worth of damages in the Estes Park/Rocky Mountain Park area.

"Major River Basins in Colorado"



CHAPTER 2
LEGAL ASPECTS OF FLOOD-PLAIN MANAGEMENT

This chapter provides a floodplain manager with an introduction to the major legal concepts which may be encountered when developing, implementing, and administering a floodplain management program. It is not a substitute for legal advice. When legal questions arise, professional legal guidance should be obtained.

Federal and State Legislation

The evolution of Federal flood-related legislation has brought about an increasing emphasis on non-structural measures and flood hazard mitigation activities. Congress enacted the first Flood Control Act in 1917. That Act specifically charged the U.S. Army Corps of Engineers with responsibility for some flood control projects on the Mississippi and Sacramento Rivers. Subsequent Flood Control Acts expanded the Corps' authorities and responsibilities with regard to flood control projects and activities for specific communities. Through those authorities the Corps is designated a role in flood control projects before a flood, in flood fights during a flood, and in a clean-up after a flood.

In 1968, the National Flood Insurance Program was created to provide flood insurance at affordable rates upon the condition that member communities institute floodplain management programs. In 1973 the program was expanded by requiring flood insurance on properties directly or indirectly financed by federal entities and by making participation in the NFIP a requirement for federal disaster assistance to local communities.

The focus of State and Federal legislation has been to leave a role for local governments to establish local programs. Federal legislation provides local governments with several kinds of assistance--i.e., Corps projects and technical assistance, the NFIP, disaster assistance--and it specifies some conditions local governments must meet to receive such assistance. It leaves responsibility for managing floodplains with local government. Similarly Colorado legislation also creates floodplain management programs and provides local governments with the authorities for floodplain management but has left the responsibility for managing floodplains with local governments.

The concept of the 100-year floodplain is used throughout this manual. It was first adopted by the State of Colorado as part of Section 24-65-105, CRS 1973, as amended, whereby the Colorado Land Use Commission was charged with designating "critical areas in the state where a one hundred-year (storm return frequency) floodway should be identified . . . ." Section 24-65.1-103 defined a floodplain as an area "subject to flooding as a result of the occurrence of an intermediate regional flood . . . ." Section 24-65.1-403(3)(b) requires designation and approval of a floodplain by the Colorado Water Conservation Board (CWCB) prior to regulation by a local government.

Legal Principles

The most frequently used tool of floodplain management is floodplain regulations. One of the most common concerns of local officials adopting and enforcing such regulations is the possibility of legal challenges to their actions. This section will address that concern by discussing generally, 1) the legal basis for most floodplain regulations and 2) the potential types of legal attacks on those regulations.

Constitutionality

Prior to passage or amendment of floodplain regulations by the local governing body, the floodplain administrator will need to be sure that the governing body is empowered to so regulate. State enabling legislation (i.e., the legislation whereby the State gives local governments the power to implement certain regulations), which is derived from the State constitution, allows a community to regulate and control the actions of individuals to the degree reasonable and necessary to guard public health, safety, or the general welfare of the community. The power of local governments to enact such regulations is called the "police power."[1]

The use of police power has been challenged by some private landowners. Generally the basis of the challenge has been a claim that the regulations have served purposes other than the protection of public health, safety, or welfare. A basic condition that local floodplain regulations must meet in order to be enforceable is that they not unreasonably interfere with citizens' constitutional rights.

In some communities property owners have claimed that, in fact, regulations have so restricted their constitutional rights that a "taking" of private property has occurred. "Taking" means that restrictions on the use of land are such as to leave no reasonable use available to the property owner while denying him just compensation for the loss of the use of the land. Several legal cases have addressed the issue of taking and the question of what constitutes "reasonable use." These cases have led to the position that "reasonable use" does not necessarily mean the highest use of the property.

REGULATORY GUIDELINES

Statutory Authority	The entity adopting floodplain or wetland regulations must be authorized to do so by general or specific enabling act or home rule powers.
Procedural Regularity	Statutory procedures for adoption and administration of an ordinance must be strictly followed.
Proper Goals	Regulations must serve legitimate goals and objectives as exercises of the public police power.
Reasonableness	Regulations must be reasonably related to the stated goals and tend to accomplish them.
The Taking Issue	Regulations must not "take" private land for public purposes without payment of just compensation.
Equal Protection	Regulations must not discriminate unreasonably or arbitrarily among different property owners.
Vagueness	Standards for issuing permits and other administrative actions must be clear and definite.

The "Pinpoint Approach"

The approach of testing the way a law deals with the individual application rather than testing the whole statute results from two rulings of the United States Supreme Court on zoning regulations. In these cases the court ruled that zoning regulations were a legal application of police power, and that even though an ordinance is valid in a general sense, it can be attacked when applied to particular lands. This is the "pinpoint" approach, under which findings of invalidity applicable to one property may not apply to the adjoining property.

Under the "pinpoint" approach a property owner can concede the general validity of floodplain regulations but challenge their constitutionality as applied to his land. He can claim they are arbitrary or capricious or claim that they take his property without just compensation.[2]

Local governments which are concerned about the possibility of legal action against floodplain regulations they adopt should be aware of legal precepts which have evolved from past court cases debating zoning and other related questions.

1) Regulations and State statutes enabling them, including floodplain regulations and enabling statutes, are presumed to be constitutional when they are enacted.

2) The individual challenging the regulations must show that a taking has occurred or that statutory procedures have not been followed.

3) Creation of a nuisance or of a threat to public safety has not been recognized as a right of property owners.

4) Properties within a floodplain delineated by accepted engineering methods are already burdened by natural restrictions without even considering zoning restrictions.

5) Even if it severely limits the individual, a regulation that prevents potential threats of injury and loss to the public is likely to be upheld.

6) The "pinpoint" approach means that the constitutionality of floodplain regulations as applied in specific circumstances can only be decided on a case-by-case basis through litigation.

(The above is not intended to be a comprehensive list of all questions which a local government administrator may encounter when adopting floodplain regulations.)

COLORADO FLOOD RELATED LEGISLATION

Subject Area	Citation	Legislation's Charge With Regard to Floodplain Management	Enactment Information
Colorado Water Conservation Board	37-60-106 *et seq* CRS 1973, as amended	Created the Colorado Water Conservation Board to secure the utmost prevention of floods, to designated storm or floodwater runoff channels or basins, to promote or participate in flood control projects.	Creation of the Colorado Water Conservation Board (1937)
Flood Control	30-30-101 *et seq* CRS 1973, as amended	Authorized county commissioners to remove obstructions to flow in any natural stream channel for flood control purposes.	Counties - Flood Control (1974)
Conservancy Districts Improvement Districts, Public Improvements	37-2-101 *et seq* CRS 1973, as amended	Authorized the creation of conservancy districts to prevent floods, regulate streamflows, and divert and control water courses. Conservancy districts were created in Fremont County, Pueblo, Weld County, on the South Platte River, and on the Dolores River	Conservancy Law of Colorado (1922)
	30-20-501 *et seq* CRS 1973, as amended	Authorized county commissioners, when petitioned by property owners, to create improvement districts in unincorporated portions of their county for the construction of storm sewer drainage systems, surface drainage systems, and street drainage facilities.	County Public Improvement District Act (1968)
	30-20-601 *et seq* CRS 1973, as amended	Authorized county commissioners to create, by resolution, improvement districts in unincorporated portions of their county for the construction of drainage facilities to convey water runoff	H.B 1163 (1983)
	38-6-101 CRS 1973 as amended	Authorized municipal governments to take, damage, condemn, or appropriate by eminent domain private property needed for public works or public improvements	----------
	3011-107	Authorized county commissioners to expend moneys and acquire land for drainage facilities.	H.B. 1163 (1983)
Urban Drainage & Flood Control District	32-11-101 *et seq* CRS 1973, as amended	Created the Urban Drainage and Flood Control District to coordinate multi-jurisdictional urban drainage activities in the Denver region.	Urban Drainage and Flood Control District (1963)
Colorado Division of Disaster Emergency Services	28-2-101 *et seq.* CRS 1973, as amended	Created the Division of Disaster Emergency Services to reduce the vulnerability of people and communities to natural catastrophes and to provide a disaster and emergency management system embodying all aspects of predisaster, preemergency preparedness, postdisaster, and postemergency response	H.B. 1600 (1973)
	28-2-110 and 28-2-501 *et seq* CRS 1973, as amended	Expanded the ability of the state government to provide emergency relief to local governments.	S.B. 399 (1973)
Land Use Regulations	30-28-101 *et seq.* CRS 1973, as amended	Required the creation of county and regional planning commissions where they did not exist, required these commissions to prepare master plans which may address drainage and flood control, and required counties to adopt and enforce subdivision regulations.	S.B. 35 (1972) H.B. 1163 (1983)
Land Use Regulations	30-28-111 *et seq.* CRS 1973, as amended	Authorized county planning commissions to regulate designated floodplains through their zoning plans and required counties to adopt subdivision regulations which include standard and technical procedures for storm drainage plans and related designs	H.B. 1017 (1966) H.B. 1163 (1983)
	31-23-201 *et seq* CRS 1973, as amended	Authorized municipalities to create planning commissions whose duties include the preparation of a master plan which promotes safety from flood waters.	

31-23-301 *et seq.* CRS 1973, as amended	Authorized municipal governments to regulate designated floodplains through zoning.	H.B. 1007 (1966)
2465-101 *et seq.* CRS 1973, as amended	Created the Colorado Land Use Commission which, among other tasks, was charged with identifying 100-year floodways.	S.B. 93 (1971)
24-65.1-101 *et seq.* CRS 1973, as amended	Gave local governments authority and responsibility for identifying and regulating "areas and activities" of state interest, including floodplains, and requiring permits for development in these areas.	H.B. 1041 (1974)
2465.1-403(3) CRS 1973, as amended	Authorized the Colorado Water Conservation Board to establish standards and criteria for floodplain studies and to designate such studies and required designation of such studies by the Colorado Water Conservation Board prior to their use by local governments for regulatory purposes.	S.B. 126 (1977)
	29-20-101 *et seq.* CRS 1973 as amended	Authorized local governments to plan for and regulate the use of land by regulating development and activities in hazardous areas	H.B. 1034 (1974)
Dam Safety	37-87-104 *et seq.* CRS 1973 as amended	Established liability of dam owners for damages resulting from dam failure floods, required approval of reservoir plans and inspection and supervision of construction by the State Engineer, required the State Engineer to annually determine the amount of water it is safe to store in a reservoir, to restrict storage to that safe amount, and to examine a reservoir upon complaint that it is unsafe	.....
	37-87-123	Required the State Engineer to compile reports on high hazard dams indicating the possible extent of flooding in the event of a breach, and to send such reports to each city, town, and county in the affected area. Required such affected local governments to review the affected areas in their community and to pay a standard fee to the State Engineer for the reports.	H.B. 1416 (1983)

Relevant Court Cases

Three cases were presented by Kusler *et al.* in *The Law of Floodplain and Wetlands Cases and Materials* as representative of the law of floodplains and wetlands. These cases are: 1) *Morris County Land Improvement Co. v. Parsippany-Troy Hills Twp*; 2) *Turnpike Realty Co., Inc. v. Town of Dedham*; and 3) *Just v. Marinette County*. Although regulation of wetlands does not always address the same public safety concerns as regulation of floodplains, many of the legal, administrative, and engineering considerations are similar.

In the Morris County Land Improvement Co. case of 1963, the landowner owned a parcel that was part of a large swamp zoned to severely restrict uses on it, due to its function as a natural detention basin during times of heavy rainfall. The court ruled that the zoning effectively preserved the land as an open space for a water-detention basin and that the local government and the public-at-large would benefit to the complete detriment of the owner. It was concluded that such zoning amounted to a "taking" and that if the government sought to acquire the subject property it should purchase it rather than acquire it through regulation.

The court's ruling in the Morris County case was strongly criticized in the case *Usdin v. N.J. Dept. of Environmental Protection*. In that 1980 case the plaintiff's property was designated as a floodway by the state. Later the owner applied for a building permit and was told that the state would have to issue approval for any development. Then refined engineering allowed the state to change the designation from floodway to flood fringe. The owner asked for damages for the loss of the use of the land until the redesignation. In ruling on this claim the court considered the Morris County Land Improvement Co. case and the whole concept of regulating floodplains to prevent public harm. The decision of the court was that the plaintiff was entitled to less in damages than requested, that the regulations were constitutional, and that the Morris County Land Improvement Co. decision was not an appropriate precedent in this case.

The Turnpike Realty Co. case of 1972 involved a low piece of property that was regulated by a floodplain zoning bylaw. The owner attacked the bylaw as unconstitutional for several reasons. The court ruled that there was evidence that showed that the land was subject to flooding and that, although there was evidence that "there was a substantial diminution in value," there was not conclusive evidence of an unconstitutional taking.

The Just case of 1972 involved a piece of property next to a lake, subject to county shoreland and wetland regulations. The owner, without obtaining a permit, filled in part of the property with sandy material.When the county charged him with a violation, the owner challenged the regulations as unconstitutional. The court held that the regulations were constitutional, that the subject property constituted wetlands, and that it was constitutional to prohibit filling of wetlands.

Liability of Government Agencies Constructing Flood Control or Drainage Facilities

A concern of government agencies considering the construction of flood control or drainage facilities will be their potential liability for flood damages which may result from the operation of such facilities (from normal operation, not from failures). Ordinarily the Federal Government is not liable for the construction or operation of such facilities due to statutory limits on responsibility. Local governments and State agencies are more often held liable, particularly when they are found to be operating in a "proprietary" rather than a "governmental" capacity. Liability often depends upon common law rules pertaining to flooding and drainage. Courts in other states have found local governments liable in cases of increased flooding due to publicly built storm drainage facilities or due to improperly designed storm drainage facilities built by landowners and dedicated to the local government. Two cases of interest are: *Oahe Conservancy Sub-District v. Alexander* and *Masky v. City of Loraine*.

Legal Basis for Dam Safety Programs In Colorado

Colorado Division of Water Resources

The State Engineer is required to approve plans for reservoirs and to supervise the construction of dams (CRS 37-87-105), to "annually determine the amount of water which is safe to impound in the several reservoirs within this state" (CRS 37-87-107) and "upon complaint" examine a reservoir and "determine the amount of water it is (sic) safe to impound therein" (CRS 37-87-109).

The safety of dams in Colorado is primarily the responsibility of the dam owners. State law holds owners of dams liable for damages resulting from flooding due to leakage, overflow, or failure of their dams. Shareholders, employees, or members of boards of directors of an entity owning a reservoir are not liable for such damages if an insurance policy, meeting certain requirements, has been purchased by the owner (CRS 37-87-104).

State law also provides that the State Engineer is not liable for damages. "Neither the State Engineer nor any member of his staff or any person appointed by him shall be liable in damages for any act done by him in pursuance of the provisions of this article." (CRS 37-87-115).

Once a reservoir is restricted by the State Engineer, that restriction remains in effect until the conditions for full utilization are met, whether or not an inspection is made within one year of the date of the restriction.

Recently the State Engineer was required to compile a report on each high hazard dam in the state. Each report will contain a topographic map indicating the possible extent of flooding in the event of a breach. The map will portray approximately all areas downstream of the dam (or dams) which would be affected by floodwaters to the point where the floodwaters would no longer exceed the boundaries of the 100-year floodplain. They will also show the peak flows and travel times of the flood.

On or before November 1, 1983 a final copy of each report will be sent to each city, town, and county in the affected area. Each local jurisdiction is then required to conduct a review of all areas which would be impacted by a breach of each high hazard dam or reservoir. The local government will be required to pay to the State Engineer the standard fee for each such report it receives.Ⓡ

In 1967, the State Engineer published the latest version of a "Manual of Rules and Regulations for Filing Claims to Water and Plans and Specifications for the Construction of Dams." A Dam Owner's Safety Manual is being prepared with funds from the National Dam Safety Program (NDSP). It will be distributed to all dam owners on record. It will instruct owners about the care, inspection, and maintenance of dams, both to prolong the dam's useful life and to provide for its safe operation.Ⓡ

Hazard Classifications

The dams under the jurisdiction of the State Engineer have been rated as high, moderate, or low hazard. The hazard ratings are based upon the potential for causing loss of life or damages in the event of dam failure during non-flooding conditions.

DAMS IN COLORADO

	High	Moderate	Low	Total
Non-Federal	197	327	1,605	2,129
Federal	35	10	75	120
Total	232	337	1,680	2,249*

*These figures were prepared on June 1, 1983. As of July 1, 1983 the state criteria for hazard ratings were changed. Revised figures were not available at the time of printing of this manual.

The hazards pertain not to the condition of a dam but to the potential for loss of human life or property damage in the area downstream of a dam in the event of structural failure or misoperation of the dam or appurtenances.

HAZARD POTENTIAL CLASSIFICATION (Re: Colorado Divison of Water Resources)

Category	Loss of Life	Economic Loss
Low	None expected (No permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agriculture)
Moderate	None expected (No urban developments and no more than a small number of inhabitable structures)	Appreciable (Notable agriculture, industry or structures)
High	One or more	Not considered

Note: There is no relationship between hazard rating and spillway capacity. Spillway design floods are based on the failure of the dam by overtopping being insignificant in relation to the design flood, i.e., no additional loss of life or property damage due to the dam break.

Information concerning the hazard classification associated with dams in Colorado is public record. To date the State Engineer and the DODES have transmitted lists of all the high hazard dams to local planning officials and requested that they prepare emergency plans for the failure of those dams. The local officials have also been notified of the availability of dam safety information which is provided on request. The importance of the hazard classification system to local officials is that it can provide information regarding potential damages that their community may or may not suffer as the result of a dam failure.

Judicial Notice of Floodplains and Wetlands

"No higher duty can devolve upon the city authorities than that of protecting the property, health, and lives of the people; this is their paramount duty--a duty which cannot be evaded, nor can their right to do so be lost by neglect or be bartered away."

City of Welch v. Mitchell, 121 S.E. 165 (1924)

"... It was not the State which placed appellant's property in the path of floods. Nature has placed it where it is and, if respondent had done nothing with respect to flood-plain (sic) zoning, the property would still be subject to physical realities."

Maple Leaf Investors Inc. v. State of Washington Department of Ecology, 565 P.2d 1162, at 1165 (Wash., 1977)

"The shoreland zoning ordinance preserves nature, the environment, and natural resources as they were created and to which the people have a present right. The ordinance does not create or improve the public condition but only preserves nature from the despoliage and harm resulting from the unrestricted activities of humans."

Just v. Marinette County, 201 N.W. 2d 761, at 771 (Wis., 1972)

"An owner of land has no absolute and unlimited right to change the essential natural character of his land so as to use it for a purpose for which it was unsuited in its natural state."

Ibid., 201 N.W. 2d, at 768

"The denial of the permit by the board did not depreciate the value of the marshland or cause it to become 'of practically no pecuniary value.' Its value was the same after the denial of the permit as before and it remained as it had been for milleniums."

Sibson v. State of New Hampshire, 336 A.2d 239, at 243 (1975)

Citations for Court Cases that May Be of Interest to Floodplain Managers and Their Legal Counsel

CASES IN COLORADO

A. *Ambrosio v. Peri-Mack Construction Co.*, 143 Colo. 49,351 P. 2d 803 (1960)
B. *Barr v. Game, Fish and Parks Commission*, 30 Colo. App. 482, 497 P. 2d 340 (1972)
C. *Baum v. Denver*, 147 Colo. 104,363 P.2d 688 (1961)
D. *City and County of Denver v. Denver Buick*, 141 Colo. 121, 347 P.2d 919 (1960)
E. *City of Colorado Springs v. Miller*, 95 Colo. 450, 319 P.2d 161 (1934)
F. *Colby v. Board of Adjustment of Denver*, 81 Colo. 344, 255 P.443 (1927)
G. *Denver v. American Oil Co.*, 150 Colo. 341, 374 P.2d 357 (1962)
H. *Docheff vs. City of Broomfield*, Colo. App., 623 P.2d 69 (1980)
I. *Famularo v. Board of County Commissioners*, 180 Colo. 333, 505 P.2d 958 (1973)
J. *Hoskinson v. City of Arvada*, 136 Colo. 450, 319 P.2d 1090 (1958)
K. *Stroud v. City of Aspen*, 188 Colo. 1, 532 P.2d 720 (1975)

CASES FROM OTHER STATES

A. *County of Clark v. Powers*, 611 P.2d 1072 (1980)
B. *County of Ramsey v. Stevens*, 283 N.W. 2d 918 (1979)
C. *Dooley v. Town Plan and Zoning Commission of Town of Fairfield*, 151 Conn. 304, 197 A.2d 770 (1964)
D. *Just v. Marinette County*, 201 N.W. 2d 761 (1972)
E. *Maple Leaf Investors, Inc. v. Washington Dept. of Ecology*, 88 Wash. 2d 726 P.2d 1162 (1977)
F. *Masky v. City of Loraine*, 48 Ohio 2d 334, 2 Op. 3d 463, 358 N.E. 2d 596 (1976)
G. *Morris County Land Improvement Co. v. Parsippany-Troy Hills Twp.* 193 A. 2d 232 (1963)
H. *Nectow v. City of Cambridge*, 277 U.S. 183 (1928)
I. *Oahe Conservancy Sub-District v. Alexander*, 493 F. Supp. 1294 (1980)
J. *Pennsylvania Coal Co. v. Mahon*, 260 U.S. 393 (1922)
K. *Texas Landowners Rights Assn. v. Harris*, 453 F. Supp. 1025 (1978)
L. *Turnpike Realty Co., Inc. v. Town of Dedham*, 284 N.E. 2d 891 (1972)
M. *Usdin v. N.J. Dept. of Environmental Protection*, 173 N.J. Super 311, 414 A.2d 280 (1980) off'd 179 N.J. Super 113, 430 A.2d 949 (1981)
N. *Young Plumbing and Heating Co. v. Iowa, et. al.*, 276 N.W. 2d 377 (1979)

CHAPTER 3
IDENTIFICATION OF THE FLOODPLAIN

The starting point of any floodplain management program is identification of the floodplain. This chapter discusses the reasons for identifying floodplain areas, the engineering methods used for *delineating* the floodplain, and the CWCB's *designation* process for floodplain studies performed in the state. It was written for an administrator who needs to know the procedures and language of the professionals who will assist in or actually perform the technical work associated with identifying a floodplain.

The Role of Floodplain Identification in a Local Floodplain Management Program

The identification of floodplains in a community begins with acknowledging the hazard, describing the characteristics of the problem, and formulating solutions.

Acknowledging the hazard

The extent of a community's drainage and flooding problems can be ascertained through good documentation of historical flood events or through a flood hazard analysis or both.

Describing the Flood Characteristics

The *hydrologic* and *hydraulic* parameters of each flood problem can be quantified through engineering principles and procedures. A floodplain study provides community officials with information to describe flooding and drainage problems. Officials will find out how high the water might rise, which structures and dwellings might be damaged, and which areas would be safe.

Formulating Solutions

Basic engineering information is necessary to formulate solutions to community floodplain problems. Engineering information helps in three ways.

1) It can help a community select a regulatory or structural improvement plan; the community's flood and drainage problems will be addressed and expenditures prioritized.
2) It can show the limits of the regulatory floodplains on the zoning map. (Showing the floodplain limits and *water surface elevations* makes implementation of regulations more feasible.)
3) It will help the community to comply with Colorado Statutes, by determining a legally enforceable floodplain boundary delineated by: an acceptable hydrologic and hydraulic investigation conforming to CWCB standards and guidelines; and an official designation by the CWCB and adoption by the local government.

Procedures and Methods

Those using floodplain information should be aware of the accuracy and the limitations of "*approximate*" and "*detailed*" study methods. Many communities have floodplains which have been identified by both methods. Development pressures, study costs, and the community's adopted management procedures for the floodplain will determine an identification procedure and method.

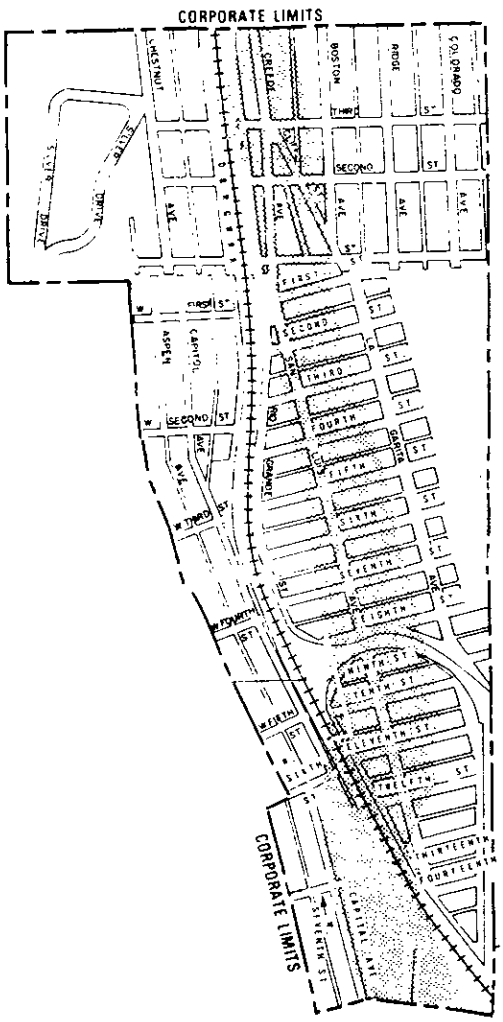
Approximate Studies

These studies are based on a minimal amount of technical data and should be used only under the following conditions:

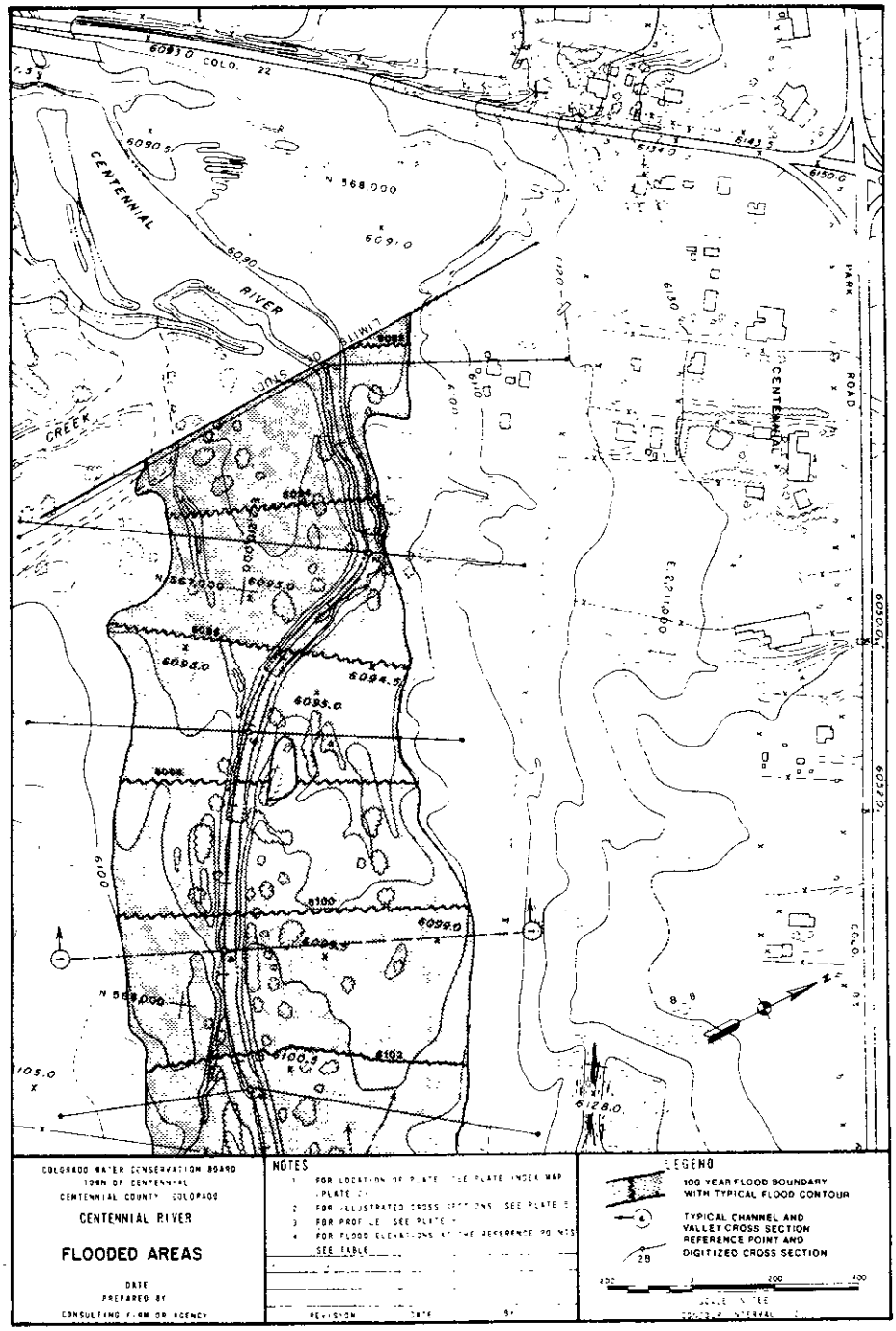
- for a limited rural area where only one or two single family residences or other structures will be constructed; and
- for a river *reach* extending up to several miles where there is no immediate need to delineate the detailed 100-year floodplain but where the local government wishes to alert potential developers to the flood hazard.

Approximate procedures allow the engineer to estimate the area that would be affected by a 100-year flood based solely on existing information. Researching the area's flood history, interpreting topographic features, using

Approximate Floodplain Map



Detailed Floodplain Map



handbooks to estimate hydrologic and hydraulic characteristics, and obtaining the opinions of qualified professionals (hydraulic engineers, hydrologists, etc.) are methods used for approximate studies. The intent of such studies is to:

- provide a reasonable estimate of the potential flood hazard at any proposed building site;
- minimize the engineering and planning costs to those using the study; and
- fulfill the regulatory requirements for local governments in the National Flood Insurance Program (NFIP).

The types of approximate floodplain studies which may be available to local officials are:

- U.S. Geological Survey's (U.S.G.S.) *Floodprone Area Maps* - a 7.5 minute quadrangle (1" 2,000') which show the 100-year flood outline.
- Federal Emergency Management Agency's (FEMA) *Flood Hazard Boundary Maps (FHBM's)* which show special Flood Hazard Areas in a community.
- FEMA's *Flood Insurance Rate Maps (FIRM's)* which show approximate areas as indicated by *un-numbered "A" zones* in those portions of the community where detailed information was not generated.

Detailed Studies

There are two types of detailed floodplain studies, *floodplain information studies* and *master drainageway planning studies.* Floodplain information studies delineate floodplains; master drainageway planning studies delineate floodplains, consider alternative approaches to problems, and recommend preferred alternatives. Another category of study incorporates features of both approximate and detailed studies; mapping of dam failure flood zones is discussed after the steps in floodplain information studies have been explained.

Floodplain Information Studies

Delineation of floodplains through detailed methods includes flood history research, review of watershed development patterns, hydrologic evaluation of the watershed to develop streamflow rates (discharges for the study streams), hydraulic computations to obtain the floodwater surface elevations, and a portrayal of flood outlines on detailed *topographic mapping.*

There are four basic steps that should be followed when obtaining floodplain information and data through detailed engineering procedures:

1. base mapping and field surveys should be performed;
2. the proper hydrologic method for a particular drainage basin should be selected and followed;
3. the water surface elevations (flood levels) which are representative of a projected event should be computed;
4. the water surface elevation data should be transferred to a flood outline map assuring that *datum* consistency between the floodplain delineations and on-the-ground conditions is maintained.

Base Mapping

The 100-year floodplain information and data must ultimately be delineated on a map of suitable scale and detail. The map may be an existing map (USGS quadrangle map, town, county, etc.) or a large scale topographic map.

Floodplain outlines shown on large scale topographic (1" = 100' or 1" = 200' with 2 foot contours) maps with cultural features are desirable because the floodplain outlines can be defined more accurately, and physical features can be shown more clearly. (Accuracy is important for effective floodplain zoning and regulation. Administrative problems and the need for costly and time-consuming field surveys increase as map accuracy decreases. Maps which are enlarged from small scale maps have only the accuracy equivalent to that of the original small scale map.)

Rectified photographic contour maps with flood outlines must be used with great caution when establishing regulatory elevations or floodplain boundaries. These maps may be distorted. Contours drawn to scale may not match the photo background because of this distortion. On the other hand, line maps showing *planimetric features* and *ortho-photograhic maps* are true to scale within their stated accuracy.

The CWCB encourages local governments to obtain large-scale planimetric or ortho-photo contour maps for floodplain administration purposes. Large-scale maps can also be used for other community purposes such as planning and design of highways and streets, water and sewer lines, and land use planning, and for planning and design of private developments.

United States National Map Accuracy Standards

[A] **Horizontal accuracy**--For maps on publication scales larger than 1/20,000, not more than 20 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well-defined will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the inter section of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable with 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as best points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would come timber lines, soil boundaries, etc.

[B] **Vertical accuracy**--As applied to contour maps on all publication scales, vertical accuracy shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

[C] The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.

[D] Published maps meeting these accuracy requirements shall note this fact on their legends, as follows: "This map complies with national map accuracy standards."

[E] Published maps whose errors exceed those aforestated shall omit from their legends all mention of standard accuracy.

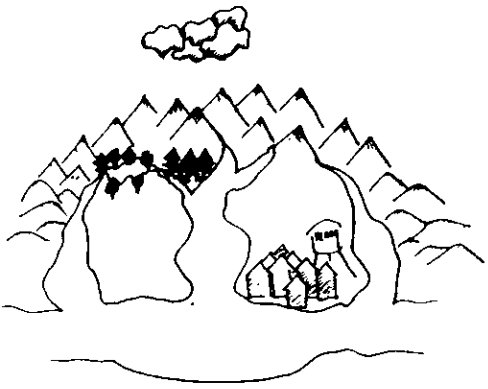
[F] When a published map is a considerable enlargement of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."

[G] To facilitate ready interchange and use of basic information for map construction among all federal mapmaking agencies, manuscript maps and published maps, wherever economically reasonable and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7.5 minutes, or 3-3/4 minutes in size.

Local governments can use the National Map Accuracy Standards as their basic criteria in determining whether maps for which they will enter into a contract or existing maps they use are sufficiently accurate. If maps meet the National Map Accuracy Standards, that fact must be stated on the maps.

Field Surveys

Preparation of accurate *field surveys* is a prerequisite to any topographic mapping project. The field survey ties specific points on the map to known points on the ground and assures anyone using the maps of their relationship to conditions in the field. The provision of surveying *monuments* in the field ensures that the maps will b easier for local officials and property owners to use. The field surveys for base maps must be performed at a standard of third-*order* control as established by the *National Geodetic Survey.* These standards are stated in a document entitled "Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys," dated June, 1980. In addition, the CWCB has prepared specifications for obtaining both field surveys and large-scale topographic mapping which are available for local governments to use. The specifications are entitled, "Specifications for Photogrammetric Services for Floodplain Studies in Colorado" dated August, 1982(R)



Typical Drainage Basin

Hydrologic Methods

Hydrology deals with the water balance in a watershed. Hydrologic methods are used to determine flood flows and volumes. Science has now developed reasonably consistent methods for determining representative flow values.

A hydrologic investigation for a floodplain study will first determine the potential cause of flooding and then determine volumes or rates of flow that would be expected for a given set of probabilities. In a detailed hydrologic analysis these calculations will be performed for the 10-, 50-, 100-, and 500-year frequency flood discharges. The analysis will be based on existing drainage basin conditions except where future development within the basin may be significant. The selected flood discharges may be computed by either an analysis of available streamflow records or by a *synthetic rainfall - runoff method.*

During the hydrologic investigations of a floodplain study the engineer will calculate the 100-year flow. A 100-year flood is a flood that would be expected to happen once every 100 years or that has a one percent chance of occurring during any given year. Sections 24-65-105, 24-65.1-103, and 24-65.1-403(3)(b), CRS, 1973, as revised, established the 100-year flood standard as the basis for land-use planning and regulatory activities.

The CWCB recommends the following guide in selecting the appropriate method(s) for a hydrologic investigation in a particular community.

For developing urban areas, the hydrologist should select a synthetic rainfall-runoff method and correlate it to available *gauge* records. Acceptable models are:

1) U.S. Army Corps of Engineers, *Flood Hydrograph Package (HEC-1)* (Davis, CA 1969.)
2) Wright-McLaughlin Engineering, *Urban Storm Drainage Criteria Manual, Volumes I and II* (Denver, CO 1969.)

3) U.S. Army Corps of Engineers, Missouri River District, "Runoff Block," in *Storm Water Management Model (SWMM)*, U.S Environmental Protection Agency, Omaha, NE: U.S. Army Corps of Engineers, 1973.
4) U.S. Department of Agriculture, Soil Conservation Service, *National Engineering Handbook, Section 4 Hydrology*. Washington, D.C., 1971 (R)

For *ungauged* rural areas, the hydrologist should use a regional analysis approach. This approach involves developing representative *regression curves* for the region based on available gauge records for both rainfall and snowmelt.Acceptable procedures are:

1) U.S. Water Resources Council, *Guidelines for Determining Flood Flow Frequency, Bulletin #17A*. Washington, D.C., 1977.
2) Colorado Water Conservation Board, *Manual for Estimating Flood Characteristics of Natural-Flow Streams in Colorado, Technical Manual ±1*. Denver, CO 1976.
3) U.S. Department of Agriculture, Soil Conservation Service, *Procedures for Determining Peak Flows in Colorado*. Denver, CO 1977.
4) U.S. Department of Commerce, *NOAA Atlas #2, Precipitation-Frequency Atlas of the Western United States, Volume III, Colorado*, Silver Spring, MD 1973 (R)

For *gauged* basins, both urban and rural, with at least 20 years of systematic stream gauging records the hydrologist should perform a *probability distribution analysis* of the gauge data in order to assign probabilities to different flows. The analysis should use the *log-Pearson III technique*, and it should include a *regional skew coefficient* appropriate to the region being studied. Acceptable procedures are:

1) U.S. Water Resources Council, *Guidelines for Determining Flood Flow Frequency*.
2) Beard, Leo R. *Statistical Methods in Hydrology*. Sacramento, CA, U. S. Army Corps of Engineers, 1962 (R)

Hydraulic Determinations

When the topographic shape of the stream channel and adjacent lands in the valley have been adequately represented by *cross-sections*, and when the flow rates and volumes have been determined, the next step is a hydraulic analysis. This analysis will describe the depth of flow along a selected study reach and present it in *profile view*. These depth-of-flow determinations assist in establishing regulatory flood elevations for the 10-, 50-, 100-, and 500-year floods and allow the preparation of a floodplain map to show the floodplain in *plan view*.

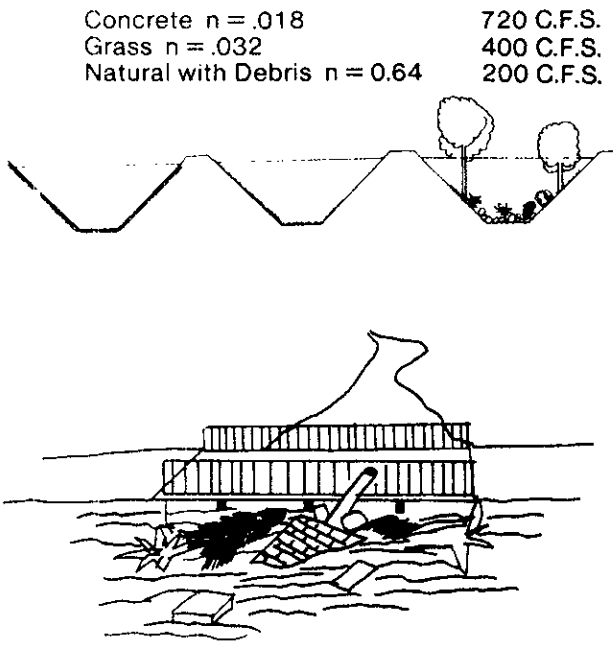
The 10-, 50-, 100- and 500-year water surface elevations and profiles must be calculated by using the Corps of Engineers' HEC-II Computer Program or an acceptable *backwater - step procedure*.

A part of the hydraulic analysis is the selection of *roughness coefficients*, "n's," for each cross-section based on the existing conditions along the stream and floodplain. These "n's," which represent the roughness or resistance to water flow created by vegetation, rocks, and other channel features, are essential for appropriately describing the flow. Past flood data, if available, are used to verify the adopted roughness coefficients, taking into consideration any alteration in the channel subsequent to those floods. If there are stream gauging stations within the study reach, the computed water surface profiles are checked against the *rating curves* for those stations to verify in the n-value.

Another part of hydraulic analysis is determining the effects of culverts and bridges. They can affect flood flows by constricting them or obstructing them completely. All culverts and bridges are evaluated for the following hydraulic characteristics:

- propensity for reduced conveyance capacity due to debris blockage of *the culvert or bridge;*
- damming effect due to undersized structures; and
- diversion of flood flows or washout of structures due to the above *characteristics.*

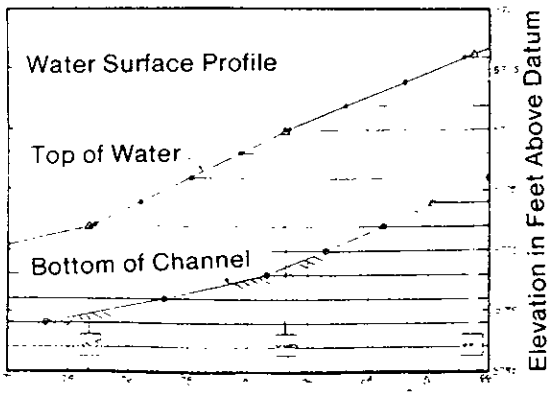
The potential for blockage of structures such as bridges and culverts and the subsequent reduction in conveyance is based on watershed characteristics such as *erodibility* of channel banks, amount and type of vegetation along the stream, and size and character of the waterway.



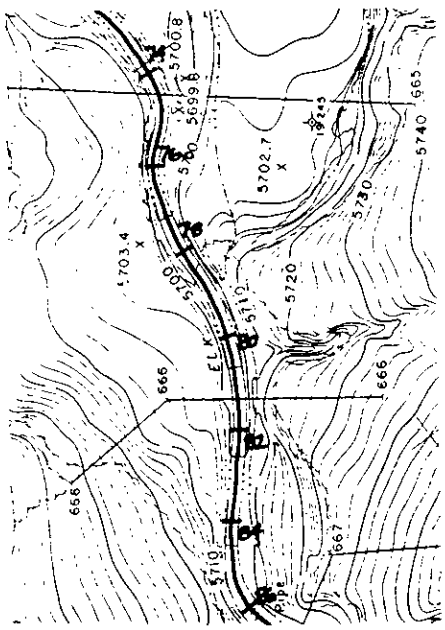
Flood Profile Reference Table

Flooding Source Cross Section	Flooding Source Distance[1]	Width (Feet)	Section Area (Square Feet)	Mean Velocity (Feet Per Second)	Base Flood Water Surface Elevation (Feet NGVD)
Big Dry Creek	10	1772	1020	10.2	5418.4
A	580	1022	995	10.5	5420.8
B	1110	78	634	16.4	5423.5
C	2290	270	1358	7.7	5430.2
D	3420	208	974	10.7	5436.1
E	3510	214	1082	9.8	5438.2
F					
Little Dry Creek	110	70	335	10.7	5411.0
A	450	164	906	4.0	5411.5
B	740	57	282	12.8	5411.5
C	880	79	371	9.7	5417.9
D	1400	185	823	4.4	5418.8
E	2800	130	473	7.6	5423.0
F	4080	159	597	6.0	5431.2
G	4850	122	508	7.1	5434.0
H	6820	59	281	11.0	5448.8
I	8300	84	471	6.8	5455.3
J	8410	81	768	4.0	5455.9
K	8440	48	527	5.9	5457.6
L	8910	67	270	11.5	5459.1
M					

[1]Feet Above Corporate Limits [2]Width Extends Beyond Corporate Limits



SAMPLE WATER SURFACE PROFILE (STEP 2)



EXAMPLE OF CHANNEL CENTERLINE STATIONING AND CROSS SECTIONS (STEP 3)

Blockage may be artificially accounted for in the hydraulic calculations by simulating:

- an increase in the width of bridge piers;
- a raising of the streambed elevation; or
- a reduction in the waterway opening by a percentage.

Once all of the hydraulic variables have been considered and a backwater analysis has been completed, floodwater surface elevations are portrayed in the floodplain report in two ways. First, flood profiles graphically show the relationship, in profile or *side view*, of the water surface elevations to the channel bottom at a particular point along the stream. Second, a reference table shows elevations at each floodplain cross-section used in the study.

The flood elevations presented in the profiles and the reference table should be calculated to a precision of ±0.5 foot for the 10-, 50-, 100-, and 500-year flood events and referenced to 1929 *Mean Sea Level* (MSL) datum. The flood elevations and outlines for an actual flood event may vary from these figures.

It is difficult to evaluate all the variables which will affect hydraulic calculations. Variables include scouring of the channel due to high velocities, sedimentation, variations in channel characteristics between cross-sections, amounts of debris accumulation, and limitations in field surveys and mapping techniques. Despite all of these engineering limitations, a detailed hydrologic and hydraulic investigation is still the most reliable method for determining flood elevations.

Floodplain Delineations and Datum Consistency

The next step of the floodplain study is the delineation of the flood limits on the topographic maps. Delineation requires the depiction in plan or *overhead view* of the information which is shown in vertical view in the flood water surface elevation tables and profiles. The plan view provides a clearer picture of the extent of actual flooding at specific locations along the stream.

Maintaining consistency is very important to developing a technically and legally acceptable regulatory document which can be incorporated into floodplain regulations and/or zoning maps. Problems may be eliminated through improved reporting and interpretation procedures.

The procedure which the CWCB recommends for delineation of the 100-year floodplain on topographic maps is as follows:

1) using the hydraulic analysis, the flood elevations at each cross-section are tabulated;
2) the flood profiles are drawn;
3) using channel centerline *stationing* from the water surface profiles, the centerline stations of the whole numbered flood elevations which correspond to the base *contour interval* elevations of the topographic maps are tabulated to produce the plotting table;
4) the location of all flood contours in the channel is marked at the appropriate station along the centerline on the base maps;
5) the flood contours are extended by drawing "wiggly," or reference, lines perpendicular to the direction of flow until they intercept their corresponding ground contours; this point is the edge of the floodplain. (The flood contours should parallel the cross-sections. If the cross-sections were incorrectly located, however, the flood contours may cross them.);
6) flooded area boundaries are drawn by connecting the ends of each "wiggly" or reference line; and
7) the flood delineation should be checked for reasonability and consistency with the cross-section data (top width of the floodplain).

This is a simplified method which has many advantages over the more common practice of drawing the flood boundaries by connecting end points of the flood boundary width at each cross-section. The most important advantage is the degree of confidence gained in the interpretation of the 100-year flood boundary. The flood contours become permanent documentation of the engineer's judgment in interpreting the flood hazards.

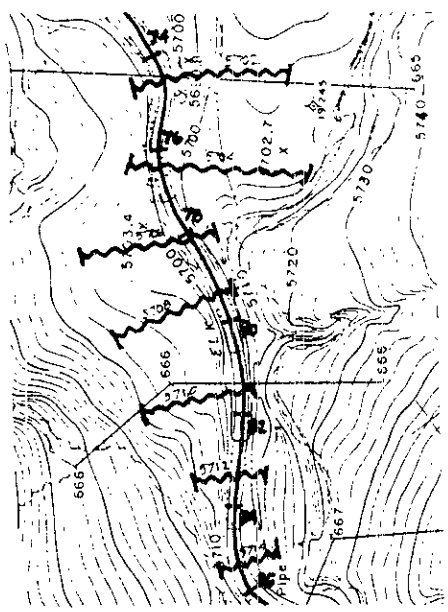
This method is also applicable to approximate floodplain mapping where a water surface profile can be drawn using an assumed depth. Once the depth has been assumed, it is easy to show in plan view which areas would be flooded and which would not.

The delineation of the floodplain will need to be re-evaluated if development activities or other factors cause a sufficient change in the floodplain to alter the threat. When reevaluation is necessary, it is important that previously published information be reviewed and adequately correlated with the new

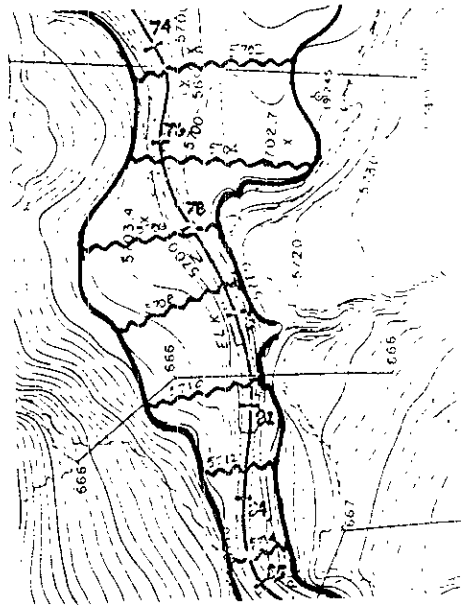
PLOTTING TABLE

FLOOD ELEVATION	STREAM STATION
5702	74 + 90
5704	76 + 40
5706	78 + 10
5708	79 + 50
5710	81 + 40
5712	83 + 30
5714	85 + 20
5716	87 + 20

SAMPLE PLOTTING TABLE (STEP 3)



LOCATING FLOOD CONTOURS (STEPS 4 AND 5)

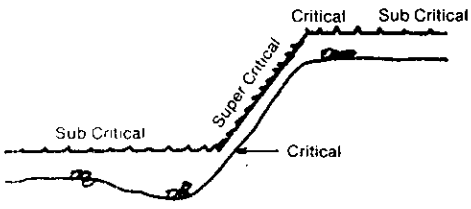


FINISHED FLOOD BOUNDARIES (STEP 6)

information. Maintaining this continuity between studies will improve the workability of a floodplain management program.

Developers of land in the floodplain who use flood elevations established in a floodplain study as a guide must use that information accurately. The establishment of field survey datum continuity between the study results and the on-the-ground conditions is a major factor to accomplish this. This can be done through:

- Uniform Datum Standards -- The base levels, elevations, and mapping may be tied to a single local datum; it is preferrable however, that they be tied to the *National Datum* (MSL for *vertical datum* and *State Plane Coordinates* for *horizontal datum*). By tying to the National Datum, uniformity is maintained within the region, the state, and the nation.
- Benchmarks -- Permanent elevations can be established in the field through a program of *monumentation* in the field. This can be accomplished easily by using Federally established *benchmarks* where available. Where Federal benchmarks do not exist within a community, it is beneficial to construct a *control marker* network. By having control markers with known elevations, property owners can more easily and accurately determine their own flood hazard risks through conventional field surveying procedures.



REGIMES OF FLOW

Floodways

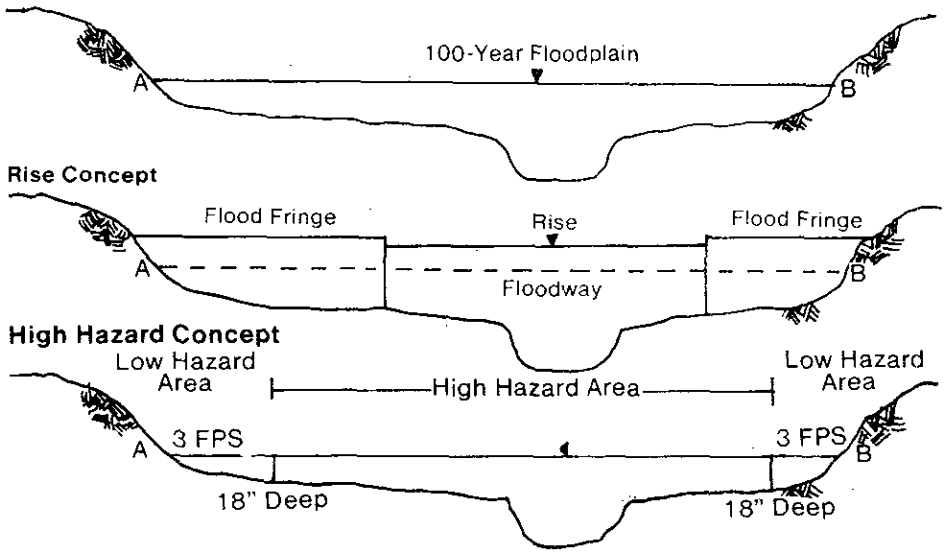
Two basic concepts for dividing the 100-year floodplain into a *floodway* and a *flood fringe* are the Rise Concept and the Hazard Area Concept.

The Rise Concept, specifies a maximum allowable rise (.5' or 1.0') in water surface elevations due to encroachment into the floodplain while still allowing passage of the 100-year flood (provided hazardous velocities, which are those in excess of 3 feet per second (fps), are not produced).

The Hazard Area Concept, specifies the area with a water depth of 18 inches or greater and a water velocity of 3 fps or greater as the floodway which must be kept free of development.

The Rise Concept is based on an "acceptable rise" criterion. This rise criterion assumes that encroachment occurs on the edges of the floodplain on both sides until the 100-year water surface is increased by .5 foot or 1.0 foot. It is suited to wide, flat-sloped, and well-defined floodplains where conveyance capacity must be preserved. By assuming encroachment into the floodplain from both sides, the floodway line may be calculated. Often this is conservative, since development may not take place at every point.

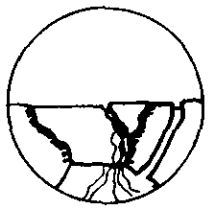
The rise floodway determination has some drawbacks. It is an expensive process and it may allow for inconsistent development. FEMA's floodway guidelines require equal reduction in stream conveynace capacity from both sides of the floodplain. This equal reduction is an attempt to treat all landowners on both sides of the stream equitably and give all an opportunity to develop some of this capacity by placement of fill. There is, however, some provision for variance from the requirement. Use of this variance provision can mean that some property owners may have more developable land in the floodplain and some property owners may have less.



Another limitation of the rise concept is that the specified but arbitrary rise criterion of 0.5 foot or 1.0 foot may actually increase damage potential in some areas. When portions of the flood fringe are filled, and protected by that fill, other areas may suffer as unconfined flows are forced into previously dry areas due to the increase in the water surface elevations. There is another limitation which can be misleading. On steep gradient streams, encroachment on the floodplain can often appear to lower water surface profiles as the computer solution of flow passes from the *subcritical* into the *supercritical regime of flow* with shallow depths and high velocities.

The Hazard Area Concept is based on depth and velocity criteria. Its application, simple to understand, does not require as much detailed engineering as the rise concept. This concept is most applicable to the confined, narrow, and steep gradient streams found in the mountain regions of the state. The criteria relate to potential damages produced by *static* and *dynamic* flood forces caused by the depth and velocity of the water. The hazard area concept does not work well in wide floodplains where development pressure is great. It is, however, often applicable in wide areas with shallow flooding and low velocities.

Floodway computations must use the HEC-II Computer Program or an acceptable backwater-step procedure. If a floodway has been computed it must be shown on the community's administrative map.



Mapping Dam Failure Flood Zones

The engineering information that you have just read deals with determining flood elevations and floodplain boundaries for floods caused by precipitation. One type of flooding which is not considered in most engineering studies is dam failure flooding.

Techniques do exist for preparing maps showing *dam failure flood zones*. As was discussed in Chapter 2 of this manual, as of July 1, 1983, maps showing the extent of flooding that would result from failure of state regulated high hazard dams are to be prepared by the State Engineer. There will still be many areas downstream of moderate or low hazard dams, and of unregulated dams, where such information will not exist. Local governments may want to consider contacting the National Weather Service (NWS), the U.S. Army Corps of Engineers (Corps), the Soil Conservation Service (SCS), the State Engineer, and the U.S. Bureau of Reclamation (USBR) for assistance in preparing such maps to better delineate potential hazards. (R)

NOTE: Most detailed floodplain studies, including the majority of those conducted by Federal and State agencies, do not consider the possibility of dam failure. Regulation of floodplains in the United States is based on the 100-year flood which is a precipitation-caused flood. As evidenced by the flood on Fall River near and through Estes Park in July, 1982, where the flood was, on the average, 2 1/2 times as deep as the estimated 500-year flood stage and where flood waters greatly surpassed the 500-year flood boundaries indicated in the city's Flood Insurance Study, dam failure floods may exceed the 100-year and 500-year floods calculated in most detailed studies.

Master Drainageway Planning Studies

Community officials may wish to quantify their flood and drainage problems and seek long-term approaches to them. In a master drainageway plan or a *feasibility study*, an analysis is performed which evaluates *structural* and *non-structural* improvement plans to mitigate or alleviate flood hazard problems and resultant damages. These studies can be performed simultaneously with a detailed floodplain information study, or they can be performed independently. In many cases the studies will include designs and plan layouts. This type of work program will include the same tasks as required for a detailed floodplain information study with some additions.

Base Mapping and Field Surveys

Ground elevations should be established for all street intersections as a basis for determining water depths at those intersections.

Hydrologic Methods

The 2- anc 5-year flood discharges should be computed. These values are required in determining baseline flood damages and designing storm drainage facilities. In addition to the stated hydrologic methods, the *Rational Method*, based on the equation Q = CIA, can be used for small drainages of two square miles or less.

Hydraulic Determinations

Computer modeling may not be practical for street and gutter storm drainage rcutings.

Floodplain Delineations

No additicnal requirements.

Floodways

Delineaticns of floodways may not be a study task in this type of study.

Problem and Damage Assessments

Street drainage and flood related problems will have to be analyzed and prioritized. Damages due to flooding are estimated to establish a "baseline" condition for the study area. Those conditions define what is likely to happen if no improvements are implemented.

Flood damage categories applicable for damage analysis

Damage to public facilities	Interruption of traffic or services
Structural damage	Missed work
Content damage	General inconvenience
Damage to stored goods	Loss of business income
Inventory loss or damage	Loss of sales taxes
Damage to livestock	Loss of salaries to employees
Erosion	Patient evacuation and emergency services
Cleanup and removal of debris	

Plan Formulation

Following the determination of the drainage and flood problems, a plan-of-improvements can be formulated for each study area. The drainage and/or flood control plans are developed for a selected frequency of protection. An array of alternative plans is formulated. Each plan is directed toward meeting any or all of the stated objectives of a contract or work program. Plan-of-improvement alternatives include structural alternatives, non-structural alternatives, or a combination to address floodplain problems, and the following street anc drainage project alternatives to address storm drainage problesm:

1) assuring adequacy of natural detention and conveyance of water,
2) using streets for conveying storm water,
3) maintaining drainage capacity of paved streets and gutters,
4) assuring ease of maintenance and access,
5) making use of available right-of-way,
6) controlling erosion,
7) assuring public safety,

Plan Selection

The community will ultimately have to address the question of "what to do." The final plan should be based on:

1) the long-term relief of street, drainage, and flood problems;
2) an impact analysis of alternatives and advantages or disadvantages of each;
3) the funding capabilities of the entities involved;
4) designation of operation and maintenance responsibility;
5) an economic analysis - costs and benefits and their distribution to various members of the community;
6) the availability of right-of-way.

Status of Floodplain Studies in Colorado

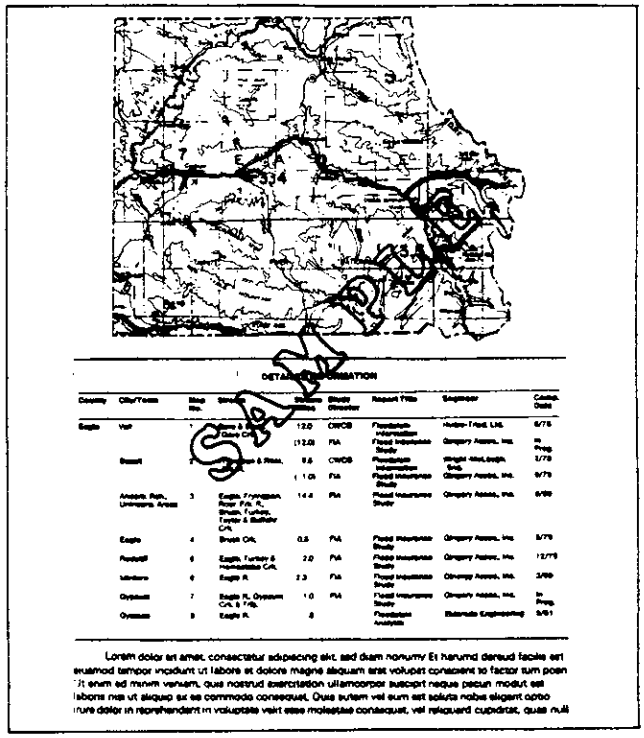
There are 63 counties and 266 incorporated municipalities in Colorado. Approximate floodplain studies are available for all of those counties and 212 municipalities. In portions of some of the counties and in some municipalities, no information is available. In other areas both approximate and detailed studies have been performed.

The fact that a detailed study has been performed in a given county or municipality does not mean that all of the floodplains in that community have been delineated. Many communities that have had detailed floodplain studies performed still have a substantial number of stream miles of floodplain that have not been studied in detail. Detailed information is available for about one-half of approximately 6,000 miles of floodplains in Colorado. Floodplains in Colorado have been studied by FEMA, the Corps, the SCS, the CWCB, the Urban Drainage and Flood Control District, local governments, and private consultants working for land owners and developers.

Public funds for floodplain studies are diminishing. Continued development in floodplains and fewer studies could cause two results: one, developers will have to study and delineate more miles of floodplains in compliance with State standards and guidelines; two, more miles of floodplains will undergo development without adequate delineation.

To best use the funds that are available for mapping each year, the CWCB prepares an annual floodplain study priority list. This list shows the floodplain study needs of all the communities in the state and prioritizes those needs according to the degree of flooding possible, current population, present and anticipated population growth, and other related factors. Federal and State agencies with funds for floodplain studies use this list to develop study and work programs. Local officials who are interested in the information on this list or who are interested in providing their own data to be used in preparing the list can contact the CWCB.®

The CWCB has prepared an index of floodplain studies that is available to you. A revised version of that index is being prepared and will be available shortly.

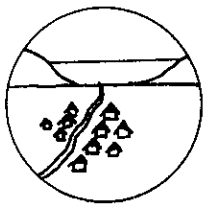


CHAPTER 4
FLOODPLAIN MANAGEMENT ALTERNATIVES

Local government officials have two sets of approaches to choose from when they decide to deal with flooding problems, *preventive* (non-structural) and *corrective* (structural).

Preventive Approaches

1) Floodplain Management Regulations -- zoning ordinances, subdivision regulations, planned unit development, building codes, 1041 permit system, etc.
2) Development Policies -- open space, public services and facilities, taxation, urban redevelopment, flood control and storm drainage facility fee structure, etc.
3) Flood Insurance
4) Emergency Preparedness
5) Education/Awareness

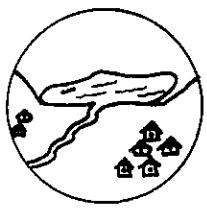


Corrective Approaches

1) Flood Control -- dams, reservoirs, detention and retention ponds, watershed treatment, levees and floodwalls and channel improvements.
2) Floodproofing -- Changes to new or existing structures to reduce or eliminate flood damages by protecting against structural failure, keeping water out, or reducing the effect of water entry

Local, State, and Federal floodplain managers have encountered problems when using only the corrective approach. Frequently, the risk of property damage and loss of life has actually been increased after structural improvements have been built because encroachment in the floodplain is allowed to continue. These improvements can also provide people with a false sense of security and thereby encourage such encroachment.

Recent experience has demonstrated that a combination of corrective and preventive approaches can be more time and cost effective. In terms of cost, the preventive approaches are usually less expensive. In some communities, however, the large amount of existing development in the floodplain precludes using only the preventive approach.



Preventive Measures (Non- Structural Approaches)

Land Use Regulations

Zoning

Zoning is the most common floodplain management regulatory tool used by local governments in Colorado. Floodplain zoning regulations consist of maps and written text. The maps (approximate & detailed) delineate floodplain areas of the community, are based on engineering information, and allow precise regulation of the floodplain. The text decribes established minimum standards for the use of the lands delineated on the maps.

One or more zoning districts and subdistricts are created by the regulations based on adopted floodplain maps and studies. Land uses in those districts are either prohibited, permitted subject to conditions or restrictions, or permitted without conditions. Variances are provided under appropriate mitigating circumstances. Any proposed development or substantial improvement of existing property within the districts must meet the requirements of the regulations. Provisions are made for amending the maps (rezoning) based on sound technical data.

The zoning regulations are generally based on the "*overlay*" concept where an area is subject both to the restrictions of the underlying zoning district and to the restrictions of the floodplain zoning district which overlays it. In some cases communities have designated one or more separate zoning districts for floodplain areas which have their own restrictions and are unrelated to any other zoning districts. The decision whether to follow the overlay concept or to create separate zoning districts can be made by the local government.

Communities that are downstream of dams can consider some sort of zoning designation for all or part of the "dam failure flood zone." Such a designation could control development downstream of a dam to reduce the threat of dam failure flood damage.

Subdivision

Subdivision regulations apply when any land is divided into smaller parcels for the purposes of development or resale. They are not used as frequently as zoning regulations for floodplain land because they do not regulate the design specifications for location and construction of structures or for development of the land around them. The requirements for floodplain land must, however, be met and the final plats approved prior to any subdividing.

Subdivision regulations usually prohibit subdividing portions of a proposed development that would be subject to flooding. Those lands could be subdivided if the flood hazards were satisfactorily addressed by filling in the flood fringe or other appropriate measures. Filling in the floodway is prohibited.

A subdivider can be required to install adequate drainage facilities and to design sewer and water systems to minimize damage by flooding and to minimize contamination of flood waters by sewer lines or contamination of domestic water by flood waters.

The subdivision review process can include consideration of the appropriateness of new subdivisions in the dam failure flood zone downstream of any dam(s) affecting the community. The review process can also incorporate consideration of safety measures such as warning systems and evacuation plans.

Development below a dam is beyond the control of the dam owner, and a dam will sometimes attract development as residents view it as "protection" from flooding.

State agencies cannot restrict subdivision activity or zoning downstream of a dam based on potential dam failure. If people and their property downstream are subject to hazard--even if those people move in after the dam has been built--the dam owner is responsible for damages and cannot require state or local government to minimize the responsibility through subdivision, zoning, or other means.

Owners of dams can protest at the hearings of the several commissions which approve developments that occur below their dams. In several cases, the dam owners have received relief from subdivision, zoning, and requirements of the approving authorities. It is the dam owners' responsibility, however, to be diligent in regard to development that would affect their dams.

Planned Unit Development

Planned Unit Development (PUD) regulations may be separate regulations or they may be part of zoning regulations, subdivision regulations, or both. PUDs are based on the premise that a community can offer some flexibility in its zoning and subdivision standards in exchange for a developer's adherence to a master plan previously approved by the community. Therefore, the PUD approval process involves a combination in fact or in concept of zoning and subdivision review.

One potential advantage of the PUD concept is the opportunity that is offered to the community and the developer to relocate proposed structures to reduce flood hazards while still maintaining the basic intent of the master plan. The developer has more freedom to plan the kind of development he wants while avoiding flood hazards because he is not necessarily constrained by the same zoning setbacks, height restrictions, lot sizes, or subdivision requirements that a more traditional development must follow. More options for addressing flood hazards are available than through strict interpretation of zoning and/or subdivision regulations; the option of avoiding the floodplain entirely may become more appealing in a PUD. PUD regulations apply, however, only to those areas of the community that are zoned and developed as PUDs.

Building Codes

Building codes are not commonly used for regulation of floodplains. Building codes establish minimum standards for building design and construction to protect the integrity of structures and the safety of their occupants. These codes apply only to new buildings or substantial improvements to existing buildings. They usually establish minimum elevations for flood protection and, sometimes, structural floodproofing requirements.

One major drawback of building codes is the way in which they are enforced. The review by building officials comes either late in the zoning and subdivision processes or after them. At that point it is expensive and difficult to redesign entire developments.

H. B. 1041 Permit System (Section 24-65.1-101 et seq. CRS 1973, as amended)

House Bill 1041 (1974) provided for the designation and regulation by local governments of areas and activities of "state interest." The areas of state interest addressed by the legislation included floodplains. H.B. 1041 gave local governments the authority to map, designate, and regulate floodplains "... so as to minimize significant hazards to public health and safety or to property...."

H.B. 1041 also gave the Colorado Land Use Commission the authority to formally request of a local government the identification and designation of these matters of state interest and the promulgation of guidelines for these matters if the local governments have not done so. The Commission was also given the authority to seek judicial review if the local governments fail to respond to requests to designate these matters and to adopt guidelines for them. These powers of the Commission have essentially remained unexercised.

Under H.B. 1041 a local government can require a special permit for any development within a floodplain. The applicant must obtain a special permit rather than meet zoning or subdivision requirements. Although the regulatory standards for obtaining a 1041 special permit must conform to State standards and are the same as the standards for other types of regulations, permit procedures are somewhat different than those procedures for other types of land use regulations.

Development Policies

Through a variety of development policies, a community can affect the use of floodplains. These policies do not have to be strictly regulatory. They may further community goals. Some can be a basis for or part of regulations which affect floodplains. They would be part of a community's fiscal and land use master plans which would be related closely to land use and other regulations.

Open Space

Setting aside floodplain areas as open space is one way of greatly reducing potential flooding damages. Open space acquisition and management can be specifically aimed at floodplain areas or it can be aimed at a broader variety of lands. It involves limiting the land uses to development that does not result in permanent or overnight residence by humans or in commercial or industrial construction and then assuring that those open space uses are maintained in the future. Examples of open space uses are parks, wildlife areas, green belt lands, or historic sites. Open space lands or open space easements can be acquired through negotiation, condemnation, tax delinquency, dedication, or tax incentives.

Acquisition of floodplain areas for open space can be part of parks policy, general open space policy, or land use policy. The latter would include designating certain floodplain areas as suitable only for open space uses on the community's zoning map, requiring dedication of portions or all of floodplain areas as part of the subdivision process, encouraging or requiring clustering of development outside floodplain areas through PUD or other regulations, encouraging relocation of existing floodplain uses as part of redevelopment, or some combination of the above.

Open space can be the designated use of all or part of the dam failure flood zone. Having a dam failure flood zone map would allow the community to develop a program of land acquisition in that zone which was in harmony with other open space goals.

Potential Benefits for Preserving Floodplain Areas for Open Space Uses

Moderation of flooding by providing buffer areas

Water quality maintenance

Ground water recharge

Air quality maintenance

Provision of fishing, wildlife, and plant habitat

Protection of archaeological and historical sites

Agricultural preservation

Recreation

Public Services and Facilities

Providing public facilities and services like streets, sewer and water lines, fire and police protection, etc. is expensive. Communities may want to consider the costs and benefits of providing them to accomodate future development in floodplain areas. Policies limiting the provision of these services in floodplain areas in order to control development would have to be preceded by one or more floodplain engineering studies. Once floodplain areas have been delineated, community officials can determine which areas would be affected, and what specific limitations are appropriate.

Taxation

How land in floodplain areas is taxed can affect how property owners view their options for that land. If floodplain land is undeveloped and a community wishes to have it remain that way, taxing the land at lower rates may encourage owners to keep it undeveloped, particularly if they knew that tax rates would increase substantially if the land were rezoned or developed. For floodplain areas that are already developed, a community can offer tax credits or provide low interest loans for floodproofing or other flood protection improvements, or for relocation.

Urban Renewal

Urban renewal areas are sometimes located in floodplains. For this reason communities may want to consider combining urban renewal objectives with those of floodplain management. Urban renewal policies affect areas of a community that are already developed. They can, therefore, address both areas that have just been damaged by flooding and areas that have not recently been damaged by flooding but for which some protection from flood hazards is desired.

An urban renewal program that addressed flooding problems could include some structural improvements to protect buildings in the flood fringe along with the removal of buildings in the floodway. The sites of those removed buildings would then be converted to open space uses. Residents of the removed buildings would be relocated to safer areas.

Fee Structure for Flood Control and Storm Drainage Facilities

Policies regarding who pays for flood control and storm drainage improvements and how they pay can be an important part of a community's floodplain management program. Any system for allocating costs for structural improvements to reduce flooding and storm drainage problems in a community involves answering two questions: first, "Is there something in the floodplain which is worth protecting by spending money for improvements?" and second, "Which members of the community should pay for those improvements?" Answering these questions can help direct the way a community's floodplains are managed.

One option is to have property owners in the floodplain or in the storm drainage service area pay for the improvements. This would be feasible for areas that are already developed through special improvement districts or the like, or for undeveloped areas, as subdivision improvements or as special improvement district projects. Under this option property owners outside the floodplain or storm drainage service area would pay nothing for the improvements.

Another option is to have everyone within a drainage basin pay for improvements in that basin. This option is based on the notion that every acre in a basin contributes runoff and therefore has a share in the problems, including both upland and lowland areas. A vehicle for implementing this option is to create a local drainage district or utility and to assess a mill levy or a monthly fee to pay for construction of improvements and for their maintenance and operation. Since every portion of the community would fall in some drainage basin, everyone in the community would pay for improvements in their particular drainage basin.

Flood Insurance

Flood insurance is a form of casualty insurance which provides protection to property owners who may incur losses from a flood. This coverage orovides a property owner with a direct means to recover financial losses. The definition of flood for insurance coverage purposes is:

- *a general and temporary condition of partial or complete inundation of normally dry land area from,*
  - *the overflow of inland or tidal waters,*
  - *the unusual and rapid accumulation or runoff of surface waters from any source,*
  - *mudslides (i.e., mudflows) which are proximately caused by a flood as defined above,*
- *the collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding the cyclical levels which result in a flood,*
- *sewer (drain) backup, which is covered only if it is caused by flood.*

The NFIP administered by FEMA, provides the basis for a large part of the Federal Government's role in floodplain management.

In exchange for assuring available and affordable flood insurance in a given community, the Federal Government requires that the local government meet certain conditions. The first condition is that the community use Federally approved floodplain delineation information, or the best information available, in making floodplain use decisions. The second, and major, condition is that the community initiate and maintain a permit system for development in the floodplain and that the community adopt and enforce floodplain management regulations which meet Federal standards. Those management aspects of the NFIP are aimed at curtailing ever increasing annual national flood damages and reducing the total annual national disaster relief expenditures.

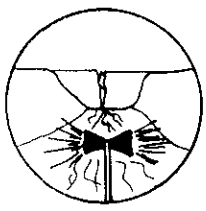
Potentia consequences of not meeting those conditions are loss of any Federally connected mortgage loans, grants, or other funding for development in floodplain areas of the community, denial of disaster relief funds for flood damages, and suspension from the NFIP, making property owners ineligible for flood insurance.

The U.S. Justice Department has filed two civil suits in Louisiana in an attempt to recover more than $90 million in NFIP payments to property owners. The suits allege "willful and negligent" activities on the part of private developers, contractors, engineers, and local public authorities. They were filec in May 1981 and are still ongoing.

For a property owner to purchase flood insurance as offered by the NFIP, the entire community *must* be enrolled in the program. The insurance can be purchased, however, from any casualty insurance agent. (Fixed rates are established by the NFIP for use by the private insurance industry.)

Any community can qualify for the benefits of the program by submitting a complete application, which is available from FEMA, and by adopting preliminary floodplain management measures. (R)

The Flood Hazard Boundary Maps and Flood Insurance Rate Maps which are the regulatory maps of the NFIP do not normally consider the possibility of dam failure floods. The 100-year flood is assumed to result from some form of precipitation. Even though the maps do not depict the dam failure flood zone, any property owner or resident in that zone may purchase flood insurance if the community is enrolled in the NFIP. Claims resulting from dam failure floods are reimbursed on the same basis as claims resulting from precipitation floods.



Emergency Preparedness

In most communities no matter how much is accomplished in the way of structural and non-structural floodplain management alternatives, there will still be portions of the community that will experience flooding on occasion. For that reason most communities need to include in their emergency preparedness plan consideration of what to do when flooding occurs.

"What to do" will consist of:

1) determining areas that might experience flooding,
2) having a systematic means for obtaining flood forecasting information,
3) disseminating appropriate warnings to those who need to be warned,
4) safely evacuating those facing danger,
5) beginning recovery efforts as soon as possible,
6) returning residents to their homes and businesses when it is safe,
7) completing the recovery process.

Step 1 has been discussed in Chapter 3 of this manual.Steps 2-4 will be discussed in this section. Plans for Steps 5-7 should be developed in conjunction with all local law enforcement and emergency preparedness agencies, the Colorado Division of Disaster Emergency Services (DODES), and FEMA(R) The CWCB and the other agencies can assist communities in developing and improving floodplain emergency preparedness plans.

Floodplain emergency plans can incorporate appropriate information regarding any dam failure flood zones in the community.

Flood Forecasting

Few communities or individuals will receive 24-hour notification of a pending flood disaster. Flood victims have only a few hours of warning, if any, of a potential disaster. Reliable, accurate, and timely forecasts of floods by Federal, State, or local officials are essential for timely evacuation.

Flood detection involves the sensing of physical phenomena such as massive cloud build-up, heavy rainfall, or rising streamflow through instruments and/or visual observation. Those data must then be transmitted to an operation center or a command location where a decision can be made regarding the type of alert that should be issued. The NWS has been charged by law with the responsibility for issuing weather alerts based on atmospheric conditions observed by their detection equipment and staff.

The messages which will be issued by the NWS are:

FLOOD WATCH Existing climatic conditions are favorable for heavy rainfall to occur. Observers should be kept informed and be ready for immediate action.

FLOOD WARNING Flooding is imminent or in progress and the public should take prompt action if they are in the alert area.

The NWS issues a "Flood Watch" or "Flood Warning" based on immediate conditions as they know them. Flood Watch implies there is some time to plan appropriate action while Flood Warning implies immediate action is needed.

A community's forecasting system can be designed to provide forecasts about conditions that would increase the likelihood of dam failure floods, such as heavy rain or snowpack, a high reservoir level, or indications of structural deficiencies in the reservoir system. Having such a forecasting capability requires some actions by local officials. First, they can contact the State Engineer's office, along with consulting U.S.G.S. 7 1/2 minute quadrangle maps, to inventory dams above their community. Once the inventory is complete, they can consider preparing dam failure flood zone maps for all dams other than the high hazard dams. They can also consider requesting that dam owners prepare these maps. The local officials can attempt to assure that the appropriate local official(s) are kept aware of any important changes in the condition of the dam or other reservoir features.

Flood Warning

Flood Warning Systems

A community may want to develop a localized flood warning system. There are basically three flood warning systems which may be considered.

DO NOTHING SYSTEM Rely upon the NWS for detection and dissemination of the warning to the local news media; rely on local sheriff and police departments for action. $ = zero.

VOLUNTARY SYSTEM A team of predesignated local officials or residents collects precipitation and streamflow data and transmits it to a local coordinator. The coordinator makes a determination of the flooding potential and notifies the NWS. The field equipment will consist of *rain gauges* and *staff gauges* painted on stable vertical abutments. This system relies completely on the human or NWS detection of a flood event. The local coordinator and NWS disseminate the warning to the news media and the local sheriff and police departments. $ = less than $5,000.

FULLY OPERATIONAL TELEMETRY SYSTEM This system would be self-contained with only a minimum degree of reliance upon other agencies or communication sources. The community would have a system which would detect early rainfall and stream-rise developments. The content of the warning would be based on the expertise and experience of the local forecaster. A system of this type consists of the following equipment:

1) an independent power source,
2) early detection devices - automatic rainfall and stream gauges,
3) transmission stations,
4) receiver and decoder facility,
5) mini-computer and display screen,

6) alarm stations for the warning areas,

7) a local forecaster.

$ = $25,000 to $75,000

The success of any of the three systems will be affected by:

- *the technical problems relating to timely and accurate assessment and prediction of a flood condition;*
- *the behavior of the public when faced with a flood condition;*
- *the factors influencing public officials charged with responsibility for preparing plans, disseminating warnings, and evacuating and caring for displaced persons;*
- *the number of rivers and streams in a particular monitoring area;*
- *the number of delineated floodplains within the alert area.*

Means of Dissemination-

The dissemination of the warning message is an important task. To be successful in mitigating losses, the warning must reach the entire portion of the community that would be affected by flooding.

RADIO Probably the best mass media system since almost everyone has a transistor or car radio which may be used during power failure. Special radio networks, such as law enforcement radio systems, citizens band, or ham radios, and tone-activated radios or paging units could aid in the dissemination process.

TELEVISION May reach a large number of people, but is subject to power failure.

SIRENS May reach large masses but may be difficult to distinguish between other warnings, such as warnings for tornados.

TELEPHONE Can be effective but highly subject to communication failure during severe storms.

DOOR TO DOOR Most effective warning system and necessary in many flood conditions to assure that everyone receives notice of the flood threat, if there is adequate time.

A PUBLIC ADDRESS SYSTEM May be effective in disseminating warnings quickly to groups of people in buildings or in remote areas.

FLARES

Evacuation

The evacuation of potential flood victims is not an easy task. The content of the warning message is very important in motivating the floodplain inhabitants. The warning message should contain the time that is available for evacuation whether it be minutes, hours, or days; the relationship of the predicted *flood crest* to familiar landmarks; specific instructions for action, such as where to go and how to get there. People will respond to the warnings in different ways; therefore, the warning should be given by a recognized authority, such as the mayor, law enforcement officers, a person well-known in the community, or a relative of the person(s) being warned.

Civil defense officials, law enforcement officials, fire officials, and others who would be involved in directing an actual flood evacuation should have rehearsed their roles in the field with the local floodplain administrator. This will improve implementation during the time before and when a flood occurs.

In communities where there are dam failure flood zones, evacuation of those zones will generally be a major part of the community response when such a flood appears imminent.

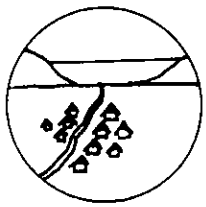
Reservoir owners with high hazard dams have been requested by the State Engineer to prepare an Emergency Preparedness Plan (EPP). These plans provide action plans to combat dam incidents/failures including evacuation plans, and they list local emergency coordinators working for communities downstream of their dams. In addition, DODES is requesting local emergency coordinators to note the potential for the failure of these dams in their emergency evacuation plans. This project will be expanded to moderate hazard dams if it is successful. A model EPP has been prepared for dam owner's use by staff members of the Dam Safety Branch at the State Engineer's office. Because warning time for a dam failure flood may be short, and because the magnitude of such floods may be substantially greater than the 100-year flows, an EPP, including evacuation plans, can greatly increase the community's ability to respond to the threat of a dam failure flood. (R)

Flood warning systems can also be used to plan sandbagging or other emergency operations by providing sufficient notice about where and when such operations are needed. Having the time to conduct such operations requires adequate warning, storage of necessary materials at suitable locations, rehearsal in the field by key personnel, and competent supervision during an actual flood emergency.

Flood forecasting, warning, and evacuation is dependent upon public education for its success. Communities will need a well-publicized emergency response plan. Public officials must know their roles. The media should know the potential hazards and responses. The residents of the floodplain should know the hazards, responses, and their roles in the response.

Education/Awareness

Any floodplain management measure, preventive or corrective, will require community support and understanding if it is to be implemented. The local floodplain administrator can develop educational and informational programs to increase public awareness of floodplain management concepts. Public meetings, individual meetings with residents and property owners in the floodplain, brochures, and slide shows are some of the means available to distribute information to the community. Educational materials are available from FEMA, the CWCB, and in appropriate communities, from the Urban Drainage and Flood Control District.



Corrective Measures (Structural Approaches)

Flood Control

Flood control projects protect specific areas from selected levels of flooding.

Changes to the Basin

Dams and Reservoirs

Reservoirs can be constructed as single-purpose flood control dams, or they may serve multi-purpose uses including water supply storage, irrigation, hydroelectric power, and recreation. Most single-purpose flood control dams are designed for a high degree of protection and have normally dry or almost dry reservoir basins. Multi-purpose reservoirs will almost always have at least a little water in them since they serve other needs.

Flood control reservoirs protect property downstream by providing capacity to store floodwaters in the event that such waters should suddenly accumulate upstream of the dam. Rather than flowing uncontrolled through developed and inhabited areas the waters collect in the reservoir and are then released at a much lower and more controlled rate that minimizes damage to those developed areas.

Although it may be possible for local governments to fund the construction of flood control dams, it is most likely that one of three Federal agencies will be involved in the construction of any such dams: the USBR, the Corps, or the SCS. Local cost sharing is a requirement of any Federally sponsored project. Depending on the specific Federal program the local responsibilities can include operation and maintenance costs, acquisition of necessary right-of-way, and freeing the Federal Government from any liability associated with the project. The CWCB can assist local governments with the acquisition of land for the project. In addition, the CWCB can assist by putting local governments in touch with appropriate agencies, providing basic information, and suggesting questions which should be answered during the initial planning process. (R)

Of the dams and reservoirs in Colorado that are either privately or publicly owned, six are single-purpose and ten are multi-purpose flood control dams. The other dams have been designed primarily to provide storage for irrigation and municipal supply and essentially have no flood control pool. During a flood, many of these reservoirs could provide incidental flood protection if the water level in the reservoir had been drawn down. If, however, no operating agreement exists which specifically provides for flood control measures, such protection cannot be relied upon.

Detention and Retention Ponds

Many communities have accomplished reduction of flood losses by slowing or storing stormwater runoff where it falls. These practices are applicable when watershed lands are developed into residential, commercial, or industrial uses. During a flood the increased runoff volumes are detained or temporarily held in ponds built on the development site. The stored waters are then released to the natural drainage course at historical rates (rates that were experienced prior to urbanization). The effect of these ponds is to lower the peak flow and spread it out over a longer time.

A potential problem with *detention* facilities is that their use within a particular basin can become widespread without any consideration of the operation of the entire basin as a system.

Detention ponds delay the peak flow within the sub-basin they serve, thereby upsetting the natural hydrolic patterns. It is possible for several detention ponds, each serving its own sub-basin, to have peak discharges at approximately the same time which could result in a basin-wide peak discharge larger than the basin-wide peak without detention ponds. It is, therefore, important that any such facilities be designed only after a basin-wide master drainageway plan has been developed. This plan will allow local governments to see the overall effect of each proposed facility alone and in combination with other facilities. In some cases such plans will need to be a joint effort of several jurisdictions. The results will be a series of facilities which serve the whole basin's needs rather than a disjointed set of projects that serve individual portions of the basin.

Permanent storage of stormwater runoff on the development site (*retention*) is not allowable under the terms and conditions of Colorado water law.

Watershed Treatment

Watershed treatment is a method of treating lands to render the soil better able to absorb and retain excessive rainfall until flood heights in nearby or adjacent swollen streams have receded.Treatments include crop rotation, terrace construction, contour strip cropping, and selective planting or reforestation.

Changes to the Channel

Levees and Floodwalls

Levees or floodwalls provide protection by acting as a barrier confining floodwaters to a floodway. The difference between a levee and a floodwall is that levees are earth embankments and floodwalls are usually concrete. Urban levee projects must be designed to the 100-year standard to remove lands from a designated floodplain. The CWCB and FEMA require that the following criteria be used when designing a flood control project:

- a minimum levee *freeboard* of 3.0 feet above the 100-year elevatin is required, with a minimum of 4.0 feet of freeboard within 100 feet upstream and downstream of any structure on or through the levee -- bridges, for example;
- a minimum width of 10 to 12 feet for the top of the levee to accommodate maintenance vehicles is recommended;
- an interior drainage system is required to minimize the potential for stormwaters to be trapped behind the levee system;
- the placement of *riprap* on the slope of the levee must be extended two feet below grade at the toe of the slope;
- additional design criteria should be adhered to as outlined in the Corps manual entitled, "Design and Construction of Levees," EM 1110-2-1913. (R)

A floodwall is subject to *hydraulic loading* from floodwaters on one side with little or no earth loading as a resisting force on the opposite side. Floodwalls must be constructed as cantilever I-type sheet piling walls, cellular walls, buttress walls, or gravity walls. Design of floodwalls by a professional engineer is necessary to assure that proper consideration is given to the *hydrostatic* and *hydrodynamic* loads involved.

Channel Improvements-

Flood heights can be reduced through improvement of a natural stream's conveyance capacity or by clearing the stream of obstructions. The concepts generally used in designing a channel improvement project are:

- straightening the channel to remove undesirable bends;
- deepening or widening the channel to increase the waterway size;
- constructing open span bridges and stream crossings;
- lining the channel with concrete to increase efficiency and conveyance capacity.

Channel improvement projects that are not designed to the 100-year standard can still reduce flood risks by lowering flood heights. Care should be taken in designing channel improvement projects to understand the whole stream system. Projects that are inappropriately designed or located can cause serious erosion problems upstream or downstream and worsen flow conditions rather than improve them.

Summary of Flood Control Measures

In communities where there is substantial existing development in the floodplain, flood control projects may be the most cost effective floodplain management option. Flood control projects may also be a particularly appealing option in the case where undeveloped lands in the floodplain have a high development potential. The value of the proposed development may

sufficiently outweigh the cost of flood control works to economically justify this approach.

Other factors than economics, such as public safety, setting of precedents for encroachment into the floodplain, public responsibility for maintenance and operation of flood control facilities, and the potential benefits of leaving floodplain lands in their natural state (water quality, wildlife habitat, open space, and recreation) should be considered. If the costs of such projects are too great to build immediately, flood insurance and a program of flood forecasting, warning, and evacuation may be interim options to reduce the burden on residents of the community.

Floodproofing

Floodproofing is the implementation of techniques for preventing or reducing flood damage to the structure and contents of a building or groups of buildings located in a floodplain. Although it is more simply and economically applied to new construction, floodproofing is also applicable to existing structures. It is not a cure for all flood problems, but it can reduce flood damages. Floodproofing is usually applied through building codes or permits and through floodplain regulations.

In addition to allowing the occupation of certain floodplain lands, floodproofing has some other benefits:

it allows structures which are sited in floodplains to remain usable in times of floods;

it can supplement protection afforded by a flood control project;

it may enhance the availability of flood insurance;

it offers an additional tool to deal with flood risks;

it offers an individual an opportunity to solve flooding problems without the collective action of the community.

Under the NFIP, floodproofing which meets FEMA's requirements can change a structure's flood insurance rating because it reduces the risk of damage to the structure from flooding. Not all floodproofing options are acceptable to FEMA for changing a structure's flood insurance rating. Even if the insurance rating cannot be changed, however, a property owner will experience the floodproofing benefits of reduced risk of damage to the structure and its contents.

FLOODPROOFING OPTIONS BY CATEGORY OF CONSTRUCTION

New Construction

Residential	a) Site planning b) Elevation on fill or pilings c) No basements d) Roadbed protection of driveways and and streets
Commercial and Industrial	a) Site planning b) Elevation on fill or pilings c) Diking d) 100% impermeable basements e) Sewer adjustment f) Roadbed protection of driveways and streets g) Proper anchorage h) Timber and material treatment i) Structural design

Existing Construction

Residential	a) Elevating structure b) Diking c) Permanent closure d) Temporary removal e) Seepage control f) Sewer adjustment g) Underpinning and anchoring
Commercial and Industrial	a) All above residential techniques b) Openings protected c) Interior protected d) Fire protection e) Appliance protection f) Utility adjustments g) Proper salvage h) Deliberate flooding of specified portions of buildings i) Reorganized use of property

CHAPTER 5
ADMINISTRATION OF FLOOD-PLAIN REGULATIONS

Once a community has adopted floodplain regulations, the local floodplain administrator and property owners may have difficulty visualizing the process that should be followed in administering the regulations. "We have these regulations, but what do we do next?" is a question they may ask.

This chapter describes a model process to guide local administrators. (Local procedures may vary from this model process.) Each page has been prepared so that the local administrator can make notes, comments, or add steps to the process as his/her experience dictates.

The model process starts with a property owner (applicant) wanting to change a land use, build one or more new structures, or modify existing structures somewhere in the community.

Development Proposal

1) The planning official will determine whether the proposed use is a permitted use or whether subdivision, rezoning, or P.U.D. compliance is required.
2) At the same time the planning official will determine whether the proposed development falls totally or partially within the floodplain shown on the maps. If not, floodplain issues are no longer a concern. If so, the rest of the process applies.

Preliminary Development Review

3) As part of the rezoning, subdivision, P.U.D., site plan or other applicable review process, the planning official will notify the floodplain administrator of the proposed project. (These may be the same person.)
4) The floodplain administrator will require that the applicant make a determination as to whether the project is located in a floodway, a flood fringe (if detailed information is available), or a floodprone area (detailed information has not been prepared).

Detailed Development Review

5) If the proposal is in an area where detailed information is available, the applicant will provide the floodplain administrator with 100-year flood elevations. If the proposal is in an area where detailed information is not available, the applicant will provide a professionally prepared study ("professionally prepared" means the study has been prepared by a Professional Engineer registered in the state of Colorado using methodologies acceptable to FEMA and the CWCB) that presents the detailed information. If any of the activities proposed would change the 100-year floodplain, the submittal materials will describe the floodplain as it would appear after construction.
6) The floodplain administrator will review the information and/or submit it to the community's engineer and/or the appropriate review agency. The review will determine whether any prohibited uses are proposed for the floodway. It will also determine whether any prohibited uses are proposed for the flood fringe or whether any proposed conditional uses fail to meet the required standards, especially standards for lowest floor elevations.
7) The reviewer will make recommendations, as necessary, to eliminate buildings, relocate them, elevate them, protect them, or otherwise modify the design.

Development Approval

8) The recommendations will be considered by the appropriate regulatory agency and the applicant will be directed to modify his design accordingly. The applicant will apply for building permits.

Building Permit Review

9) The building permit application will include a Pre-Construction Elevation Certification in which the applicant provides information about 100-year flood elevations and lowest floor elevations proposed to be built, signed by a registered professional engineer, surveyor, or geologist.-

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Building Permit Approval

10) The building permit official will confirm with the floodplain administrator that all necessary floodplain management conditions have been included as part of the building permit application.

Start of Construction

11) The floodplain administrator or the building permit official and/or the appropriate engineering official will visit the site during construction and verify that all floodplain management conditions are being met.

Completion of Construction

12) Once structures have been completed, the building permit official will ensure that a Post Construction Elevation Certification is filled out for each structure by a registered architect or engineer, certifying that lowest floor elevations have been located where they should be in relation to 100-year flood elevations.

Certificate of Occupancy

13) If, as part of the development, any changes have been made to the 100-year floodplain that result in changes in 100-year flood elevations or changes in the area that would be affected by a 100-year flood, the floodplain administrator will assure that the engineering information describing the revised floodplain is accurate. Then he will assure that the official floodplain maps are revised accordingly and that FEMA and the CWCB approve. CWCB designation of the new information will be required if 100-year flood elevations change.

Part of Subdivision Improvements Agreement

14) The floodplain administrator will assure that any ongoing operational or maintenance responsibilities for facilities in the floodplain are upheld by the appropriate parties.

CHAPTER 6
IMPLEMENTING A FLOODPLAIN MANAGEMENT PROGRAM

Floodplain managers face pressure from at least two directions. From one direction there is pressure to let property owners in the floodplain develop their land as they feel is best. From another direction there is pressure to protect people and their property from the potential hazards of flooding. The local floodplain manager has the responsibility to develop a balanced program. This can be done by educating members of the community who voice objections to floodplain management, showing how those relate to other community concerns, and avoiding common pitfalls that can lead to legal problems.

Balancing Demands for Floodplain Areas

One of the most common ways for floodplain regulations to balance conflicting demands is to divide the floodplain into two portions--the floodway and the flood fringe. The purpose of this division is to preserve enough of the floodplain to ensure sufficient capacity to carry a 100-year flood without causing undue damage, while permitting economic use of that portion of the floodplain that can be safely developed if stringent standards are enforced.

Another consideration with regard to balance is that it is certain that someday a large flood (larger than a 100-year flood) will inundate the entire floodplain. The entire area cannot be restricted but it is clear that leaving it unrestricted poses a threat to public safety. Identifying and regulating the 100-year floodplain and the 100-year floodway is a way of balancing the need to protect public safety against pressures to use floodplain land.

Relationship of Floodplain Management to Other Community Concerns

For a community with areas subject to flood hazard, floodplain management is still just one concern among other community concerns. Floodplain management techniques can be applied without conflicting with the other goals for which a community plans. The three most important concerns to communities with floodprone areas are land use, public safety, and fiscal issues.

Land Use

Some land use considerations,

1) assuring the efficient use of public resources;
2) provision of certain community services, facilities, and aesthetic benefits in some areas and different ones in other areas;
3) protection of property values; and
4) promotion of public safety.

Floodplain management can be a major part of a community's land use program. There may be unique conditions, restrictions, and prohibitions affecting land use patterns in the floodplain which can affect land use patterns throughout the community. For example, providing or denying services in the floodplain can encourage or discourage development.

Floodplain regulations are not intended to single out certain types of uses for restriction but are intended to address the potential hazards posed by various types of development if the manner and/or the location of the development is inappropriate. For example, not all residential uses are precluded. Properties in the floodplain will require more protection than others to assure maintenance of property values. Yards and gardens could be developed in the floodplain and the houses could either be elevated sufficiently or located outside the floodplain.

Public Safety

Some of the functions of a community's public safety program are,

1) to protect lives;
2) preserve property values;
3) minimize victimization of unwary home and land purchasers; and
4) use public resources efficiently.

Floodplains present a threat to public safety. Development and transportation corridors in floodplain areas can subject people to hazards. During a flood emergency, police, civil defense, and fire personnel are called in to assist in recovery operations and so are taken away from the community's day-to-day public safety needs.

Floodplain management serves the goals of public safety by seeking to protect people and their property from the dangers of floods. Residents are educated to the hazards, protected by regulations which lessen the threat to life and property, and protected by structural improvements such as dams and levees which are intended to keep water away from them. It also serves those goals of public safety by reducing the number of times public safety personnel must help those in the floodplain.

Fiscal Issues

Fiscal issues involve,

1) efficient use of public resources;
2) protection of property values;
3) the mutual benefits from sharing services and facilities; and
4) the enhancement of the community's lifestyle.

Floods can bankrupt a community's budget for years. There are costs for flood fights, clean-up, and restoration of services, and loss of revenue from sales tax and other sources. Building flood protection structures or administering non-structural programs can be costly; it can, however, be more cost effective than dealing with an actual flood disaster. One aspect of these fiscal concerns is that floodplain management costs or disaster recovery costs are generally borne by the whole community, but the benefits of such expenditures tend to fall much more on only a portion of the community. The question of costs and benefits associated with floodplain management naturally raises the questions of costs to whom and benefits to whom.

Anticipating Problems

The following are some recommendations for avoiding problems with floodplain management regulations. Regulatory programs at state and local levels have been most successful where public education, a comprehensive and creative approach, a sound data base, and an effort to provide fair treatment to land owners have been included early in the implementation process.

Public Education

Public education forms the underpinning of regulations since landowners cannot comply with a law about which they do not know and have difficulty complying with one they do not understand. It takes many forms, including marking of floodplain areas to inform owners of boundaries, mapping and distribution of maps, public hearings and workshops, development and distribution of brochures, and, perhaps most important, personal discussions with landowners to explain the goals of regulations and their operation.

A well-educated public can affect the support that is valuable when it is time to implement your management program. Community organizations such as conservation commissions, can assist in developing public support for many local programs through an educating role. Initiative by community leaders such as bankers, lawyers, and industry owners has also been important.

A Comprehensive and Creative Approach

Floodplain management programs have often been most successful where they have been adopted as part of broader planning and regulatory efforts designed to serve multi-purpose land and water management goals such as economic development and environmental protection. Flood events provide the opportunity for examining past development mistakes and tailoring future floodplain development to the needs of the community through urban renewal, relocation, and open space acquisition.

A Sound Data Base

Both State and local programs have often been most successful where detailed maps were prepared. A rational basis for regulation is needed (whether provided through maps or case-by-case data gathering) to provide necessary popular and legal support for regulations.

An Effort to Provide Fair Treatment to Landowners

Even-handed treatment of landowners can be provided by regulating all affected landowners to the same standard, making a serious attempt to permit financially practical uses for land, and coordinating regulatory, taxing, and public works policies.[2]

Potential Objections to Floodplain Regulations

A program of floodplain management can bring opposition from sectors of the community ranging from those opposed to certain aspects of the floodplain program to those opposed to the whole concept of floodplain management. Below are some hypothetical objections raised by members of the community and some information which can be used in response.

Objection

"I don't know why you're worrying about floods in this area. Your maps are wrong. My grandfather homesteaded here seventy years ago, and it's never come close to flooding. I'd like to subdivide that land, and you're just devaluing it by drawing that line on your map."

Response

The areas that are studied in a particular community are selected jointly by Federal, State, and local officials. An attempt is made to select areas where a combination of potential flood hazard and existing and anticipated development may pose problems for the community. When the areas have been selected, the most current, accepted engineering and mapping methods are used to delineate the 100-year floodplain. It is entirely possible for one hundred years to have passed without a 100-year flood on a given stream reach, just as it is possible to have had three 100-year floods in a ten-year period. Federal and State agencies will always provide for appeals of floodplain delineations. Anyone affected may appeal by submitting to State and Federal officials engineering data which may show that there are errors in the floodplain delineations or that conditions have changed sufficiently to warrant a modification of those delineations.

With regard to devaluing the property: if an area is found to be within the 100-year floodplain, then it was within the floodplain before the map was prepared, it was just not previously delineated. As legal decisions have indicated, the land was already burdened by a "natural drainage easement" and was thereby less suited for certain land uses than similar land outside of the floodplain.

Objection

"If you institute these floodplain regulations, all of this land will be useless. None of us will be able to do anything with it."

Response

Most floodplain regulations divide the floodplain into a floodway and flood fringe. In the floodway, land uses are strictly limited; certain uses, however, are allowed, such as agricultural development, recreation, or open space associated with nearby residential, commercial, or industrial uses. In the flood fringe uses are not as strictly limited. The prime concern in the flood fringe is that certain engineering standards are followed; then residential, commercial, or industrial uses can be permitted. In some communities it is possible to build flood control facilities to make more land developable. Property owners still have options for using their land as long as potential dangers to public safety are addressed.

Objection

"We're being blackmailed into joining this flood insurance program with threats of holding back mortgage money and disaster relief money; if we did join they'd tell us what to do with our land."

Response

Every year 100-year floods which cost money occur somewhere in Colorado. The traditional pattern has been to spend public money on disaster relief and on flood control facilities. Every year those public expenditures have increased.

The intent of the NFIP is to have those who stand to benefit most from floodplain expenditures (those who own property and those who live in the floodplain), pay part of the cost of recovery through insurance premiums, and to reduce expenditures of public funds by decreasing the number of persons and structures at risk in the floodplain through regulation. By withholding Federally insured mortgage money and disaster relief funds to non-participants, the Federal Government is attempting to stop the flood-rebuild-flood cycle.

Although there are Federal requirements to follow in regulating floodplains in communities in the NFIP, there is still a certain amount of freedom allowed to land owners in the floodplain. Regulations and court cases related to them have sought to find a balance between preventing public harm and promoting private benefit.

Objection

"All we need to do is build a dam and some levees and then we can develop without having to worry about floods. Regulations make it hard for everyone."

Response

There are situations where flood control structures alone or in combination with other floodplain management tools offer the best approach to floodplain problems. Which times those are will be determined through engineering analysis and the public decision process.

Frequently, it is difficult or impossible to obtain funding for flood control projects. Federal funding can take a long time to obtain, if it is ever obtained. There may not be sufficient State or local funding available. A local consideration will be who benefits from the project as opposed to who pays for it. The decision must be made whether those who benefit will pay the majority of the cost or whether they will be subsidized by other members of the community. If the project is properly designed and built, existing development will be protected and future development will become more feasible. The community should be prepared to meet these funding hurdles and to pursue careful design and construction if it considers this option.

Floods larger than the 100-year flood do occur, and development which takes place after a project is built can face the risk of damage from floods larger than those for which the project was designed. A "false sense of security" can lead to having additional people and property at risk *after* a project is built.

More frequently than not, analysis has shown that regulations are a more cost effective means of floodplain management than flood control projects. The situations where flood control projects are more cost effective are usually those in which there is substantial existing development in the floodplain. In such situations regulations will not offer much protection from flood hazard.

Assistance When Developing or Expanding A Floodplain Management Program

If you have decided to begin (or expand) the process of developing and implementing a floodplain management program, this section can provide some help.

To supplement what is found in this manual, the staff from both the CWCB and FEMA are available for presentations to city councils and county commission meetings to: (1) outline floodplain management program implementation procedures and provide any necessary details; (2) discuss the legal basis for developing a program; (3) discuss the NFIP as it applies to the proposed floodplain management program; and (4) discuss program development in relation to the State's floodplain management activities.

Steps to Implement a Local Floodplain Management Program

The step-by-step process for implementing or expanding a local floodplain management program follows. The fact that every community in Colorado is different means that each program must be tailored to meet local needs. Some communities will have already completed some of these steps, or similar steps. This is simply a guide.

1. _____ Determine the local official who will administer the program if one is not already designated.

2. _____ Determine the community's needs and goals for floodplain areas as part of the whole community.

3. _____ Inventory existing development in the floodplain.

4. _____ Research past flood history and floodplain policies.

5. _____ Solicit public input regarding the use of floodplain areas.

6. _____ Consider applying for admission into the NFIP.

7. _____ Determine the community's flood hazard area.

8. _____ Determine requirements by Federal and State government with regard to development in the floodplain.

9. _____ Identify sources of technical assistance to help the community analyze information on needs and goals.

10. _____ Write and adopt floodplain regulations to guide development in the floodplain.

11. _____ Promote public education programs within the community that deal with floodplain use and protection from flood hazards.

12. _____ Strengthen floodplain regulations through a strong enforcement program.

13. _____ Convert your community from the Emergency phase of the NFIP to the Regular phase of the NFIP.

14. _____ Make an annual assessment of your floodplain management program to consider,
map amendments,
regulation changes, and
implementation of other floodplain management options.

RESOURCES

Roles of Federal, State, and Local Governments in Floodplain Management Regulations

There are many government agencies involved in floodplain management. Some of them are involved in flood disaster relief, flood hazard identification, flood control projects, flood insurance, or floodplain regulation. Government roles and the government subsidized assistance programs which are available to a community following a flood disaster are discussed throughout this manual. This chapter summarizes the information on specific flood control and floodplain management activities and publications you can expect to obtain from local, State and Federal agencies. There is a phone number and address supplied by which further information can be obtained if needed.

Government Roles

Federal

1) Perform flood control reconnaissance studies.
2) Perform flood control feasibility studies.
3) Perform flood insurance rate studies.
4) Research and develop design procedures for design of facilities.
5) Make subsidized flood insurance available to property owners.
6) Construct local flood control projects.
7) Construct large multi-purpose dams and reservoirs.
8) Implement relocation and rehabilitation programs.
9) Provide disaster relief funds.
10) Provide disaster relief technical and administrative assistance.
11) Provide technical assistance to states.
12) Manage publicly owned watersheds to minimize flood hazards.

State

1) Perform floodplain information studies.
2) Perform hydrologic and hydraulic investigations.
3) Perform flood history and economic research.
4) Provide technical assistance to local governments.
5) Prepare "work programs" and "scopes of work."
6) Assist with Master Drainageway Planning Studies.
7) Assist in selecting contractors and supervising their work for floodplain mapping and flood control engineering studies.
8) Prescribe standards for surveys, mapping, and engineering for floodplain management studies.
9) Certify technical accuracy of floodplain information and data.
10) Participate in public educational and informational programs regarding flood hazards and floodplain management practices, including provision of written materials.
11) Coordinate Federal assistance programs.
12) Coordinate the National Flood Insurance Program.
13) Seek authorization and funding for Federal and State projects and programs.
14) Co-sponsor Federal flood control projects.
15) Coordinate flood hazard mitigation activities as mandated by a Federal disaster declaration.

Local

1) Implement a floodplain management program.
2) Adopt flood hazard data and information.
3) Determine local floodplain problems and management needs and work with state and federal agencies to develop options to address them.
4) Enforce floodplain regulations.
5) Monitor changes in the floodplain and take appropriate action.
6) Operate and maintain federally constructed local flood control or drainage projects.
7) Cost-share with Federal and State agencies in flood hazard study and report costs.
8) Perform field surveys.
9) Secure rights-of-way and rights of ingress and egress for completion of studies and projects.
10) Disseminate flood hazard information and data.
11) Conduct public educational and informational programs on land use aspects of the floodplain management program.
12) Construct street and drainage projects.

Federal Agencies

Federal Emergency Management Agency (FEMA)

FEMA was created by Executive Order No. 12149 of President Carter in April 1979 to place agencies with responsibility for responding to peace and war emergencies under one federal roof. FEMA is authorized to administer the Federal Insurance Administration (FIA) and the Federal Disaster Assistance Administration (FDAA). FEMA is the federal agency which dictates federal policy regarding floodplain land-use regulations, flood insurance, and flood disaster relief and recovery procedures. FEMA is a partner to public organizations which assist or deal with emergency management and disaster. It provides funding, technical assistance, services, supplies, equipment, and direct federal support to respond to civil defense emergencies, floods, earthquakes, hurricanes, tornados, nuclear power plant accidents, acts of terrorism, dam safety, radiological and hazardous material incidents, and other national, state, and local emergencies. Another dimension of FEMA's activities is to assist State and local governments in mitigating the effects of future disasters and emergencies through research and planning efforts.

Programs of Interest to Floodplain Managers

- National Flood Insurance Program (NFIP) (see Chapter 4)
- Disaster Assistance Programs

  The greatest single source of Federal disaster assistance is provided under the authorities of the Disaster Relief Act of 1974, Public Law 93-288, which is implemented by FEMA. FEMA administers grants to the states and to communities, and directs and coordinates the disaster assistance functions of all Federal agencies, whether under Public Law 93-288 or their own authorities. Assistance is made available

  after a Presidentially declared "Major Disaster;"
  after a Presidentially declared "Emergency;"
  after a "Undeclared" federal disaster;

  through buy-out programs, (NFIP and Disaster Relief funds are used to purchase properties located in the floodplain which experience "Substantial Total Losses" when those properties are part of the NFIP; under either the Constructive Total Loss Policy or Section 1362 of Public Law 90-488).

For More Information Contact:

The Federal Emergency Management Agency Bldg. 710, Denver Federal Center, Denver, CO 80225

Natural and Technological Hazards (including NFIP)	234-6582
Emergency Management	234-2557
Disaster Assistance Program	237-6542

U.S. Army Corps of Engineers (Corps)

The Corps of Engineers is engaged in planning and constructing projects for flood control, navigation, and water conservation as primary functions under Federal law. Activities in Colorado include flood control, flood protection, water conservation, floodplain management, and repair and restoration of flood damaged public works following a disaster declaration.

Programs of Interest to Floodplain Managers

- Flood Control Programs

  Survey Investigations for Basins - The Flood Control Act of 1936 authorized the Corps to implement a flood control works program. The Flood Control Act of 1944 expanded the Corps' role into planning and constructing multi-purpose projects. Today, a Corps' survey investigation includes all aspects of water resources investigations; the primary feature, however, is flood control.
- Small Flood Control Projects - Section 205 of the 1948 Flood Control Act, as amended, gives the Corps the authority to design and construct small projects such as levees, floodwalls, channels, and small dams. (Federal share for each project may not exceed $4,000,000 at any single locale.)
- Snagging and Clearing of Stream Channels - Section 208 of the 1954 Flood Control Act, as amended, authorizes the Corps to spend up to $250,000 annually in a single locality for the construction, repair, restoration, or modification of emergency streambank and shoreline protection works to prevent damage to highways, bridge approaches, public works and utilities, churches, hospitals and schools, and other non-profit public services. The authority does not apply to privately owned property or structures except as indicated above.
- Flood Fighting and Rescue Operations - Public Law 99 authorizes the Corps to assist the State and local governments in fighting floods and in certain recovery operations where there has been no Presidential declaration. When an emergency exists which is beyond local and State capabilities, DODES or the Governor's Office can request assistance from the Corps. Generally, authorization to spend funds can be obtained within a period of a few hours to three working days.
- Floodplain Information - The Corps is authorized by the Flood Control Act of 1960 to provide information to states and local communities upon their request. With the advent of the NFIP this information program has been somewhat curtailed. Today, the Corps continues to undertake hydrologic and hydraulic investigations; they do not, however, publish floodplain information booklets. Preparation of surveys, mapping, and publishing of studies is a State or local government responsibility.

For More Information Contact:

U. S. Army Corps of Engineers

Albuquerque District
P. O. Box 1580
Albuquerque, NM 87103
(505) 766-2781

Kansas City District
700 Federal Bldg.
Kansas City, MO 64106
(816) 374-3896

Omaha District
7410 U. S. Post Office
& Court House
215 N. 17th St.
Omaha, NE 68102
(402) 221-3020

Sacramento District
650 Capitol Mall
Sacramento, CA 95814
(916) 440-2292

Tulsa District
P. O. Box 61
Tulsa, OK 74102
(918) 581-7396

U.S. Soil Conservation Service (SCS)

The U.S. Department of Agriculture, Soil Conservation Service provides technical assistance in the conservation, development, and productive use of soil and water resources. Their activities in Colorado include watershed planning programs, flood protection projects, Resource Conservation and Development (RC&D) Programs, soil surveys, snow surveys, and water supply forecasting.

Programs of Interest to Floodplain Managers

- Watershed Protection and Flood Control Projects

  Public Law 83-566 provides the SCS with the authority to prepare plans and to construct small watershed projects for flood prevention, agricultural water management, recreation, municipal water supply, and fish and wildlife development. The plans describe:

  the problems,

  the proposed solutions and when, how, and by whom they are to be installed,

  the environmental effects, and

  the methods of financing.

  A watershed or subwatershed area may not be larger than 250,000 acres, nor include any structure providing more than 12,500 acre-feet of floodwater detention capacity or more than 25,000 acre-feet total capacity to qualify for such projects.

- Resource Conservation and Development Program (RC&D)

  This program is designed to expand economic opportunities for people in approved planning areas. Under the program, USDA agencies provide technical, cost-sharing and loan assistance to local sponsors by developing and carrying out action plans for conservation improvement, development, and wise use of natural resources. Projects developed through this program do not have to be tied closely to watershed conservation measures. Plans and projects can be formulated on the basis of regional or community needs.

- Floodplain Management Studies

  The SCS assists State agencies and communities in the development, revision, and implementation of their floodplain management programs by carrying out cooperative floodplain management studies in accordance with Public Law 83-566. These studies may serve as the source of technical data for a community's floodplain management program.

  For implementing a study, a "Plan of Work" is prepared which is an agreement by which the State and local governments agree to share the study cost. Generally, the State and local governments furnish the base mapping and field surveys, and the SCS provides the engineering services and publishes the final report.

For More Information Contact:

Soil Conservation Service
2490 W. 26th Ave., Denver, CO 80218

State Conservationist	837-4275
Engineering & Design	837-5688
River Basin/Watershed Planning	837-5653

U.S. Geological Survey (U.S.G.S.)

The Geological Survey was established by Congress on March 3, 1879, to classify public lands and examine the geological structure, mineral resources, and products of the country. Over the years, other Congressional acts have enlarged its duties and functions to include making geological and topographic maps, gauging streams, and determining water supplies of the United States. The Survey can assist communities and State agencies in collecting, developing, and computing basic data and information for floodplain engineering studies and investigations.

For More Information Contact:

U.S. Geological Survey
Bldg. 53, Denver Federal Center, Denver, CO 80225

Public Inquiries Office	837-4169
Engineering Geology	234-3721
Resource Analysis	234-6376
Natl. Cartographic Info Center	234-2326
Water Resources Division	234-3815
Regional Hydrologist	234-3661

U.S. Bureau of Reclamation (U.S.B.R.)

The Bureau administers the Federal program in western states for water resource development and use, which provides multiple-purpose projects furnishing fish and wildlife protection and recreational opportunities, water for farm irrigation, municipal, and industrial use, hydroelectric power, flood control, and other natural resource conservation benefits.

The program was established by the Reclamation Act of Congress in 1902.

For More Information Contact:

U.S. Bureau of Reclamation:

Regional Director
Lower Missouri Region
Denver Federal Center, Bldg. 20
Denver, CO 80225
(303) 234-4441

Regional Director
Upper Colorado Region
P.O. Box 11568
Salt Lake City, UT 84147
(801) 524-5592

Regional Director
Southwest Region
714 Tyler, Suite 201
Amarillo, TX 79101
(806) 378-5445

National Weather Service (NWS)

The National Weather Service is responsible for 36-48 hour weather forecasting, issuing severe weather warnings and watches, flash flood warnings and watches, and flood warnings.

For More Information Contact:

National Weather Service
10230 Smith Road
Denver, CO 80239
398-3964 Public Weather Information
837-3788 Staff Hydrologist

NOAA/NWS
Central Region
601 E. 12th Street, Room 1836
Kansas City, MO 64106
(816) 374-3220 Staff Hydrologist

State Forecasting Offices:

Salt Lake City	(801) 524-5231
Cheyenne	(307) 638-6762
Albuquerque	(505) 243-4890

State Agencies

Colorado Water Conservation Board (CWCB)

The CWCB was established by the Colorado General Assembly in 1937 "...to promote the conservation of state waters in order to secure the greatest utilization of such waters and the utmost prevention of floods." Floodplain management activities are centered in the Flood Control and Floodplain Management Section of the Board.

Programs of Interest to Floodplain Managers

1) Flood hazard identification and review
2) National Flood Insurance Program coordination
3) Flood emergency response activities
4) Flood control and drainage plans
5) Flood data collection and documentation
6) Coordination with and review of federal and non-federal flood control projects
7) Hydrologic and hydraulic investigations
8) Floodplain management services

The CWCB is the primary State agency responsible for flood control planning. The Board coordinates the floodplain management activities of all federal agencies within Colorado.

Publications of Interest

The CWCB publishes handbooks, brochures, and manuals about floodplain management in Colorado in addition to floodplain information reports and flood documentation studies.

- "Managing Floodplains in Colorado," May, 1982. A three-fold brochure outlining the role of the CWCB in floodplain management; free.
- "Principles of Floodplain Management," May, 1983. A three-fold brochure describing the concepts and benefits in Floodplain Management, free.
- *Fee System for the CWCB Technical Services in Flood Control and Floodplain Management*, CWCB, November, 1982; 4 pages; free.
- *Specifications for Photogrammetric Services for Floodplain Studies in Colorado*, CWCB, Revised August, 1982; 27 pages; $5.00.
- *Engineering Specifications and Guidelines for Floodplain Information Studies in Colorado Streams*, CWCB, July, 1979; 18 pages; $5.00
- *Model Floodplain Information Report, Centennial River, Centennial, Colorado*, CWCB, September, 1975; 35 pages; $5.00.
- *Model Floodplain Regulations for Local Governments in Colorado*, CWCB, June 3, 1982; 27 pages; $5.00.
- *Colorado Flood Insurance Handbook*, December, 1982. An 8-page handbook explaining the National Flood Insurance Program in Colorado; free.

For More Information Contact:

Colorado Water Conservation Board
Flood Control and Floodplain Management Section
1313 Sherman Street, Room 823
Denver, Colorado 80203
(303) 866-3441

Colorado Division of Water Resources (State Engineer)

The State Engineer has statutory responsibilities for the administration of all waters of the state, both surface and subsurface, by means of various conveyances including ditches, wells, tunnels, pipelines, reservoirs, and livestock water tanks. With regard to flooding, the responsibilities include "assisting various ditch companies in times of flood to alleviate all possible damage to structures, crops, and land, and in seeking repairs of structures damaged as a result of the floods."

Programs of Interest to Floodplain Managers

1) Administration of "Dam Safety Program"
2) Review and approval of dam and reservoir plans
3) Inspection of existing dams
4) Recording and maintenance of State stream gauges
5) Review of subdivision and development proposals for inundation through spillway releases or dam failures
6) Mapping of the Dam Failure Flood Zone

For More Information Contact:

Colorado Division of Water Resources
1313 Sherman Street, Room 818
Denver, Colorado 80203
(303) 866-3581

Colorado Geological Survey (CGS)

The Survey is a technical support agency to other State agencies and local governments in the areas of "Natural Hazards" and "Mineral Resources." The Survey was created by a law enacted by the 16th General Assembly on April 24, 1907. In their geologic hazards identification programs, the CGS takes into account the issues of floods and natural floodplains.

Programs of Interest to Floodplain Managers

1) Assistance and consultation with other State and local governmental agencies on geologic problems
2) Performance of studies to develop geological information
3) Collection and preservation of geologic information

The CGS works closely with the CWCB and the State Engineer's Office on water and flood-related problems.

For More Information Contact:

Colorado Geological Survey
1313 Sherman Street, Room 715
Denver, Colorado 80203
(303) 866-2611

Colorado Division of Disaster Emergency Services (DODES)

The Colorado General Assembly enacted House Bill 1600, called the "Colorado Disaster Emergency Act of 1973," to address disasters within the state. This act created DODES under the Department of Military Affairs. The Colorado Disaster Emergency Act of 1973 declares that funds shall always be available to meet emergency situations following a flood.

Programs of Interest to Floodplain Managers

1) Mitigation
2) Preparedness
3) Response
4) Recovery

DODES is responsible for coordinating the work of other State agencies in these four areas. Statutory authorities are less strong in the area of mitigation than in the other three areas. These authorities have been strengthened in recent years through Executive Orders. The authorities are to coordinate the work of other agencies. The Division has prepared the Colorado Natural Disaster Emergency Operation Plan, which details response activities of State agencies during emergencies.

By Executive Order, DODES has responsibility to oversee the preparedness and emergency planning work of local governments. DODES also reviews the preparedness plans of local governments to see how well they address local potential hazards.

For More Information Contact:

Colorado Division of Disaster Emergency Services
Camp George West
Golden, Colorado 80401
(303) 279-2511

Department of Local Affairs

The Department of Local Affairs was created by the Administrative Act of 1968 to assist local units of government, towns, cities, and counties. Three Divisions within the Department have programs dealing with drainage, flood control, and floodplain management:

- the Division of Local Government,
- the Division of Housing,
- the Division of Commerce and Development.

These divisions have grant and lending programs which are made available to local governments annually by application requests.

Programs of Interest to Floodplain Managers

1) Water and sewer facilities
2) Land use planning (presently not funded)
3) State Impact Assistance
4) Community Development Block Grants
5) State Housing Grant Fund

For More Information Contact:

Colorado Department of Local Affairs
1313 Sherman Street, Room 500
Denver, Coloado 80203
(303) 866-2771

Local Agencies

Urban Drainage and Flood Control District (UD & FCD)

The District was established by the Co orado General Assembly in 1969 to assist the 34 cities and counties in the Denver Metropolitan area in the solution of multi-jurisdictional drainage and flood control problems.

Programs of Interest to Floodplain Managers

1) Preparation of drainage and flood control master plans and flood hazard delineation reports for major streams. gulches, and other multi-jurisdictional drainage problems, design and construction of drainage and flood control facilities
2) Assistance to local governments with the maintenance of flood control facilities which were constructed with District funding assistance
3) Coordination of the collection and dissemination of drainage information
4) Assistance to local governments in the formulation of floodplain management programs including the adoption and enforcement of adequate floodplain regulations
5) Collection and documentation of flood events and rainfall
6) Dissemination of information to local officials and engineering consultants through conferences and seminars
7) Assistance to local governments ir the formulation and implementation of flood warning plans

UD&FCD coordinates flood studies with the CWCB and FEMA.

For More Information Contact:

Urban Drainage and Flood Control District
2860 West 26th Avenue
Denver. Colorado 80222
(303) 455-6277

Local Jurisdictional Bodies

In Colorado, towns, cities, and counties have many of the legislative authorities of State agencies. In flood control and floodplain management, they are the only units of governments, except the UD&FCD, which can regulate the use of lands. For floodplain lands, their regulatory authority carries a stipulation requiring the State to review and approve the base information and data to delineate floodplains.

FOOTNOTES

1. George R. Phippen, "On a Flood Plain, Can a Right Go Wrong?" Vol. 6, No. 1, 1974, "Water Spectrum," U.S. Army Corps of Engineers.
2. Kusler, Jon A. and Rutherford H. Platt, *The Law of Floodplains and Wetlands: Cases and Materials*, Draft prepared for the American Bar Association Special Committee on Housing and Urban Development Law, Jan. 1, 1982.

GLOSSARY

This appendix defines those terms frequently encountered in floodplain management.

Approximate -- Prepared by approximating mathematical analysis for one or more of the following steps; topographic mapping, hydrologic calculations, and hydraulic calculations; arriving at floodplain delineations without precise water surface profiles.

Areal -- Pertaining to the land area covered, as measured in square miles or other units of area.

Backwater - Step Procedure -- A mathematical methodology for calculating a water surface profile over a given stream reach by starting at the downstream end of the reach and, through incremental steps, balancing energy losses at upstream points to arrive at water surface elevations at those points until the entire stream reach has been analyzed.

Backwater Effect -- The rise in water surface elevation caused by an obstruction such as a building, fill material, or bridge that limits the area through which water must flow.

Basin -- The total land area from which surface run-off is transported away by a drainage system. Also known as a "watershed."

Benchmark -- A U.S. Coast and Geodetic Survey (National Geodetic Survey) elevation mark established on some stationary object and used as a vertical reference point in other surveys.

Breach -- A gap or rift in a solid structure such as a dam or a levee.

Channel -- The bed of a stream or river.

Channelization -- Improvement of flow characteristics or water carrying capacity of an artificial or natural channel by excavation, bank stabilization, clearing, or other means.

Channel Capacity -- The maximum flow which can pass through a channel without overflowing the banks.

Contour Interval -- The difference in elevation between adjacent contour lines on a topographic map, usually 1 foot, 2 feet, 5 feet, or some multiple of 10 feet.

Constriction -- A place or feature that makes the channel and/or floodplain smaller or narrower, thereby reducing its ability to pass flow.

Control Marker -- A U.S. Coast and Geodetic Survey (National Geodetic Survey) position mark established on some stationary object and used as a horizontal reference point in other surveys.

Corrective -- (see *Structural*)

Critical Depth -- That depth of flow for a given discharge of water, where the specific energy (energy per unit weight of water) is at a minimum.

Cross Section -- A plot or graph of ground elevation across a stream valley or portion of it, along a line perpendicular to the stream or direction of flow.

Cubic Feet Per Second (CFS) -- A unit of measurement that describes the amount of flow passing a given point in a stream channel at a given point in time. One cubic foot per second is equivalent to approximately 7.5 gallons per second.

Cyclical -- Recurring in a regularly repeated time interval.

Dam -- A barrier constructed across a waterway to control the flow or raise the level of water.

Dam Failure Flood Zone -- That area downstream of a dam that would be subject to flooding by the waters stored behind the dam if the dam were to fail.

Datum -- An assumed, given, measured, or otherwise determined point, line, or surface used as a reference in surveying or mapping.

Delineating -- (See *Floodplain Delineation.*)

Designation -- Approval and adoption by official action of a local governing body of the delineation of an area subject to flooding by a 100-year flood; for which water surface elevations have been established by a detailed engineering study that has been reviewed and approved by an official action of the Colorado Water Conservation Board, as required by State Statutes.

Detailed -- Prepared using mathematical analysis for the following steps, topographic mapping, hydrologic calculations, and hydraulic calculations, to arrive at precise water surface profiles and floodplain delineations.

Detention -- The slowing, dampening or attenuating of flows by temporarily holding (generally less than 72 hours) the water on a surface area, in a storage basin, or within the storm or combined sewer itself. All detained water will be returned to the stream after the storm has passed at rates which will not adversely affect downstream occupants and water users.

Discharge -- The amount or rate of flow of water through a given stream reach.

Duration -- The time that elapses between when water first flows over a stream's banks until floods are again confined to the stream's banks.

Dynamic -- (see *Hydrodynamic*)

Embankment -- A mound of earth or stone built to hold back water.

Ephemeral Stream (or *Stream Reach*) -- A stream (or stream reach) that flows only in direct response to precipitaiton; measurable discharge generally occurs less than 10 percent of the time.It receives no long-continued supply from melting snow or other surface sources. Because an ephemeral stream channel is at all times above the water table, it also receives no water from springs or sustained ground-water seepage.

Erodibility -- The tendency of a stream bank or other area near a stream to be worn away during periods of high flow.

Feasibility Study -- A study to evaluate the feasibility of a flood control project based on the benefit/cost ratio, the availability of public funding, the likelihood of participation by private entities in funding and so on.

Field Survey -- The process of measuring dimensional relationships such as horizontal distances, elevations, directions, and angles on the earth's surface for locating property boundaries, construction layout, and mapmaking.

Flood or Flooding -- Temporary inundation of otherwise normally dry land adjacent to a river, stream, lake, etc.

Flood Crest -- The elevation or maximum height reached or expected to be reached by the waters of a given flood at a given location.

Flood Frequency -- A measure of the likelihood of the occurrence of a flood expressed by the period of years during which one would expect such a flood to occur once; the frequency is calculated through a probability distribution analysis.

Flood Fringe -- The part of the floodplain located outside of the floodway but still subject to flooding.

Flood Hazard Boundary Maps -- Maps prepared by the Federal Insurance Administration or the Federal Emergency Management Agency showing areas of potential flood hazard as determined through approximate methods.

Flood Insurance Emergency Phase -- That phase of the National Flood Insurance Program when limited amounts of flood insurance are available. Communities use Flood Hazard Boundary Maps to identify flood hazard areas and they also adopt general flood resolutions or measures. Subsidized rates are charged regardless of flood risks since technical flood information has yet to be determined.

Flood Insurance Rate Maps -- Maps prepared by the Federal Insurance Administration on the Federal Emergency Mangement Agency showing areas that have a 1% chance of being flooded in any given year (100-year floodplain) as determined through detailed methods and showing Flood Insurance Rate Zones for determining insurance rates for the National Flood Insurance Program.

Flood Insurance Regular Phase -- That phase of the National Flood Insurance Program when communities approve their Flood Insurance Study (FIS) and adopt a legally enforceable floodplain ordinance that meets FEMA criteria. In Colorado, a floodplain ordinance is legally enforceable only after the Colorado Water Conservation Board approves and designates a community's floodplain study. Actuarial insurance rates are used which reflect the degree of risk. Higher limits of coverage both for structures and their contents are available under the regular program.

Flood of Record -- The greatest flood recorded for a location.

Floodplain -- The low lands adjoining the channel of a river, creek, stream or other water course, lake, or body of standing water which may be or has been covered by a floodwater.

Floodplain Delineation -- The process of showing in graphic form on a map or photo mosaic, areas which may be or have been inundated by a specific or predicted flood.

Floodplain Information Study -- A study prepared using detailed methods to determine water surface profiles and floodplain delineations including delineation of the 100-year floodplain.

Floodway -- The channel of a stream and the portions of the adjoining floodplain required to pass the discharge of the 100-year flood with an insignificant increase in flood levels. As used in the National Flood Insurance Program, floodways must be large enough to pass the 100-year discharge without causing the flood elevation to increase more than a specified amount (usually one-foot).

Freeboard -- A factor of safety usually expressed in feet above a design flood level for flood protection or control works.

Gauge -- An instrument for measuring precisely the flow of water past a given point on a stream.

Gauged -- Measured by one or more stream gauges which provide data about historic volumes of water through a particular stream reach.

Horizontal Datum -- An assumed set of lines in the two horizontal dimensions used as a reference in surveying or mapping and expressed as longitudinal and latitudinal coordinates.

Hydraulic Analysis -- The study of determining water levels for particular flood events.

Hydraulic Loading -- Pressure from the forces of water at rest or moving water.

Hydrodynamic -- Resulting from water in motion pressing against adjacent surfaces.(also *Dynamic*)

Hydrodynamic Loads -- Forces imposed on structures by flood waters due to the impact of moving water on the upstream side of a structure, negative pressures on the downstream side, and drag along the sides.

Hydrologic Analysis -- The study of determining rainfall run-off (flood waters) for a specific watershed.

Hydrostatic -- Resulting from the weight of water at rest.(also *Static*)

Hydrostatic Loads -- Forces imposed on structures due to the weight of the flood water.

Intermittent Stream (or *Stream Reach*) -- A stream (or stream reach) which has surface discharge generally between 10 and 80 percent of the time. Because an intermittent stream channel is at or near the water-table surface, discharge can be the result of a discontinous supply from springs or ground water seepage, a discontinuous supply from surface sources, including runoff or rainfall and seasonal snowmelt, or both. If a channel has a sustained period of no streamflow interrupted by a seasonal period of continous streamflow, at least 1 month in length, the stream or streams is intermittent.

Levee -- An artifical barrier constructed to prevent a river or stream from overflowing.

Liquefaction -- The process of becoming liquid.

Log-Pearson III Technique -- A statistical distribution technique which is used in analyzing observed peak flows in order to calculate projected peak flows for various flood frequencies considered in a floodplain study.

Magnitude -- The largest measured volume of flow during a particular flood.

Master Drainageway Planning Study -- A study prepared using detailed methods to determine water surface profiles and floodplain delineations, including delineation of the 100-year floodplain, and to determine alternative structural and non-structural plans for dealing with 100-year flows and drainage problems.

Mean Sea Level -- The average height of the sea for all stages of the tide over a 19-year period.

Monument -- A known station, defining horizontal and/or vertical position, established by any entity other than the U.S. Coast and Geodetic Survey (National Geodetic Survey).

Monumentation -- A network of surveying monuments, tied to one another, providing precise information on elevations and positions in a given region, thereby facilitating the determination of elevations and positions at places between the monuments.

National Datum -- The vertical and horizontal data that have been defined by the National Geodetic Survey; Mean Sea Level (MSL) for vertical control and state plane coordinates within each state for horizontal control.

National Geodetic Survey (NGS) -- The federal agency within the U.S. Department of Commerce which is responsible for establishing standards for vertical and horizontal data and for establishing surveying criteria. (Formerly the U.S. Coast and Geodetic Survey)

Nonstructural Measures -- Designed to address floodplain problems by minimizing or avoiding conflicts between development and occupation of land and its propensity to be flooded; pursuing a policy of preventing such problems before development occurs.(also *Preventive*)

Numbered A Zone -- A zone on a Flood Insurance Rate Map that delineates in a detailed fashion the 100-year floodplain with precise engineering information showing detailed water surface elevation and floodplain boundary information.

Order of Control -- A classification of surveying based on the accuracy of the ground control used and on the accuracy of the survey results; categories established by the National Geodetic Survey are First Order, Second Order Classes I and II, and Third Order Classes I and II.

Orthophotographic Map -- A composite of aerial photographs of an area that have been corrected for the tilt of the airplane and that have, through a scanning process, been adjusted to assure true scale throughout the composite.

Overhead View -- (see *Plan View*)

Overlay -- A zone district which is in addition to an existing, underlying zone district and whose restrictions are in addition to the restrictions of the underlying zone district.

Perennial Stream or (*Stream Reach*) -- A stream (or stream reach) which has measurable surface discharge more than 80 percent of the time. Discharge is at times in part or in total the result of springflow or ground-water seepage because the streambed is lower than surrounding ground-water levels.

Physiographic -- Pertaining to the physical features of a place or region.

Piping -- The state of developing cylindrical cavities through which water may pass.

Planimetric Features -- Man-made features shown in the horizontal plane on a map.

Plan View -- A two-dimensional representation of a stream channel and floodplain which shows the area as viewed from above without showing vertical features (also *Overhead View*).

Preventive -- (see *Non-Structural*).

Probability Distribution Analysis -- A mathematical analysis to determine the likelihood of occurrence of various volumes of streamflow expressed as a ratio of the number of times given volumes of streamflow can be expected to occur in a certain time period over the number of years in that time period.

Probable Maximum Flood (PMF) -- Theoretically the greatest flood physically possible in a drainage basin.

Profile View -- A two-dimensional representation of a stream channel and floodplain which cuts vertically through the center of the channel in the direction of flow. (also *Side View*)

Rain Gauge -- A gauge for measuring the intensity and the amount of rainfall.

Rating Curve -- An algebraic curve showing the relationship between the volume of water flowing past a given point on a stream and the depth of flow at that point.

Rational Method (Q = CIA) -- A method for determining the maximum rate of runoff in cubic feet per second according to the Rational Formula (Q = CIA) where Q is the maximum rate of runoff, C is a runoff coefficient expressing the ratio between the maximum rate of runoff and the average rate of rainfall intensity in inches per hour, I is the average rate of rainfall intensity, and A is the area from which the runoff originates.

Reach -- A hydraulic engineering term to describe longitudinal segments of a stream or river.

Rectified Photographic Map -- A composite of aerial photographs of an area that have been corrected for the tilt of the airplane but that have not been adjusted to assure true scale throughout the composite.

Regime of Flow -- A categorization of flow based on its specific energy allowing for three categories of flow: subcritical, critical, and supercritical.

Regional Skew Coefficient -- A numerical measure of the lack of symmetry in a frequency distribution of peak flows, specific to a particular geographic region.

Regression Curve -- An algebraic curve which correlates a dependent variable with one or more independent variables allowing the prediction of values of the dependent variable based on the observed correlation between past values of the dependent and independent variables.

Retention -- The prevention of runoff from entering a stream, storm sewer system, or combined sewer system by storing it in some type of storage basin.

Riprap -- An assemblage of broken stones erected in water or adjacent to water, as on a stream bank, to protect the ground in or near the floodplain from erosion.

Rise -- An increase in water surface elevations due to increased flow, obstructions to flow, or some combination of those factors.

Riverine -- Located on or near the banks of a river.

Roughness Coefficent -- A measure of the degree of resistance to water flow offered by a stream channel and the adjacent floodplain, which is a function of vegetation, rocks, channel material, and other such stream characteristics.

Runoff -- That portion of rainfall or snowmelt that is not absorbed by the soil.

Seepage -- The act or process of water passing through small openings or pores.

Side View -- (see *Profile View*).

Staff Gauge -- A vertical board or rod graduated in hundredths of a foot to measure stream depths; a rating curve is used to convert the depths to flows in cubic feet per second.

State Plane Coordinates -- A network of coordinates which define any point using horizontal projection of latitudes and longitudes, as administered by the State Surveyor.

Static -- (see *Hydrostatic*)

Stationing -- An arbitrary system for locating a position along a baseline, (reference line) usually a stream centerline, by starting from one end of the baseline and numbering at regular intervals.

Structural Measures -- Designed to address floodplain problems by constructing facilities which reduce or eliminate flooding of a given area thereby protecting facilities that would otherwise be subject to greater flooding and more frequent flooding. (also *Corrective*)

Subcritical Flow -- That type of flow, for a given discharge of water, where the depth is greater than critical depth and velocities are low.

Supercritical Flow -- That type of flow, for a given discharge of water, where the depth is less than critical depth and velocities are high.

Synthetic Rainfall - Runoff Method -- A mathematical method to calculate runoff on a particular stream reach based on rainfall amounts, durations, and distributions and on average water losses, ground slopes, and other hydraulic parameters.

Topographic Mapping -- Mapping which graphically represents the exact physical configuration of a place or region, including elevations, water bodies, and man made features.

Torrential -- Resulting in a raging flood or deluge.

Undermining -- The weakening of a structure or of ground by wearing away of the base material from below by water.

Ungauged -- (see *Gauged*)

Un-Numbered A Zones -- A zone on a Flood Insurance Rate Map that delineates in an approximate fashion the 100-year floodplain without precise engineering information showing detailed water surface elevation and floodplain boundary information.

U.S.G.S. Flood-Prone Area Maps -- Maps prepared by the U.S. Geological Survey on topographic quadrangle map bases showing areas of potential flood hazard as determined through approximate methods.

Vertical Datum -- An assumed elevation used as a reference in surveying or mapping and expressed in feet above Mean Sea Level.

Water Surface Elevation -- The heights, usually in relation to Mean Sea Level, reached by flows of various frequencies and magnitudes at pertinent points in the floodplain.