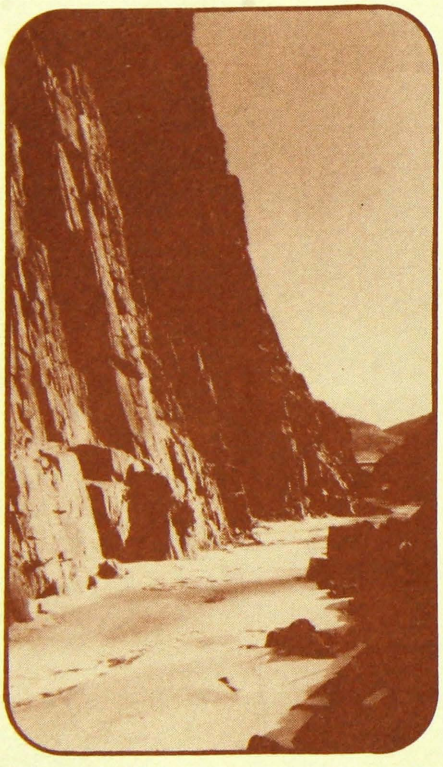
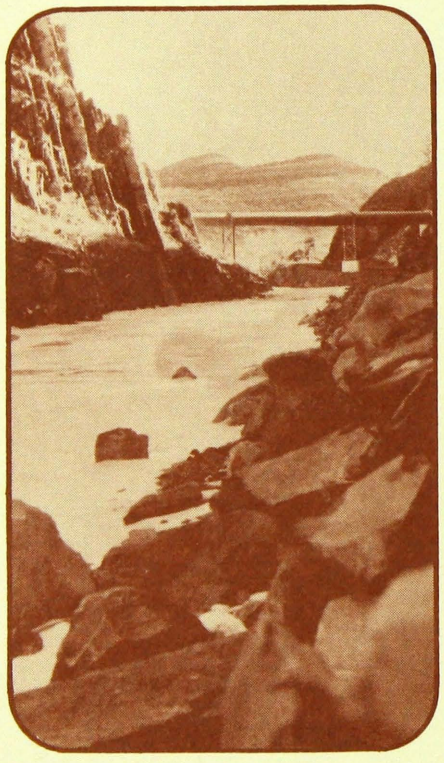
big thompson disaster recovery planning report





toups corporation

VOLUME 1

BIG THOMPSON DISASTER RECOVERY
PLANNING REPORT
(PHASE A)

May, 1977

PREPARED FOR:

Larimer-Weld Regional Council of Governments
201 East Fourth Street
Loveland, Colorado 80537
(303) 667-3288

AND

Big Thompson Recovery Planning Office
201 East Fourth Street
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PREPARED BY:

Toups Corporation
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The preparation of this report was financed in part through an urban planning grant from the Department of Housing and Urban Development, under provisions of Section 701 of the Housing Act of 1954, as amended.

toups corporation

May 10, 1977

Big Thompson Recovery Planning Office
201 East Fourth Street
Loveland, Colorado 80537

ATTN: Mr. Willard Quirk
Flood Recovery Coordinator

Dear Willard:

In accordance with our contract with the Larimer-Weld Regional Council of Governments, Toups Corporation is pleased to submit this report entitled "Big Thompson Disaster Recovery Planning Report - Phase A". The report presents the results of our data collection and mapping efforts conducted during the first phase of the Big Thompson Disaster Recovery Planning Program.

Volume I of the report is divided into five chapters as follows:

Chapter I	-	Introduction
Chapter II	-	Goals and Objectives
Chapter III	-	The Flood
Chapter IV	-	Environmental Characteristics
Chapter V	-	Environmental Impact of the Flood

Volume II includes the maps and figures supporting the documentation presented in Volume I.

The report includes a summary of the planning process, preliminary goals and objectives for the Big Thompson Recovery Planning Program, and a description of the July 31, 1976 Big Thompson River flood. The social, economic, and environmental consequences of the flood and the characteristics of the project area necessary to prepare a comprehensive land use plan are also discussed.

We wish to acknowledge the assistance and consideration demonstrated by all persons and organizations who contributed to the preparation of this report. Should any questions arise regarding the content of this report, we would be pleased to discuss them at your convenience.

Very truly yours,

TOUPS CORPORATION

Curt Smith

Curt Smith
Project Manager

CS/bt

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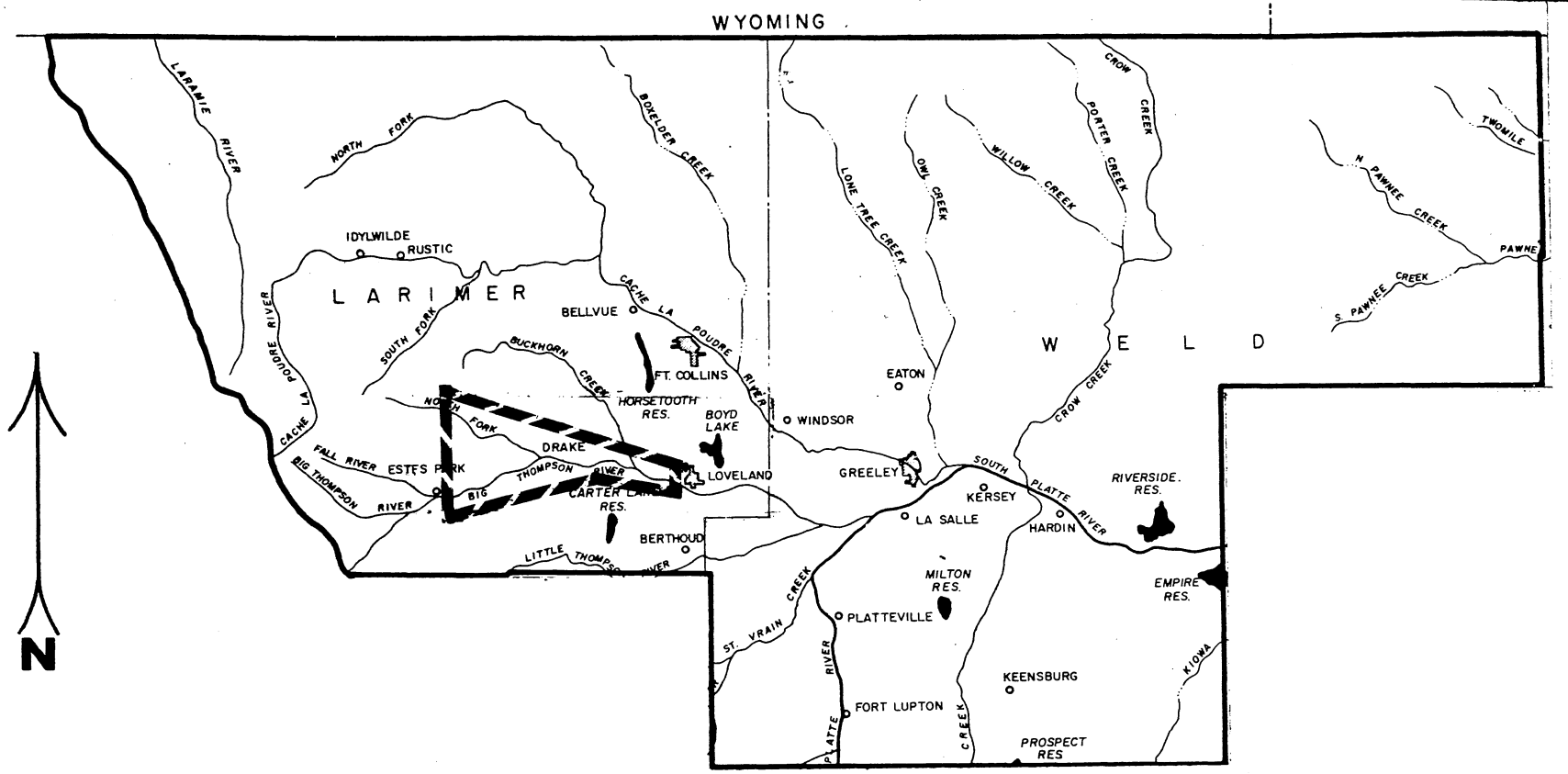
CHAPTER I

INTRODUCTION

On the evening of July 31, 1976, and the morning of August 1, 1976, one of the worst disasters in the history of the state of Colorado occurred along the Big Thompson River between the towns of Loveland and Estes Park in Larimer County (Map 1). Two to four inches of rain per hour fell on the drainage basins of the main channel and North Fork of the Big Thompson River between 6:30 p.m. and 10:30 p.m. during the night of July 31, 1976. In some areas, as much as twelve inches of rain fell during this four hour period, an amount nearly equal to the normal average annual rainfall for the area. The torrential rains resulted in a devastating flood destroying life and property throughout the Big Thompson Canyon area. Disaster relief and recovery efforts commenced on August 1, 1976, and will not be completed for several years.

The purpose of this report is to document the results of the first phase of the comprehensive recovery planning program undertaken subsequent to the flood. The objective of the program is to develop a comprehensive plan to guide redevelopment of the flood impacted area. The comprehensive planning program is jointly funded by Larimer County and the United States Department of Housing and Urban Development (HUD) through a comprehensive planning grant under the provisions of Section 701 of the Housing Act of 1954, as amended. Included in this report is a statement of the goals



regional map 1

SOURCE: LWRCOG, 1976

and objectives for the Big Thompson Comprehensive Planning Program and a discussion of how these goals and objectives relate to the Larimer County goals and objectives for county-wide comprehensive planning. This discussion is followed by documentation of the characteristics of the Big Thompson Canyon area prior to and subsequent to the flood disaster. The final section of the report addresses the social, economic, and physical consequences of the flood.

The purpose of compiling this information has been to build a base for a comprehensive land use planning and implementation program for the project area. Without such a base it is impossible to develop a meaningful plan which is both responsive to the particular characteristics of the area and readily amenable to implementation.

The information presented regarding pre- and post-flood conditions and impacts of the flood is not intended to constitute a detailed environmental inventory or impact assessment of the flood. Investigations have been tailored toward development of information which is critical to the formulation of a land use plan. In addition, information reported herein has been limited by the state of available knowledge at the time of report compilation.

Unfortunately, very little published information is available pertaining to conditions in the canyon prior to the flood, and some of the post-flood information is still in preparation. As new information becomes available during Phase B of this program, it will be incorporated into the data base. This information will include extensive input from canyon residents pertaining to the use and location of structures destroyed by the flood as well as of structures still standing and the social and economic characteristics of the residents.

SUMMARY OF THE PLANNING PROCESS

As indicated above and discussed in greater detail in Chapter V, the Big Thompson flood caused significant destruction of property and loss of life. To a certain extent, the magnitude of this devastation can be attributed to an absence of planning as the canyon area was developed. Planning obviously cannot prevent floods such as that which occurred on July 31, 1976. However, through effective planning much can be accomplished to reduce the tragedy associated with such a flood in terms of property damage and loss of life.

INITIAL PLANNING

The Big Thompson Recovery Planning Office (BTRPO) has been vested with the responsibility for preparing a comprehensive redevelopment plan for the Big Thompson Canyon. Subsequent to a resolution passed by the Big Thompson Recovery Planning Council on September 14, 1976, the BTRPO established a task force comprising representatives of the U.S. Forest Service, National Park Service, Bureau of Outdoor Recreation, Colorado Division of Wildlife, Colorado Division of Parks and Outdoor Recreation, Colorado Highway Department and Larimer County. This task force developed a variety of recreational alternatives for the Big Thompson Canyon that were intended to lead to a more detailed, long range redevelopment planning effort.

COMPREHENSIVE REDEVELOPMENT PLANNING

In November, 1976, the Larimer-Weld Regional Council of Governments (COG) and the BTRPO applied for and received a "701" comprehensive planning grant from HUD. The Grant

provides $187,667 in Federal funds and $93,833 in local matching funds to develop a comprehensive plan for the flood impacted area. Subsequent to award of the contract, Toups Corporation of Loveland, Colorado, was contracted to develop the comprehensive recovery plan. The planning process was initiated in January, 1977.

The comprehensive plan will guide redevelopment efforts in the flood impacted area. This will be accomplished by identifying suitable land uses in the canyon on a parcel by parcel basis as determined by natural constraints such as geologic hazards and legal constraints such as the flood plain zoning regulations. Numerous other critical determinants will be explored including public input from canyon residents obtained through an extensive public participation program. It is anticipated that the comprehensive plan for the flood impacted area will become part of the Larimer County Comprehensive Plan.

Figure 2 portrays the Program Schedule for the long range comprehensive planning effort. Included in the program schedule is the planning process, a time schedule, and designation of the method by which public input and review will be incorporated into the program. The program has been divided into two phases, Phase A and Phase B, to allow flexibility in defining Phase B through response to the needs of the BTRPO and Larimer County.

In the definition of the program, the planning (flood impacted area) boundary was identified. The primary planning area includes the area within the Big Thompson Canyon between Olympus Dam and the canyon mouth, the area within the North Fork canyon between Glen Haven and the confluence of the North Fork with the Big Thompson River, and the flood impacted area between the mouth of the canyon and an area just north of Boedecker Lake.

The long range of comprehensive redevelopment planning effort is being conducted at a canyon-wide (study area) scale, and at an individual community scale. The canyon-wide planning will provide an overview as to how the redevelopment within the individual communities will be coordinated. To facilitate redevelopment planning for the individual communities, the study area was divided into ten communities as demarcated on Map 3. It was determined that detailed planning will be necessary for seven of these ten areas based upon the level of development within the areas. The communities shaded on Map 3 are designated for detailed planning, including: Glen Haven, Loveland Heights/Glen Comfort, Waltonia, Drake/Midway, Cedar Cove, Sylvan Dale, and Big Thompson Canyon East. The information compiled and mapped during Phase A has been detailed and portrayed at a community scale for these seven communities in addition to its portrayal on the canyon-wide scale.

The information that has been compiled during Phase A includes: the limit of the flood; the number of structures removed as a result of the flood; the impact of the flood upon circulation systems; geologic events that occurred during the flood; the number of people that were killed or dislocated by the flood; the revenues lost by local businesses as a result of the flood; the delineation of the floodway and flood fringe areas as defined by the Federal Insurance Administration studies; topographic characteristics; geologic hazard areas; land use patterns; ownership patterns; existing and proposed circulation systems; vegetation distribution; and significant wildlife habitat areas.

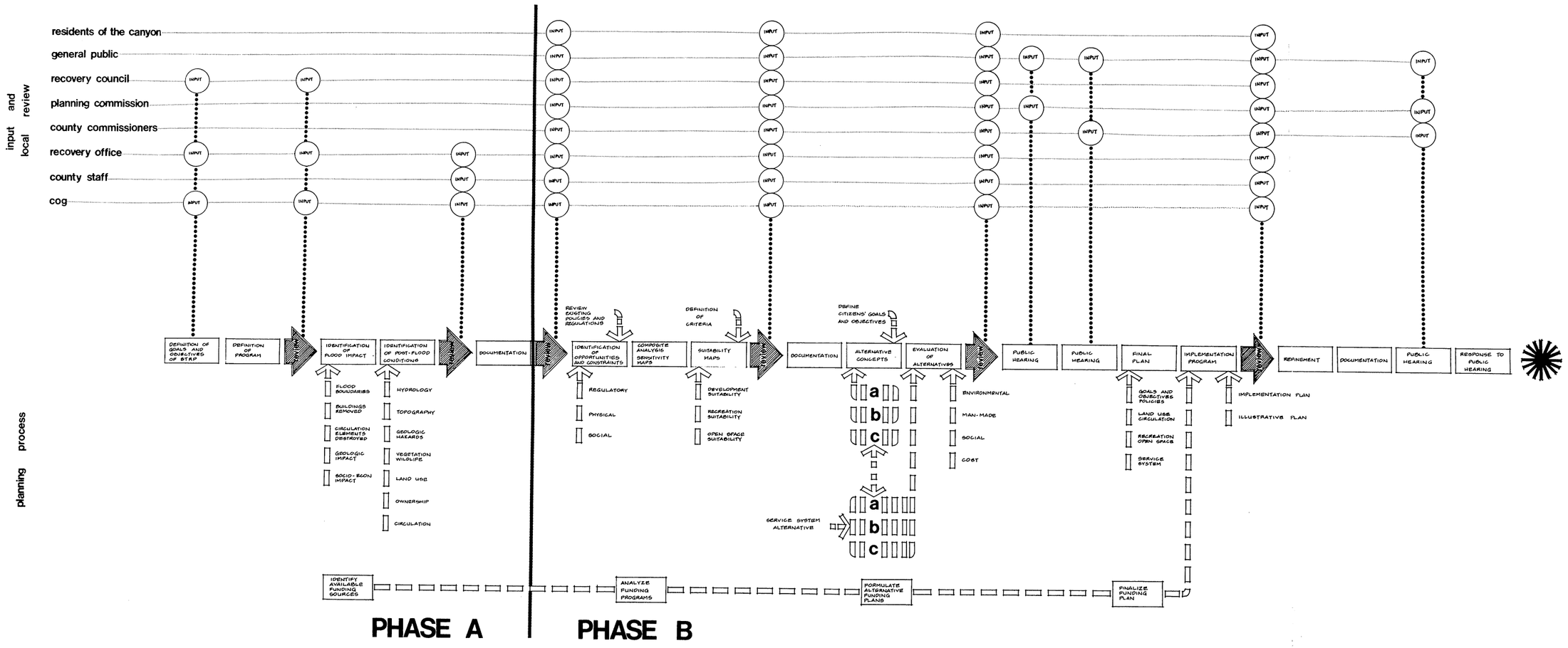


figure 2

PROGRAM SCHEDULE

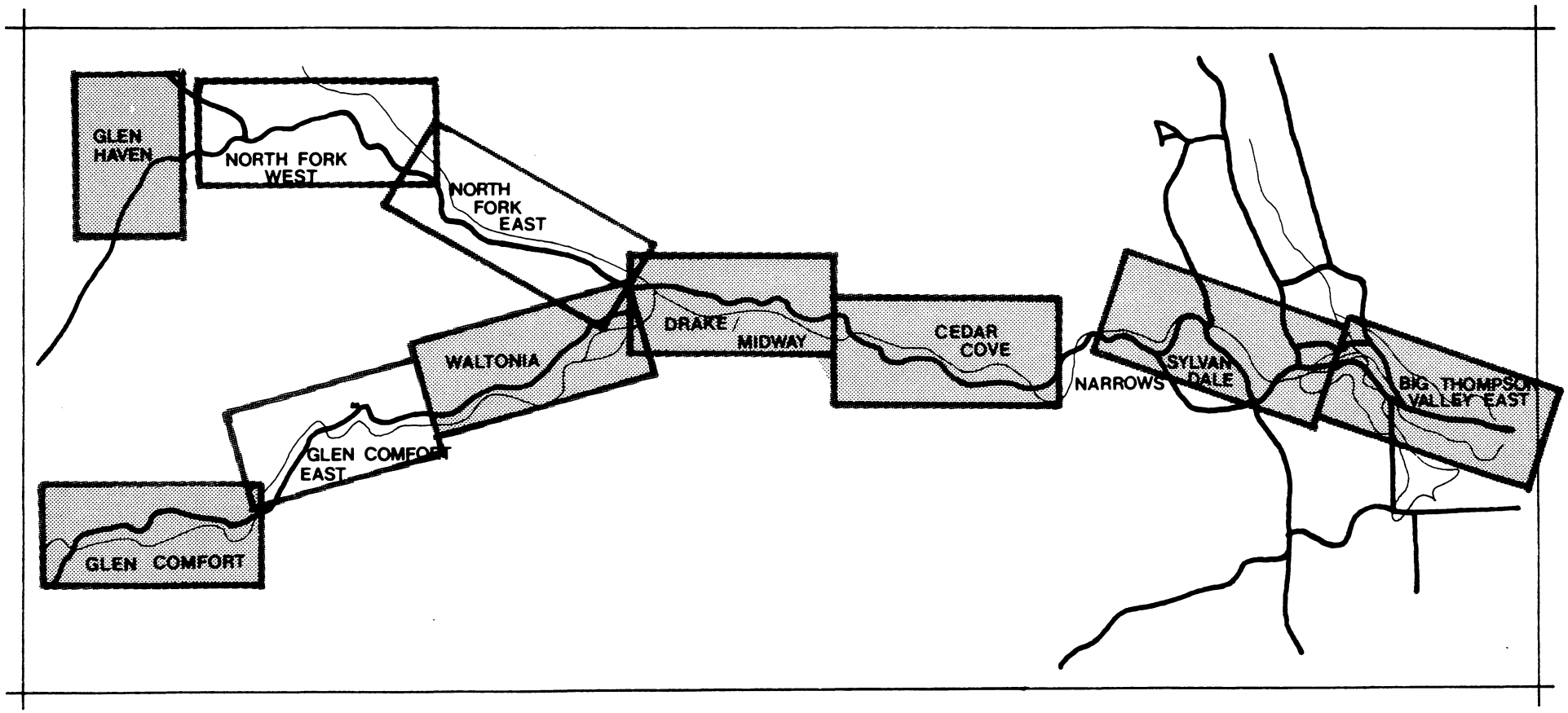
BIG THOMPSON DISASTER RECOVERY PLANNING PROGRAM

The preparation of this report, map, document, etc., was financed in part through an urban planning grant from the Department of Housing and Urban Development, under the provisions of Section 701 of the Housing Act of 1954, as amended.

prepared for:
larimer/weld regional council of governments, colorado

prepared by:
toups corporation loveland, colorado

BIG THOMPSON
PLANNING COMMUNITIES



location map 3

A detailed scope of services is presently in preparation for Phase B. This scope will respond to the results of the work completed during Phase A, the needs and desires of canyon residents, and the needs of Larimer County and the BTRPO. It is anticipated that Phase B will generally follow the planning process as outlined in Figure 2 and will result in a final product comprising a plan for the entire study area and for each of the ten planning communities.

The canyon-wide plan will portray general land use categories for the study area and the relationship between these land uses. The canyon-wide plan will designate proposed land uses including residential, commercial, recreational and open space uses, and circulation patterns to support the land uses. The basis for this plan will be a series of overall goals and objectives.

The community plans will be designed to provide the Larimer County Planning Commission and the Board of Commissioners with guidelines for land use decisions within each of the communities on a parcel by parcel basis. Each community plan will include a land use plan, and a zoning and implementation plan. The zoning and implementation plan will identify and key individual parcels of land to programs necessary for implementation of the plan. Each parcel of land will be designated according to the proposed zoning classification that should be applied to it. In addition, those parcels of land that could be acquired or receive assistance through a particular funding program, such as the Bureau of Outdoor Recreation land acquisition funding program that is presently being processed, would be keyed to the appropriate program. Where more than one program was applicable to a parcel of land, this would also be reflected. The land use plan will be based on individual community

goals and objectives and will designate proposed land uses for the entire community including residential, commercial, active recreation, and open space areas. Where appropriate, residential and commercial land uses will be designated according to permanent or seasonal uses. The circulation system and water and sewer facilities necessary to accommodate the proposed land uses will also be included in the land use plan.

The process suggested in Figure 2 for development of the above described final products is presently under review by the BTRPO and Larimer County. The finalized process for implementation of Phase B will reflect any changes suggested by these agencies. As presently outlined, the process includes identifying the environmental, man-made, and social opportunities and constraints for redevelopment within each of the communities. This information will be utilized to develop a series of maps designating areas that could accommodate residential and commercial development and areas that would be best used for recreational and open space uses. These maps will be prepared for the entire study area and for each of the individual planning communities. Based upon the above-mentioned maps, alternative canyon-wide and community land use plans will be formulated. These alternatives will then be evaluated in terms of their environmental, man-made, social, and economic consequences. Subsequent to documentation of the alternatives and their consequences, the alternative plans will be reviewed by canyon residents, the Larimer County Planning Commission and County Commissioners in public hearings.

PUBLIC PARTICIPATION

An extensive public participation program has been incorporated into the process suggested by Figure 2. Study area residents will be involved in developing the opportunities and constraints for redevelopment and will participate in developing the canyon-wide and community land use alternatives. The general public will be involved with the process during review stages of Phase A, and subsequent to the completion of the suitability maps and the completion of the alternative and final plans. Other public agencies that will be involved with the process as indicated in Figure 2 include: the Big Thompson Recovery Council, the Larimer County Planning Commission, the Larimer County Board of Commissioners, the Big Thompson Recovery Planning Office, Larimer County staff, and the Larimer-Weld Regional Council of Governments.

CHAPTER II

GOALS AND OBJECTIVES

The comprehensive plan for the Big Thompson Canyon, including the canyon-wide plan and the plans for the planning communities, will become part of the Larimer County Comprehensive Plan upon adoption. Consequently, it is imperative that the goals and objectives for the Big Thompson Comprehensive Plan are consistent with the goals and objectives for the Larimer County Comprehensive Plan, as adopted on November 13, 1974, by the Larimer County Planning Commission and on December 5, 1974, by the Larimer County Board of Commissioners [Larimer County, 1974]. Goals are defined as "statements of ideal conditions which are theoretically attainable, which provide principles for the development of processes." An objective is defined as "an end of action, a point to be reached. It is capable of both attainment and measurement. Objectives are successive levels of achievement in the movement towards a goal." [Larimer County, 1974].

The goals adopted by Larimer County that have been determined relevant to recovery planning for the Big Thompson Canyon area are included below. These goals are extracted directly from the goals and objectives for Larimer County Comprehensive Plan [Larimer County, 1974].

The objectives following each goal should be considered preliminary. They have not been reviewed by the residents of the canyon or adopted by any official government agency. These goals and objectives will be reviewed with the residents of the canyon during Phase B and revised as necessary. Objectives for canyon redevelopment will be adopted by the Larimer County Planning Commission in their revised form as part of the Big Thompson Comprehensive Plan. Goals and objectives, as finally adopted, will guide canyon redevelopment planning.

GOAL: "All new development should be located in areas suitable for such development in terms of the environment, economic feasibility of providing daily necessities, availability of and efficiency of support systems, aesthetics, community identity, natural resources, public health, safety and welfare, character of existing development in the area, and overall plan for the area."

OBJECTIVE: The Big Thompson Comprehensive Plan should establish policies, standards, and regulations that are specifically applicable to the canyon.

OBJECTIVE: Land use patterns in the canyon should be designed to promote community identity.

OBJECTIVE: The plan should designate land use type, location, and intensity based upon environmental considerations.

OBJECTIVE: Commercial activities should generally be confined to prescribed areas.

OBJECTIVE: Existing residential areas in the canyon should be preserved.

GOAL: "Development in the mountains must be harmonious with the natural patterns and suitabilities of the land, must minimize damage and encroachment upon ecosystem sensitivities, and must be compatible with socio-cultural and economic characteristics."

OBJECTIVE: Mountain development should utilize the node concept in order to preserve the natural amenities and minimize the negative impact upon natural, socio-cultural and economic characteristics.

OBJECTIVE: Regulation of construction practices in the mountains should minimize negative impacts upon the land and natural resources.

GOAL: "Development in the mountains should be located and designed to reduce the impact of support systems (roads, utility lines, telephone lines, water and sewer pipelines, etc.) associated with urban development."

OBJECTIVE: Redevelopment and/or new development in the canyon should be limited so as not to require services beyond the capabilities of available support systems, or feasible expansions thereof.

GOAL: "A clean water supply must be maintained for mountain residents and subsequent downstream users."

OBJECTIVE: Community water supply systems should be encouraged for mountain development.

OBJECTIVE: Sewage in mountain areas must be managed in a manner which is most protective of existing land, health, and water resources.

OBJECTIVE: Developments should be encouraged to have an organized entity coordinating sewage management.

GOAL: "Population growth or change in land use should not degrade natural or scenic beauty, wildlife or wildlife habitat, or other natural resources of the mountain area."

OBJECTIVE: Extension of service systems to support new development should be constrained by environmental considerations.

GOAL: "New development should pay its own way."

OBJECTIVE: Redevelopment assistance grants for public services and facilities in the canyon should be limited to rebuilding facilities destroyed or damaged by the flood. Expenses involved in the extension of new facilities to provide services to a new development should be borne by the proponent of the new development.

GOAL: "Attempts to provide low-cost housing should receive favorable consideration from local officials and administrators, insofar as they do not negate accepted land use concepts."

OBJECTIVE: Development of low-cost housing areas in the canyon should be considered so that opportunities would exist for relocation within the canyon of all residents displaced by the flood.

GOAL: "Transportation systems should be planned, designed, classified, and managed to protect the health, welfare and safety of their users; to preserve and maintain air quality; to minimize noise pollution; to enhance ease and efficiency of travel; to be aesthetically pleasing; and to comply with the land use and environmental elements of this plan.

OBJECTIVE: Development of access points to U.S. Highway 34 through the canyon from individual properties should be coordinated to minimize the number of intersections and promote safety for all highway users.

OBJECTIVE: U.S. Highway 34 should be designated a scenic highway and provisions along the highway should be made for scenic lookouts and parking turnouts.

GOAL: "Emergency protection facilities should be organized and distributed to render aid quickly."

OBJECTIVE: Redevelopment and new development in the canyon should be compatible with the capability of providing emergency services.

OBJECTIVE: An emergency flood warning system should be developed throughout the canyon.

GOAL: "As growth and development takes place, all natural resources of Larimer County must be conserved and maintained wisely."

OBJECTIVE: The plan should identify and preserve significant and unique natural areas within the canyon.

GOAL: "The type, design, and location of potential land uses should be compatible with ecosystem sensitivities."

OBJECTIVE: Architectural guidelines and standards should be established to protect the visual characteristics of the canyon.

OBJECTIVE: Redevelopment and new development in the canyon should be restricted in natural hazard areas, including geologic hazard areas and the floodway.

GOAL: "Major recreational development in mountain areas should be located and designed to minimize impacts upon existing land use and transportation patterns, natural resources, valuable aesthetic conditions, and upon the quality of life in existing residential areas."

OBJECTIVE: The areas designated as floodways in the canyon should be acquired for utilization as public recreational areas.

OBJECTIVE: A system of bicycling, hiking, and equestrian trails should be developed for the canyon, linking existing and proposed recreation areas.

GOAL: "The existing diversified economic base of the county should be preserved and where possible, expanded, commensurate with the goals of this plan."

OBJECTIVE: New development in the canyon should be evaluated as to the costs and benefits to the county.

OBJECTIVE: New development in the canyon that is advantageous to the economic base of the county should be encouraged.

CHAPTER III

THE FLOOD

The following discussion of the Big Thompson River flood of July 31, 1976, is based upon information provided in the following documents: USCE [1976]; USGS/CWCB [1976]; GAI [1976]; and Judkins [1976]. This discussion combines and summarizes the pertinent information from each of these documents.

The Big Thompson Canyon flood of July 31, 1976, was the most deadly flood that has occurred in the United States since the Rapid City, South Dakota flood of 1972. Immediately prior to the flood the weather forecast for the area called for widely scattered showers. However, by 7:30 p.m. a thunderstorm system over 60,000 feet in height was stalled over the portion of the canyon between Drake and Estes Park. Drake is located approximately 12.5 miles downstream from Estes Park. Another intense thunderstorm was concentrated above the Glen Haven area, located approximately 6.5 miles northeast of Estes Park on the North Fork of the Big Thompson. Between 6:00 p.m. and 8:00 p.m. heavy rainfall had brought traffic to a standstill and deposited debris across U.S. Highway 34.

At about 7:30 p.m., the first section of U.S. Highway 34 was washed out at a locality 7.5 miles east of Estes Park. The Big Thompson River, normally a controlled flow river, was quickly converted into a raging torrent of water, trees, debris, and boulders between Estes Park and Drake. The

water and debris moved downstream at tremendous pace with devastating force. Debris accumulated against bridges that provided access to residences and businesses across the river from the highway. The debris buildup created dams which quickly caused inundation of areas on both sides of the river.

As river flows increased, the bridges gave way releasing floodwaters in waves and creating repeated rushes of water which swept boulders, vehicles, houses, foundations, and surface soils completely away and left the ruins strewn along the downstream reaches. Ironically, rainfall in the lower end of the canyon, east of Drake, was very light. However, as floodwaters from the upper Big Thompson Canyon and the North Fork raged down the canyon, structures and major portions of U.S. Highway 34 were washed away.

Early in the evening portions of U.S. Highway 34 in the "Narrows", that portion of the canyon between Cedar Cove and the canyon mouth, were washed away. This situation, combined with road washouts upstream, created a death trap for people traveling through or staying overnight in the canyon. People were told to leave the area or find higher ground, but many ignored the warning. They felt they could safely remain in their familiar surroundings and survive any flood since they had survived previous high water situations. Many who tried to outguess the devastating potential of the river were swept away and died either from drowning or battering against rocks and boulders in the river bed.

The floodwaters flowed unchecked for nearly five hours. The reported peak stages on the Big Thompson River occurred as follows: 8:00 p.m. at Glen Comfort; 8:30 p.m. at Waltonia; 9:00 p.m. at Drake; 9:30 p.m. at the Loveland power plant; and almost 11:00 p.m. at the mouth of the canyon about 8 miles west of Loveland. Since the river remained extremely high from the first peak stage until after midnight, it is apparent that several periods of intense rainfall produced secondary rises in the canyon area. In the North Fork, heavy rainfall began about 7:30 p.m. The first peak stage was reached at about 9:00 p.m. at Glen Haven. Another rise almost as high as the first occurred at about 11:00 p.m. north of Glen Haven. The relative timing of the peak stages was such that the peak on the Big Thompson River just downstream from Drake occurred before the peak from the North Fork arrived at Drake. Consequently, the flood peak moved through the 7.3 mile length of channel between Drake and the canyon mouth for more than two hours with no apparent reduction in discharge.

East of the canyon mouth the Big Thompson River valley widens rapidly and the flood discharge was quickly reduced by valley storage and overflow to reservoirs. The peak discharge at the confluence of the Big Thompson and South Platte Rivers was about 2500 cubic feet per second (cfs) occurring around 12:00 midnight on August 1, as compared to 31,200 cfs at the mouth of the canyon. Table 1 indicates the peak discharges associated with the flood at 33 locations along the Big Thompson River, the North Fork, and other rivers in the immediate vicinity that experienced flooding.

TABLE 1. BIG THOMPSON RIVER, COLORADO - FLOOD OF JULY 31-AUGUST 1, 1976 [a]

(Preliminary Data - Subject to Revision)

Site No.	Station Number	Station Name	Drainage Area (sq.mi.)	Date	Discharge c.f.s.
1	06735500	Big Thompson River near Estes Park (lat 40°22'35", long 105°29'06")	155	7-31-76	(1/)
2	--------	Dry Gulch near Estes Park (lat 40°24'22", long 105°28'37")	2.00	7-31-76	3,210
3	--------	Dry Gulch at Estes Park (lat 40°22'42", long 105°29'15")	6.12	7-31-76	4,460
4	--------	Big Thompson River below Estes Park (lat 40°22'59", long 105°28'11")	164	7-31-76	4,330
5	---------	Big Thompson Tributary below Loveland Heights (lat 40°23'44", long 105°27'34")	1.37	7-31-76	8,700
6	---------	Dark Gulch at Glen Comfort (lat 40°23'44", long 105°26'17")	1.00	7-31-76	7,210
7	---------	Noels Draw at Glen Comfort (lat 40°23'25", long 105°26'00")	3.37	7-31-76	6,910
8	---------	Rabbit Gulch near Drake (lat 40°24'23", long 105°24'17")	3.41	7-31-76	3,540
9	---------	Long Gulch near Drake (lat 40°23'46", long 105°24'04")	1.99	7-31-76	5,500
10	---------	Big Thompson River above Drake (lat 40°25'39", long 105°20'37")	189	7-31-76	28,200
11	---------	North Fork Big Thompson River at Glen Haven (lat 40°27'17", long 105"27'05")	18.5	7-31-76	888

TABLE 1. BIG THOMPSON RIVER, COLORADO - FLOOD OF JULY 31-AUGUST 1, 1976

(Preliminary Data - Subject to Revision) (Cont.)

Site No.	Station Number	Station Name	Drainage Area (sq.mi.)	Date	Discharge c.f.s.
12	--------	Fox Creek at Glen Haven (lat 40°27'17", long 105°27'13")	7.18	7-31-76	1,300
13	--------	Devils Gulch near Glen Haven (lat 40°26'24", long 105°27'31")	.91	7-31-76	2,810
14	--------	West Creek near Glen Haven (lat 40°26'32", long 105°27'40")	23.1	7-31-76	2,320
15	--------	North Fork Big Thompson Tributary near Glen Haven (lat 40"27'14", long 105"26'04")	1.38	7-31-76	9,670
16	--------	Black Creek near Glen Haven (lat 40"27'04", long 105"25'28")	3.17	7-31-76	1,790
17	--------	Miller Fork near Glen Haven (lat 40°27'47", long 105°25'13")	13.9	7-31-76	2,060
18	--------	North Fork Big Thompson Tributary near Drake (lat 40"26'55", long 105°24'11")	1.26	7-31-76	3,240
19	--------	North Fork Big Thompson River above Drake (lat 40°26'20", long 105°21'52")	80.2	7-31-76	8,710
20	--------	Big Thompson River below Drake (lat 40°25'52", long 105°19'37")	276	7-31-76	30,100
21	06738000	Big Thompson River at mouth of canyon, near Drake (lat 40°25'18", long 105°13'34")	*305	7-31-76	31,200
22	--------	Big Thompson River below Green Ridge Glade (lat 40°25'05", long 105°12'02")	311	7-31-76	27,000

TABLE 1. BIG THOMPSON RIVER, COLORADO - FLOOD OF JULY 31-AUGUST 1, 1976
(Preliminary Data - Subject to Revision) (Cont.)

Site No.	Station Number	Station Name	Drainage Area (sq.mi.)	Date	Discharge c.f.s.
23	--------	Redstone Creek near Masonville (lat 40°30'19", long 105°11'49")	29.1	7-31-76	2,640
24	--------	Little Thompson River near Estes Park (lat 40°20'06", long 105°25'48")	2.77	7-31-76	1,940
25	06744000	Big Thompson River at mouth, near LaSalle (lat 40"21'00", long 104"47'04")	828	8- 1-76	2,500
26	--------	Dale Creek Tributary at Virginia Dale (lat 40°57'36", long 105°21'39")	.68	7-31-76	727
27	--------	Deadman Creek near Virginia Dale (lat 40°55'50", long 105°20'57")	23.7	7-31-76	7,400
28	--------	Stonewall Creek near Livermore (lat 40°48'37", long 105°15'06")	31.9	7-31-76	3,470
29	--------	Lone Pine Creek near Livermore (lat 40°47'44", long 105°17'24")	86.3	7-31-76	2,590
30	--------	North Fork Cache la Poudre River at Livermore (lat 40°47'15", long 105°15'03")	539	7-31-76	9,460
31	06752000	Cache la Poudre River at mouth of canyon, near Fort Collins (lat 40°39'52", long 105°13'26")	1,056	7-31-76	7,340
32	--------	Rist Canyon near Bellevue (lat 40"37'43", long 105°12'44")	5.27	7-31-76	2,710
33	06752260	Cache la Poudre River at Fort Collins (lat 40°35'17", long 105°04'08")	1,129	7-31-76	5,700

* Revised
1/ No flow out of Lake Estes
[a] USGS/CWCB, 1976

The meteorological conditions that caused the July 31, 1976 flood included: an abundant supply of moisture in the atmosphere, a strong means of forcing that moisture upward, and a relatively intense but stationary cloud system to process the moisture into rain. Although these conditions are rarely present in concert along the Front Range of the Rocky Mountains, they were all present on the night of July 31, 1976. According to the National Weather Service:

> "Eastern Colorado was under conditions favorable for heavy rain on July 31 1976. for a number of reasons. The surface map of that morning showed a slowly moving cold front in the state. Such fronts are lines of convergence that lift air to form thunderstorms. Also favorable was the east wind just north of the front, moving air upslope and aiding the frontal lifting.
>
> "The low-level air was very moist, well above the seasonal normals, and the moisture aloft was also unusually high. These factors combined to give stability conditions unusually favorable for thunderstorms.
>
> "That these are valid conditions for thunderstorms was soon borne out by radar and satellite data when a line of thunderstorms developed in extreme east-central Colorado and quickly extended eastward paralleling and just north of the cold front. The thunderstorms extended westward less rapidly until early in the evening when a sudden explosive thunderstorm developed on or just west of the front range of the mountains southeast of Estes Park. The cause of such a strong development at this place and this time is not yet fully understood.

"Thunderstorms move with the speed and direction of the winds aloft, and the 500-mb (millibar) level is usually adequate for judging such movement. The 500-mb wind was only about 5 knots and was not expected to change much during the day. This was the case with the thunderstorms near Estes Park. They moved very slowly while putting out large amounts of water over a period of several hours."

CHAPTER IV

ENVIRONMENTAL CHARACTERISTICS

The purpose of this chapter is to provide a description of environmental, social, and economic characteristics of the Big Thompson planning area. As explained earlier, this discussion is limited to those factors considered to be significant towards preparation of a comprehensive plan for the study area. The information included is not intended to represent an exhaustive environmental inventory of the study area and is based primarily upon existing studies and reports.

A detailed land use inventory of the study area was completed subsequent to the July 31, 1976 flood. To complete this inventory, Toups Corporation surveyed the study area and identified the use of the structures within the study area. Information compiled during this survey was also used to update the base maps for the seven planning communities by designating structures that were not originally portrayed on the base maps. Additional data was collected to identify the age and income characteristics of the area residents. During Phase B of this project, the canyon residents will be interviewed and the information gathered during these interviews will be utilized to improve the data base documented in this chapter.

The Big Thompson flood significantly changed some of the characteristics of the study area. In light of this fact, the present chapter is divided into sections describing

pre-flood and post-flood conditions. Pre-flood conditions are presented in summary form since only limited information exists describing conditions in the study area prior to the flood. Post-flood conditions are discussed in greater detail according to the level of information available or developed during Phase A.

Where appropriate available information permits, existing post-flood conditions are described both in canyon-wide terms and on an individual community basis for each of the seven communities designated for detailed planning. Community descriptions appear in the final section of this chapter. To supplement the textual information presented in this chapter, a series of data maps have been prepared portraying selected information on a canyon-wide scale and a community scale for each of the seven planning communities. The maps are included in this report to confer an accurate understanding of the conditions that exist within the study area. In some cases, as noted, the coverage of the mapped information has been necessarily limited to that portion of the study area west of the canyon mouth due to the absence of information for the communities east of the Narrows; Sylvan Dale and Big Thompson Valley East.

GENERAL PRE-FLOOD STUDY AREA DESCRIPTION

The Big Thompson Canyon area serves as a gateway to Rocky Mountain National Park, one of the most heavily used national parks in the United States. Consequently, thousands of people from all over the United States drive through the Big Thompson Canyon every year. The scenic characteristics of the canyon, including steep canyon walls contrasting with broad valleys, provide the traveler with experiences found in few other places. Colorado Division

of Highway statistics reflect average daily traffic (ADT) figures through Big Thompson Canyon of 2,390 cars throughout the year, with a peak ADT of 8,326 during June, July, and August.

The Big Thompson River was one of the most heavily fished rivers in the state of Colorado. This was partially due to the number of people that drove through the canyon on their way to Rocky Mountain National Park, but was also due to the quality of the Big Thompson River as a fishery. The meandering river intermixed with rapids and pools provided excellent fishing opportunities as well as breeding grounds.

As an integral part of the Colorado-Big Thompson Project, the Big Thompson River is also an extremely important water resource for the Larimer and Weld region. The Project provides much of the water used to irrigate the highly productive agricultural lands of the area and partially satisfies the municipal water needs for the major cities in Larimer and Weld Counties. The relationship of the Big Thompson River to the Colorado-Big Thompson water project is discussed in greater detail in the following section.

The Big Thompson Canyon also has served as a home and summer retreat for people seeking a quiet and peaceful alternative to the urban lifestyle. Many of the people that live on a permanent basis in the Big Thompson Canyon built their homes thirty to fifty years ago as mountain cabins and have since retired and now live in them as permanent residents. In spite of the increasing mobility of people throughout the country, the permanent residents of the Big Thompson Canyon are very stable.

Although there are no detailed surveys upon which to base the characteristics of the canyon, it is estimated that the average age of the canyon residents is over 50 and the average annual income is approximately $9,000 [BTRPO & Inter-Faith, 1977]. Both of these characteristics point to the retirement nature of the Big Thompson Canyon as a permanent residential community. The canyon supported a very active recreational second home community. Based on tax roles it has been estimated that 28 percent of the homes in the study area were owned by permanent residents. The remaining homes were owned by people who maintained permanent residences in other areas; 18 percent in Larimer County, 31 percent in other parts of Colorado, and 19 percent in the rest of the United States. [Wright-McLaughlin, 1976].

POST-FLOOD STUDY AREA DESCRIPTION

As defined in Chapter I, the primary study area for the Big Thompson comprehensive planning process encompasses the land within the main canyon, the land within the canyon along the North Fork, and the area along the Big Thompson River east of the canyon mouth that was impacted by the flood. The preponderance of data collected and portrayed on the canyon-wide scale is limited to this study area. Where information is available for the lands outside of the defined study area, it has been portrayed on the canyon-wide data maps. As explained earlier, the purpose of portraying information at the canyon-wide scale is to indicate the relationships between different areas of the canyon and to supply an overall data base from which to generate conceptual plans for the entire study area.

CLIMATE

The climate of the study area is influenced by its elevation and location on the eastern slope of the Rocky Mountains. The high mountains to the west remove a large portion of the moisture borne by the prevailing westerlies from the Pacific Ocean. Mountains to the east and north provide shelter much of the time from the invasions of cold air from the north. Moist air originating over the Gulf of Mexico supplies a major portion of the precipitation to the area primarily during spring and summer months. These factors combine to produce a climate which is characterized by moderately cold winters and cool summers, a wide daily temperature range, low humidity and precipitation, abundant sunshine and generally light winds.

Temperatures vary greatly in mountainous regions temporally and geographically due to elevational differences, temperature inversion phenomena, and local variations in wind conditions and cloud cover. Generally speaking, minimum temperatures during summer nights in the study area dip below 50° F. with freezing temperatures occurring at least some nights of almost every month. Daily high temperatures during summer rarely exceed 90° F. throughout the study area and average somewhat over 70° F. during June through September. Extreme cold is experienced periodically in the area during winter when cold air from the north pushes into the area over the mountains. These periods are normally of only short duration and soon give way to more typical winter conditions during which daytime temperatures exceed freezing. Winter afternoon temperatures quite commonly exceed 50° F. while mid-winter nighttime temperatures often fall below 20° F.

Published data discloses average annual precipitation figures in or near the study area of approximately 14 [ECCO Corp. 1972] to 16 inches [USCE, 1976] at Estes Park and 12 inches [USCE, 1976] at Loveland. Winter is generally the dry season, while the greatest daily amounts of precipitation normally occur during the months of May and June. Summer precipitation usually occurs in the form of thundershowers which build up in the afternoon over the mountains and move easterly.

Such thunderstorms are seldom severe and normally of short duration in a single area since they pass rather swiftly over the region. A dramatic exception to this norm is the deluge which produced the Big Thompson flood. This storm was unusual both in intensity and length of time remaining over one area. The specific metereological conditions producing this unusually severe storm have been summarized in Chapter III on pages 21 and 22.

Mean monthly snowfall in the study area is less than two feet, producing snow accumulation that only occasionally exceeds one foot and rarely reaches two feet. Snowstorms infrequently develop to an intensity that forces temporary road closures in the area. Maximum annual flood peaks in the Big Thompson River basin are normally produced in late spring by snowmelt runoff from the mountain snowpack.

Prevailing winds in the area are westerly, although these may become locally reoriented to flow with the terrain. Available information indicates that, in general, the mountains afford considerable shelter to the study area from the strong winds common to higher elevations.

However, winds may vary greatly in the area according to local topography such that broad valley floor areas not protected by forest cover may be occasionally subjected to high winds if the valleys are oriented in the direction of the prevailing flow.

TOPOGRAPHY

The Big Thompson River is a western tributary to the South Platte River with headwaters in the Rocky Mountains at the Continental Divide. The river drains through the Front Range of the Rocky Mountains in north-central Colorado flowing in an easterly direction through Big Thompson Canyon enroute to its confluence with the South Platte in the plains. Two major tributaries, Buckhorn Creek and the Little Thompson River, join the main stream downstream of the canyon mouth. Several minor tributaries, among them the North Fork of the Big Thompson and Cedar Creek, feed the main stream as it flows through the canyon. Map 1 depicts the geographic setting of the river basin and delineates that portion of the basin included within the study area addressed by this report.

Basinwide elevations range from approximately 12,500 feet mean sea level (msl) at the headwaters to 4,670 feet at the confluence of the Big Thompson and South Platte Rivers. Study area elevations vary from 7,440 and 7,680 feet msl at the upper extent of Big Thompson Canyon and the North Fork, respectively, to 5,360 feet at the mouth of the canyon and 5,080 feet at the eastern extent of the study area near Loveland. The stream slope of the Big Thompson

River ranges from approximately 220 feet per mile between the headwaters and Lake Estes, to 113 feet per mile between the lake and canyon mouth and 26 feet per mile from the canyon mouth to the South Platte confluence [USCE, 1976].

The Big Thompson Canyon itself is characterized by rugged terrain comprising alternately steep or moderately sloping boulder-strewn slopes, and in some cases a narrow twisting gorge bounded on both sides by extremely sheer cliff walls rising several hundred feet above the canyon floor. The floor of the canyon is alternately constricted and widened, varying in width from a narrow strip accomodating only the river and roadway to relatively broad valleys encompassing a few square miles of gently sloping land.

Above the mouth of the canyon the Big Thompson River drains an approximate total 304 square miles of land, including 83 square miles drained by the North Fork subbasin [GAI, 1976]. Below the mouth of the canyon, the river drains a total area of 828 square miles at the mouth. Table 2 lists the basin drainage areas and stream lengths at various locations within the basin.

TABLE 2

BIG THOMPSON RIVER

DRAINAGE AREAS AND MILEAGES [a]

Location	Drainage Area (sq.mil)	Mileage Above Mouth
Mouth, near LaSalle	828	0
Lower study limit, near Loveland	509	31.3
"The Narrows", mouth of canyon	304	38.1
Below Drake	274	45.5
Above Drake	191	46.2
Lake Estes, near Estes Park	156	58.9
North Fork above Drake	83	0
North Fork, below Glen Haven	51	8.5

[a] GAI, 1976.

GEOLOGY

The study area has undergone a long and complex geological history which is thoroughly documented in Fuller [1924], Cutter [1949], Boos and Boos [1957], and Unites [1973] .

The processes of weathering, erosion, and deposition interacting with the basic materials layed down during its very early geologic history have acted in relatively recent times to shape the area into its present form. These ongoing processes together with geologic composition impose certain geologic constraints upon land use and development in the area.

Weathering and erosion are the primary surface processes which operate to shape land form and they therefore dictate some of the major geologic limitations to land use. The thin, scattered soils which exist in the Big Thompson basin have been formed primarily from the action of mechanical and chemical weathering upon bedrock. On steeper slopes, the soils have been eroded away almost as rapidly as they have been formed. Examination of the area [Unites, 1973] has disclosed that a substantial portion of the study area, perhaps as great as 35 percent, is underlain by bare rock or very thin soil. The only areas possessing relatively thick soils are the broader ridge crests and valleys plus some scattered areas where transported soil occurs on slopes. Areas of thin soil or bedrock present great difficulties to development, requiring such costly excavation operations as drilling, blasting, and removal of broken rock material. Also, uneven distribution of soils limits the suitability of some areas for septic tank wastewater management systems. Soil depth insufficient for tanks or proper accomodation of leach fields renders waste disposal a primary limitation upon density of development in the mountain area.

There are also a number of local problems of a hazardous or limiting nature associated with geologic composition and processes. These include unstable slopes, debris flow hazards, and landslide and rockfall areas. The following section defines these hazards and briefly discusses their influence upon land use planning.

Geological Hazards

The hazardous processes described in this section are the direct and indirect results of downslope movement of water and solid earth materials occurring in response to the forces of gravity and/or running water. Actual hazards to humans prevail only when their activities and structures are situated in hazardous locations without consideration of the dangers, or when the danger is accurately recognized but mitigative measures are inadequate. Some hazards may be of such severity as to render protective measures impractical or prohibitively expensive.

Damages are caused not only by running water, but also by abrasion and impact from moving flood debris, landslides, rockfalls and debris slides from adjacent slopes, and by undercutting by erosion. The geological hazard areas discussed in this section constitute locations particularly susceptible to landslides, rockfalls, and debris slides, while later in Chapter V areas are documented and discussed where these and other hazardous geologic and geomorphic processes were actually activated or accelerated by the Big Thompson flood.

The office of the Colorado Geological Survey (CGS) has recently completed mapping of geological hazards existing in the Big Thompson Canyon area between the mouth of the

canyon and Estes Park, and along the North Fork of the Big Thompson between Drake and Devils Gulch. In addition, geomorphic features resulting from the Big Thompson flood have been mapped concurrently throughout the entire study area. The following discussion presents an explanation of the Big Thompson Canyon area geological hazards as depicted in Maps 4 and 5 and described by Soule, et al., [1977]. Flood-formed geomorphic features discussed in Chapter V are also depicted in the same two maps.

Existing geological hazards in that portion of the study area below the mouth of the canyon are not treated herein since current mapping is unavailable and relatively few hazards occur in this area of generally level topography. For the results of geological mapping of this area conducted prior to the flood, the reader is advised to consult Unites [1973].

Geological hazards described in this report are depicted on a canyon-wide basis (Maps 4 and 5) for general reference and orientation, and on an individual community basis (Maps 11, 16, 21, 26 and 31) to permit future detailed analysis of land use constraints posed by these hazards. Community-specific geological hazards are discussed in the final section of this chapter. Three different, but related, aspects of geologic hazards and hazard areas have been mapped: (1) storm and flood related geologic features; (2) areas of known, House Bill 1041-defined geologic hazards; and (3) additional areas where adverse geologic conditions occur that threaten serious problems for many types of land use, especially residential development, if planning and engineering fail to adequately address the geologic conditions.

Most locations in the Big Thompson Canyon area demonstrating geologic hazards are located adjacent to major streams but outside their flood plains. Moreover, many of these hazard areas are aesthetically attractive and present the apparent advantages of being located outside the boundaries of legal flood plains and on moderate slopes which offer ease of access and relatively low development costs. Such areas have comprised some of the preferred building sites in the past and presumably will continue to experience pressure for both seasonal and year-round recreational/residential development. The foremost objective of the geological hazards study summarized herein is to aid interested parties in understanding the implications of these hazards as they relate to (re)development of the disaster area.

Four general types of geologic hazards have been examined and mapped: (1) debris fans; (2) areas of existing or potential slope instability; (3) potential landslide areas; and (4) potential rockfall areas. A description of each of these categories follows in conjunction with a discussion of how they may affect land use planning.

Debris Fans

Debris fans are triangular-shaped landforms that form by deposition of water-transported rock fragments, soil and vegetation debris at the confluence of tributary streams with a larger trunk stream. Rock fragments may vary in size from sand and silt particles to pebbles to boulders. In the Big Thompson drainage basin, debris fans or vestiges thereof are found at nearly every stream confluence, including those formed by "dry washes". In many places, debris fans have been removed by man and used for fill material or eroded away by main-stream flooding.

Modes of material movement on debris fans generally can be placed in three classes:

1. Major flooding on a tributary stream without major flooding of the main stream results in confinement of material movement and associated damages to the area of the debris fan and possibly the opposite main-stream bank.

2. Major flooding of the main stream with little, if any, flooding of the tributary stream usually results in restriction of damages on the debris fan to that portion of the fan that lies within the main-stream flood plain; erosion by main-stream flooding may partially or completely remove the debris fan.

3. In the case of flooding of both main and tributary streams, material moving across the debris fan may be carried away by main-stream flooding, resulting in partial to complete removal or modification of pre-existing debris fan deposits.

The mapped localities of debris fans (Maps 4 and 5 and Maps 11, 16, 21, 26, and 31) show areas subject to these processes.

Debris fans are moderate to severe hazards for most residential developments. As evidenced by debris fans that were active during recent flood-producing storms, structures situated any place on debris fans whose drainages received the large amounts of rainfall or experienced great rainfall intensities were typically obliterated. In other places, where runoff was less, only those structures located adjacent to stream channels on debris

fans were most apt to receive heavy damages. Thus it appears that the potential for damage to structures on debris fans is less the farther a structure is placed from active drainage channels. As recurrence frequency of major events in these areas subject to debris and water movement is not known, determination of risks for structures placed in these areas is difficult. However, site-specific investigations may indicate that for some land uses, relatively safe sites may exist on some debris fans.

Areas of Slope Instability

Areas of existing or potential slope instability comprise slopes composed of earth materials that are undergoing, or are susceptible to, mass downslope movements. Slope stability is dependent upon composition and thickness of residual soil and loose rock material above bedrock, slope aspect and inclination, vegetative cover, and local seasonal changes in ground moisture. Related hazards within these areas vary in severity from minimal to very great, and generally potential hazard increases with slope steepness.

Types of mass downslope movements include rockfalls, rockslides, landslides, debris slides and debris avalanches, and accelerated creep. Predominantly south-facing slopes are more susceptible to debris avalanches and debris slides, whereas predominantly north-facing slopes commonly experience landsliding. Landslides frequently occur where slopes are undercut by natural erosion or by man-made excavations. Irrespective of slope aspect, rockfall and rockslide areas are typically located adjacent to sparsely vegetated, jointed bedrock cliffs; the lower slopes of these areas consist of rock rubble strewn on steep to very steep slopes. Unstable or potentially unstable slopes are

delineated in a very general fashion on the maps, and while not permitting any precise evaluation, the indication is that most of the steeper slopes in the Big Thompson Canyon area are to some degree susceptible to the above described processes. Arrows in the mapping symbol graphically indicate the general movement of material downslope. The amount of potential movement in each occurrence or series of occurrences is usually difficult to determine.

The wide ranges of severity and variety of geologic hazards in unstable areas are such that in most cases site-specific engineering and engineering-geologic investigations to determine feasibility of development and construction are advisable. Safe low- to moderate-intensity land uses are possible if the potentially hazardous conditions are recognized and seriously considered in site and construction plans. It should be anticipated that portions of these areas will very likely not be amenable to safe and economical development for many types of land uses.

Landslide Areas

Slopes composed of materials highly susceptible to landsliding are indicated on the maps as landslide areas. Landslide areas are differentiated from unstable/ potentially unstable slopes because of local severity and importance of this type of potential hazard for some areas that may be redeveloped following the recent flooding.

Landslides cause severe problems for most construction. Mapped landslide areas are marginally stable at best, and loading of slopes by structures or cutting of slopes in order to construct roads can be expected to cause slope movements. Consequently, these areas should be considered severe hazards and probably should not be developed.

Rockfall Areas

Rockfall areas are locations subject to frequent free-falling and/or rolling and bounding masses of coherent rock or individual, large rock blocks. These areas have been differentiated from unstable/potentially unstable slopes in the mapping for the same reasons indicated above for landslide areas. Rockfall areas are found on and below very steep, nearly barren bedrock cliffs. Jointing, foliation, and weathering characteristics of the bedrock can greatly affect the severity of the hazard.

Mapped rockfall areas include only those for which potential for frequent rock movements is considered so great that potential hazard for most human activities is high. Some relatively small areas of equivalent rockfall hazard and larger areas of lesser hazard are included in areas mapped as unstable or potentially unstable slopes.

Potential hazards in mapped rockfall areas are severe in most places. Because of technical difficulties associated with removing or stabilizing large numbers of potentially mobile rocks, corrective engineering to ensure adequate safety for residents will be, in most cases, prohibitively expensive. In some places, site-specific, detailed evaluation of rockfall potential may indicate that a few appropriately located and engineered structures are feasible.

Distribution of Hazards

Examination of study area geological hazards as depicted on Maps 4 and 5 (recall that mapping does not extend below the canyon mouth) discloses that unstable or potentially unstable slope conditions exist over essentially the entire main canyon area, and into the North Fork about half the distance between Drake and Glen Haven. Potential rockfall areas are distributed throughout the Big Thompson area, with some particularly large areas located between Galuchie Gulch and Miller Creek on the North Fork.

Landslide areas and debris fans also occur throughout the canyon area, reaching their maximum frequency in the Drake area. A total of 176 debris fans are present along the extent of the two forks of the Big Thompson River falling within the study area [Soule, et. al., 1977].

LAND USE

Maps 6 and 7 indicate the land use and ownership patterns presently occurring within the study area. Areas that are located along the Big Thompson River and the North Fork that are not designated residential, commercial, active recreation, or public facilities are presently open space areas. In general, residential development in the study area follows the river channels and roadways. Topographic features define the extent of development both along the main river channels and into tributary canyons. Since much of the land suitable for development is adjacent to the rivers, much of the previous development was destroyed by the flood. Commercial development within the canyon area is located adjacent to U.S. Highway 34 and the county road

through the North Fork. Commercial areas are generally located within or adjacent to larger residential areas. Commercial activities are frequently intermixed with residential development and in some cases commercial and residential activities occupy the same structure.

The large active recreation area designated in Map 6 is Loveland Mountain Park, a picnic and hiking area owned and operated by the city of Loveland. The majority of the picnic grounds in this park were previously located adjacent to the Big Thompson River and were destroyed by the flood. However, the hiking trail system extends up the sides of the canyon and was not seriously affected by the flood. The other active recreation areas within the study area are primarily public owned lands where the river is readily accessible from public roads. Detailed descriptions of land use patterns within the communities designated for detailed planning are presented in the final section of this chapter.

Public and private ownership patterns for the study area and for the total area covered by the canyon-wide base maps are depicted in Maps 6 and 7. At the canyon-wide scale it is not possible to indicate individual ownership or parcel boundary lines; consequently, Maps 6 and 7 depict the boundaries of private and public land. As shown, most of the land west of the mouth of the canyon is publicly owned. The lands along the Big Thompson River, the North Fork, and to the east of the Narrows is generally under private ownership. The U.S. Forest Service owns the largest amount of land indicated on the canyon-wide ownership maps. Other significant land owners include the city of Loveland and Sylvan Dale Ranch.

CIRCULATION

The major access route to and within the study area is U.S. Highway 34. Larimer County maintains the road that provides access to the developments and lands along the North Fork. The Big Thompson flood totally destroyed the North Fork road and significantly damaged U.S. Highway 34 within the canyon area (see Chapter V for details). At the present time both of these roads are open but are undergoing major repairs and reconstruction. U.S. Highway 34 has been temporarily paved throughout the study area, but the North Fork road has not.

The Colorado Department of Highways is responsible for rebuilding U.S. Highway 34 through the canyon. Their construction plans are to elevate the road above the 100 year flood plain or to protect the road from high velocity flow damage such as that which occurred during the flood. The Department of Highways has estimated that it will cost $16.5 million to reconstruct U.S. Highway 34 through the canyon. Completion of the work is not expected until 1979 since the state governor has ordered that no highway construction be conducted during peak tourist season (June through August). Larimer County is in the process of rebuilding the road through the North Fork.

Many of the private parcels in the Big Thompson Canyon have direct access onto U.S. Highway 34. During the peak tourist season these individual access points create unsafe conditions. Prior to the flood, access to the properties across the river from U.S. 34 was provided by private bridges. The flood destroyed all but one of these private bridges; hence, the Larimer County Board of

Commissioners has established a bridge district responsible for rebuilding the bridges. The slated location of the new bridges is indicated and discussed in the final section of this chapter. All of the bridges built by the County Bridge District will become county property although they will be providing access to private property. The district has received monies from the state and county governments and the Inter-Faith Task Force to offset the cost of construction. The remaining funds necessary to construct the bridges will be paid by the property owners benefitting from the bridges.

PUBLIC SERVICES

Police

Larimer County excercises jurisdictional authority over the study area and administers police protection therein. Post-disaster protection funds obtained through the Law Enforcement Assistance Act (LEAA) enabled the county to establish temporary police stations throughout the canyon following the flood. These will remain in operation until Federal funds are exhausted in July, 1977, and then the county will return to its normal policing responsibilities in the study area [Larimer County Sheriff's Office, 1977].

Fire

The Larimer County Sheriff is the designated fire warden for the county. However, the county deals primarily with brush fires. The county will assist in combating any fire which exceeds the capabilities of local volunteer fire-fighting groups. Structural fires and other minor fires within the study area are dealt with by the Big Thompson

Volunteer Fire Department, Estes Park Fire Department, and the Glen Haven Volunteer Fire Department. The Big Thompson Fire Department operates within the Loveland Rural Fire Protection District. Boundaries of this district are the mouth of the Narrows and Grandpa's Retreat in the main canyon, and Drake to approximately 2 miles up the North Fork. The district firefighters operate from substations in Drake and Cedar Cove. The Estes Park Volunteer Fire Department provides fire protection to the area west of Grandpa's Retreat and the Glen Haven Volunteer Fire Department operates in the community of Glen Haven and southeast along the North Fork. Fire protection of U.S. Forest Service lands is administered by the U.S. Forest Service.

Electric

Electric service is provided to communities in the Big Thompson Canyon by the City of Loveland Department of Light and Power which owns the power lines from Loveland to the Waltonia area, and by the Town of Estes Park Department of Light and Power which owns the power line from Estes Park to Grandpa's Retreat. The Poudre Valley REA services the Cedar Park and Cedar Springs area of the North Fork via a power line across Storm Mountain, and the town of Estes Park services the Glen Haven area.

Water

No community water systems exist within the study area; all parties with water are supplied by individual wells.

Sewer

The study area is not serviced by a community wastewater collection and treatment system. Wastewater management is accomplished chiefly by septic tank/leach field systems, and less frequently by holding tanks.

SOCIO-ECONOMICS

No scientific surveys describing the socio-economic characteristics of the people living within the study area have been completed at the time of report preparation. Information presented in this section is based upon data collected by the Inter-Faith Task Force and the BTRPO and generally applies to victims of the flood. As such, it may not fully reflect the characteristics of the study area. It is recommended that a detailed scientific survey be conducted to document the socio-economic characteristics of the study area.

In socio-economic terms, the study area can be divided into two communities--one in the Big Thompson Canyon and the other east of the canyon. Within the canyon the average age of residents is estimated at 57 years of age. The average income is estimated at less than $9,000 per year, compared to the Larimer County average income of $10,800 and the national average of $14,500 [BTRPO and Inter-Faith, 1977]. Many of the canyon residents are retired and living on fixed incomes. No statistics are available for the portion of the study area east of the mouth of the canyon, but it is assumed that the characteristics of this area are similar to those of Loveland where the average age is 25 to 34 and the average income is $10,000 [Loveland Chamber of Commerce, 1977]. No estimates have been made of the socio-economic characteristics of the part-time or seasonal residents.

Within the seven communities designated for detailed planning, there are an approximate total of 1200 residential and 200 commercial structures designated on the community base maps. The majority of these existing residential and commercial structures are considered either habitable or suitable for rehabilitation. A few of the structures in Drake and Cedar Cove appear to be more than 50 percent damaged but were not removed. Any such structures located in the floodway would not be considered suitable for rehabilitation. Approximately 200 residential structures are located in the floodway and an additional 48 structures are located in the flood fringe areas of the planning communities. Approximately 61 commercial structures are located in the floodway and 13 commercial structures are located in the flood fringe areas. Data on the number of structures in each of the planning communities is presented in the final section of this chapter (see pages 63 through 78).

HYDROLOGY

As indicated earlier, the Big Thompson River is a major western tributary of the South Platte River in north-central Colorado. The watershed area of the Big Thompson is bounded by the Cache la Poudre River basin on the north, the Little Thompson River and St. Vrain Creek basins on the south, and the Continental Divide on the west. The 828 square mile Big Thompson drainage encompasses a rugged mountainous headwater region, the Front Range of the Rocky Mountains, and a plains area which extends to the South Platte River near LaSalle.

In its decent from the basin headwaters, the Big Thompson River descends to Lake Estes near Estes Park where it is

impounded by Olympus Dam. Downstream from the reservoir the river flows through Big Thompson Canyon for a distance of about 18.5 miles to the canyon mouth. It then descends to the plains area and continues in an easterly direction for about 30 miles to its confluence with the South Platte. The nature and extent of flows in the main-stem river as it enters Big Thompson Canyon are subject to a high degree of manipulation. The natural hydrologic regime has been greatly modified by facilities of the Colorado-Big Thompson Project.

Colorado-Big Thompson Project

Western Slope waters collected by components of the Colorado-Big Thompson Project are routed northeasterly from Grand Lake and Lake Granby to the hydrologic drainage of the Big Thompson River. Major hydrologic features of the upper Big Thompson River system are depicted in Figure 8. Lake Estes was originally formed by construction of Olympus Dam on the Big Thompson River. In addition to serving as the regulatory reservoir for all Project flows, Lake Estes is the receiving water for flows in the Big Thompson River, in Fish Creek, and for the Estes Park Sanitation District discharge. The bulk of the lake inflow is diverted eastward through the Bureau of Reclamation facilities.

Lake Estes is essentially a flow-through system. Study of Lake Estes has determined that the reservoir experienced an annual exchange rate of 120 times, or once every three days [Ecco Corp., 1972]. Lake Estes has a surface area of 185 acres and a total capacity of 3,100 acre-feet. Active storage is on the order of 2,700 acre-feet [USBR, 1974].

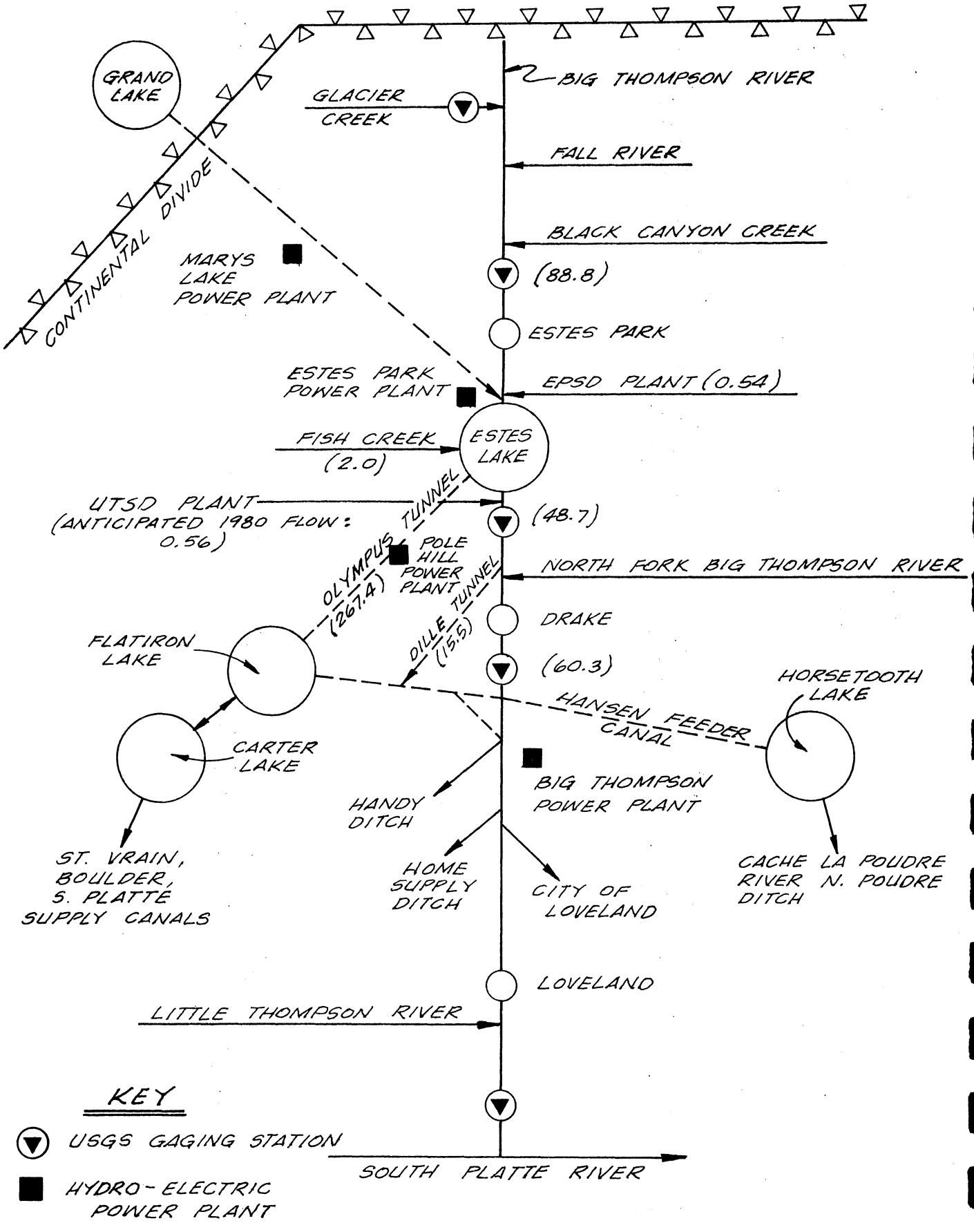


FIG. 8 SCHEMATIC DIAGRAM OF PRINCIPAL FLOWS OF THE UPPER BIG THOMPSON RIVER AND THE C-BT PROJECT WATER YEARS 1966-1975 (1000 AF/YR.)

The primary purpose of the reservoir is water regulation. Because of its relatively small size Lake Estes exercises no significant flood control effects.

Major hydrologic components of Lake Estes include:

Inflow:

- Colorado-Big Thompson Project water
- Big Thompson River
- Estes Park Sanitation District effluent
- Fish Creek

Outflow:

- Olympus Tunnel
- Olympus Dam releases to Big Thompson River

Big Thompson Canyon

As indicated, flows in Big Thompson Canyon are a result of water releases or spills from Olympus Dam, localized wastewater discharges, contributions from Dry Gulch and other minor tributaries, and inflow of the North Fork. The magnitude of runoff generated within the North Fork drainage can be substantial. This tributary possesses a total drainage area of 80.2 square miles. Miller Fork, Fox Creek, and West Creek are significant tributaries to this watercourse.

The regulated discharge to the Big Thompson River from Olympus Dam is generally in accordance with criteria established by the State Fish and Game Commission. Releases are usually defined by the following schedule:

50 cfs - October
25 cfs - November through April 15
50 cfs - April 16 through April 30
100 cfs - May 1 through August 31
75 cfs - September 1 through September 15
50 cfs - September 16 through September 30

If inflow to Lake Estes is less than the Fish and Game Commission criteria for release of water below Olympus Dam on any given day, the Bureau is required to discharge to the river a volume of water equal to the inflow to Lake Estes.

The pattern of river flow through the canyon is generally characteristic of a geologically aging stream. Hydro-geologic conditions have resulted in the present characteristics of the Big Thompson River--a steep, slightly meandering drainage. The pronounced descent of the Big Thompson Canyon generates rapid flows in spite of the energy dissipation capabilities of the naturally curving channel. Sharp changes in stream direction have resulted in deposition of sediment over the years, producing localized wide alluvial areas. Such areas are close to the stream channel and have been considered as areas for settlement due to the flatter topography. Thus, many settlements in the Big Thompson Canyon are located where the meandering nature of the stream is apparent.

Flood Characteristics

Occurrence of major floods on the Big Thompson River and its tributaries is attributable to intense rainfall over the basin associated with localized thunderstorms.

Such floods typically exhibit large peak discharges of only a few hours duration. The steep and hydraulically confined river channel above the canyon mouth possesses little bank storage capacity to reduce or attenuate flood volume. Below the mouth, channel and flood plain storage reduce flood discharge, velocity, and elevation. Location and capacity of irrigation ditches contiguous to the Big Thompson also exert a significant impact upon main-stem flows. During the flood of July 31-August 1, 1976, eleven ditches in a 32-mile reach below the canyon mouth exhibited peak inflows totaling nearly 2,800 cfs [USCE, 1976].

Representative flood discharges at selected locations within the Big Thompson drainage are summarized in Table 3. Peak discharge of the Big Thompson River during July 31-August 1, 1976, is compared with historical flood peaks in Table 4. The 1976 flood is undoubtedly the largest event of the last 100 years. It appears to be approximately a 300 year event [USCE, 1976].

WATER QUALITY

In its natural state the water quality of the Big Thompson River below Estes Park could be expected to closely resemble the water quality of the Big Thompson in Rocky Mountain National Park. The quality of Big Thompson River water in the National Park is extremely high with very low levels of ammonia and fecal coliform organisms.

TABLE 3

BIG THOMPSON RIVER AND TRIBUTARIES

FLOOD FREQUENCY-DISCHARGE [a]

Location	Discharge (cfs) 10-Yr.	50-Yr.	100-Yr.	500-Yr.
Big Thompson, west of Loveland	5,000	13,000	19,000	44,100
Big Thompson, below Buckhorn Creek	5,500	14,600	21,600	47,400
Big Thompson, mouth of canyon	4,250	11,500	16,900	38,900
Big Thompson, below Cedar Creek	4,200	11,400	16,800	38,700
Big Thompson, above Cedar Creek	3,750	7,900	10,500	19,300
Big Thompson at Drake below North Fork	3,700	7,850	10,400	19,200
Big Thompson at Drake above North Fork	2,750	5,700	7,500	13,600
Big Thompson, below Dry Gulch near Lake Estes	2,250	3,800	4,700	7,200
North Fork, above Drake	1,500	4,100	6,100	14,100
North Fork, below Devil's Gulch near Glen Haven	1,450	3,400	4,400	11,500

[a] Gingery Associates, Inc., 1976.

TABLE 4

PAST FLOOD RECORD

BIG THOMPSON RIVER AND TRIBUTARIES [a]

Year	Flood Discharge (cfs)	Location
1864	Unknown	Thompson Valley, near Loveland
1894	Unknown	Destroyed dam near mouth of canyon
1906	6,000	Mouth of canyon
1919	8,000	1.5 miles below Drake
1921	Unknown	Drake gage destroyed
1923	3,590	Mouth of canyon
1923	7,000	Below canyon
1938	5,600	Mouth of canyon
1938	3,620	Dixson (Dickson) Gulch above Narrows
1938	2,940	Cedar Creek at Cedar Cove
1941	4,690	Mouth of canyon
1942	3,730	Mouth of canyon
1945	7,600	Mouth of canyon
1949	3,330	Mouth of canyon
1949	7,750	Near Loveland
1951	3,530	Mouth of canyon
1976	31,200	Mouth of canyon
1976	28,200	Above Drake

[a] Gingery Associates, Inc., 1976.

The water quality of the river in the study area is, however, impacted by man. Effluent from a sewage treatment plant is discharged to the river system. The highway along the Big Thompson River and along the North Fork is a non-point source of sediment. Another source of pollution is septic tank/leach fields present along the river. Occasionally residents drain gray water from such appliances as washing machines directly into the river. Pollution from the latter two sources was much more prevalent prior to the flood. In addition, prior to the flood, a fish hatchery discharged waste effluent to the North Fork just above Drake.

During the summer of 1976 prior to the flood, the Colorado Department of Health Water Quality Control Division collected water quality data on the Big Thompson and North Fork Rivers. Although the streams were determined suitable habitat for both stocked and indigenous trout, some degraded water quality was noted.

Before the flood, many diseased rainbow and brown trout were observed along the upper stretch of the Big Thompson above Drake. Wildlife Department officials investigated and determined that the actual disease was a secondary effect. The primary cause was never found.

As expected, increased levels of ammonia and fecal coliforms were found below the Upper Thompson Sanitation District sewage outfall, and increased levels of ammonia were noted below the outfall from the fish hatchery on the North Fork. At the time the samples were taken, the Upper Thompson wastewater plant was still undergoing start-up procedures. The nitrification tower, which converts ammonia

to nitrate, was not operating, which explains why ammonia was so high as it was (0.5 mg/l as N) at the Whispering Pines Motel. With the nitrification tower in use, the levels of ammonia at this point should decrease substantially.

Certain other stretches of the two streams exhibited degraded water quality similar to that found immediately below the two point sources of wastewater. These areas were from Glen Comfort to below Drake on the Big Thompson, and downstream from the U.S. Forest Service picnic grounds on the North Fork. Increased levels of ammonia and fecal coliforms, both indicative of domestic wastes, were found in these areas.

In the course of the survey, degraded water quality was also found along other stretches of the river after partial recovery had been observed. This is indicative of contamination from the septic tanks and leach fields present along the two rivers. Practically all residential and commercial development between the city of Loveland and the town of Estes Park was served by individual septic tanks prior to the flood. Records of the Larimer County Health Department and the Colorado Water Quality Control Division show that pollution of stream waters and associated groundwaters has been a continuing problem in the Big Thompson Canyon, particularly during summer periods when septic tank loads were increased by tourism and recreational activities. Due to exceptionally high coliform counts, leaching from septic tank systems was suspected as the principal cause of water quality degradation in the Big Thompson River.

Most of the septic tank systems were constructed in close proximity to the stream bed, as were the domestic water wells supplying individual homes and commercial establishments. Some of the leach fields were so close to the stream that wastewater undoubtedly seeped directly to the stream through rock fissures. Records of the Larimer County Health Department indicate that the proximity of septic tanks to the wells was a primary cause of water pollution in domestic supplies.

The location of the septic tanks in relation to the stream bed resulted in the destruction of many septic tank systems and damage to many more by the flood. Although the majority of pollution caused by destruction of some septic tank systems has passed with the flood, there is more than likely a continuing pollution problem due to discharges from slightly damaged systems belonging to residents who still remain in the canyon.

Local residents and commercial interests have expressed a strong desire for construction of alternative means of sewage collection and treatment. Prior to the flood, the cost of developing alternative systems was probably prohibitive considering the investment that residents and commercial interests had in their existing septic tank systems. However, now that a substantial investment will be required to replace and repair septic tank systems, alternatives to this type of system may be more feasible.

BIOLOGY

Vegetation

Generally speaking, three major plant communities may be distinguished within the study area, with two others occurring to a much lesser extent. Major communities are grassland, ponderosa pine forest, and douglas fir forest; the former generally dominating the rolling hills and plains east of the Big Thompson Canyon mouth, and the latter two characterizing the canyon and its North Fork. The two forest communities vary in character from almost pure monotypic stands to thoroughly intermixed associations with neither community type apparently dominant.

Small mountain shrub communities are distributed in a scattered fashion amidst the grassland throughout the area below the canyon mouth and infrequently in the canyon itself. Comprising this community type are such representative species as: mountain mahogany, bitterbrush, chokecherry, gooseberry, and rabbitbrush. A variety of grasses and forbs are also usually present. Nowhere in the study area is this community type well developed.

A rather poorly developed riparian community was present along some stretches of the Big Thompson River and North Fork prior to decimation by the flood. A few scattered areas of riparian vegetation remain. Most components of the community in the study area are shrubby varieties such as willow and currant. A few scattered cottonwoods are present along the stream channels throughout various portions of the study area; sparse growth of aspen are present at a few localities along the North Fork.

In addition to forming the principal cover in that portion of the study area below the mouth of the canyon, grassland communities occur sporadically throughout the canyon on mountain slopes and in broad valleys, although they are seldom without at least occasional ponderosa pines. This vegetation community consists of a variety of grasses and forbs, and may also be invaded by a variety of introduced weeds if in the proximity of human habitation or activities.

The foothills of the Big Thompson Canyon and North Fork are dominated by two conifer forest communities: ponderosa pine forest and douglas fir forest. The former community typically predominates at lower elevations and/or dryer slopes and consists chiefly of open stands of ponderosa pine. A wide variety of shrubs, grasses, and forbs comprise the understory. In most localities within the canyon, this community is long-lived and usually quite stable. In areas with dependable moisture and deep soils, the community is moderately productive and capable of withstanding considerable disturbance. On steep slopes of southwest aspect, the community must be considered unstable, easily damaged, and difficult to re-establish following disturbance. At some locations within the canyon, ponderosa pines have been subjected to intense attack by mountain-pine beetles. The problem is currently under investigation by the State and Federal Forest Service.

Douglas fir communities are most common at higher elevations and on north-facing slopes and protected ravines. Understory vegetation is less abundant than in the ponderosa forest and consists primarily of shrubs and forbs. Douglas fir forms a stable community on most sites and can withstand considerable disturbance and vegetative removal providing certain

environmental factors are given due consideration. At the lower elevational limits of its distribution, such as in Big Thompson Canyon, this community typically occurs on north-facing slopes, as indicated above. These slopes are usually quite steep and disturbance can produce significant erosion. Removal of tree cover from large areas will allow for soil temperature increase and soil moisture decrease discouraging regeneration of the disturbed site by douglas fir. Concentrated cutting of part of the tree cover may open a stand to wind damage. Though ponderosa pine and douglas fir interdigitate considerably in many portions of the study area, the two communities are quite distinct in others. Generally speaking, the distributional pattern of the two forest types in the Big Thompson Canyon and North Fork involves ponderosa pine forest typically dominating below Drake, and douglas fir increasing in dominance with elevation and habitat moisture within the study area above Drake. Both forest communities provide shelter and cover for a fairly wide variety of birds and mammals, as discussed in the following section. The understory of the ponderosa pine community is typically abundant in important wildlife forage shrubs, and therefore this community may see substantial winter use by elk and deer. The Abert's squirrel is particularly dependent upon this community. Douglas fir forests may serve as cover for larger mammals, but their forage is typically limited in this community.

The vegetational distribution information for the study area presented in Maps 9 and 10 is based upon a different vegetational categorization than the plant community breakdown just discussed. These distribution maps were derived from wildfire hazard maps prepared by the Colorado State Forest Service and are based upon fuel availability

(reference wildfire hazard maps were not available for the study area east of Cedar Cove). Differentiated on these maps are conifer forest with substantial understory vegetation, conifer forest with little understory vegetation, and essentially barren areas. These maps leave much to be desired as indicators of plant community geography, however they are the only vegetative maps currently available for the study area.

Wildlife

The distribution within the study area of certain species of wildlife selected by the Colorado Division of Wildlife for investigation in Larimer County is depicted on Maps 9 and 10.

Mammals which are found in the study area include American elk, mule deer, bobcat, and coyote. Among the smaller mammals are: Abert's squirrel, yellow-bellied marmot, snowshoe hare, striped skunk, long-tailed weasel, and raccoon. Two mammals particularly characteristics of the study area are the Colorado chipmunk and the Estes Park cliff mouse.

Birds which are common in the study area include the kestrel, red-tailed hawk, great horned owl, red-shafted flicker, Lewis' woodpecker, Say's phoebe, black-billed magpie, rock wren, mountain bluebird, western meadowlark, Brewer's blackbird, green-tailed towhee, and vesper sparrow.

As shown in Maps 9 and 10, three golden eagle eyries are known in the study area. Activity has been observed in the one near Drake and the one above the Narrows within the

last two years [Marcoux, 1977]. Golden eagles are sensitive to human disturbance and encroachment could result in abandonment of their eyries. Since the eyries are not situated in localities attractive to development, this problem should be easily avoided. The endangered southern bald eagle has been observed during winter over the study area from its eastern extent to the general vicinity of Drake. This raptor occasionally rests in the area, but does not breed therein. Yearly observations of the endangered peregrine falcon are made within the Big Thompson drainage but no nesting sites have been located. Raptors present in greatest numbers in the study area are the red-tailed hawk and kestrel.

Amphibians and reptiles fairly common in the study area include the Rocky Mountain toad, boreal chorus frog, leopard frog, eastern fence lizard, common garter snake, bullsnake, western milksnake, and prairie rattlesnake. Most of these species are quite secretive and seldom are seen by the casual observer.

Prior to the flood, the Big Thompson River and North Fork supported substantial fisheries consisting primarily of resident and stocked rainbow trout, and to a lesser extent brown trout. Based upon 1974 electrofishing data, the Colorado Division of Wildlife (DOW) has estimated that the pre-flood Big Thompson supported a minimum of 83 fish (19 pounds of fish flesh) per surface acre [Todd, 1976]. North Fork fish populations measured at the same time were at a minimum level of 203 fish (66 pounds of fish flesh) per surface acre, and West Creek populations were at a minimum level of 69 fish (8 pounds of fish flesh) per surface acre.

In response to heavy fishing pressure, the Big Thompson and North Fork receive an average annual stocking of 18,000 (65,000 individuals) and 5,000 (18,000 individuals) pounds, respectively, of catcheable rainbow trout (six inches or larger) to supplement natural fish populations [Todd,1976]. Random fisherman contacts by DOW Conservation Officers indicate three-year (1973-1975) catch per man hour averages of 0.40 for the Big Thompson River and 0.48 for the North Fork. DOW extrapolation of fishing pressure data obtained from a study of the neighboring Cache la Poudre River [Marshall, 1973] has produced average fishing pressure estimates for the Big Thompson River and its tributaries of at least 3,000 fishermen per mile per year.

DOW data indicates that Larimer County is the most popular fishing county in Colorado for residents and the third most popular for non-residents. A recent study by the Colorado State University Economics Department revealed that state resident stream fishermen expended an approximate annual figure of $8,860,000 pursuing their sport in Larimer County, and non-resident fishermen spent approximately $990,000 during the same period. Considering that the Big Thompson and its tributaries comprise one of the two major river systems in Larimer County, it can reasonably be assumed that at least half the county fishing pressure and related expenditures are tied to its fishery. Actually, it is likely that more than half of the non-resident fishing pressure and expenditures are tied to the Big Thompson due to its location along the route to Estes Park and Rocky Mountain National Park.

Big game species occurring in the Big Thompson drainage include elk, mule deer, bear, mountain lion, and bighorn sheep. The two major big game species in terms of numbers are elk and deer. The flood impacted area lies within a 750 square mile elk distribution area that supports approximately 1200 elk at a density of 1.6 individuals per square mile [Todd,1976]. A mule deer distribution area encompassing about 650 square miles lies within the elk range and supports approximately 2200 deer at a density of 3.4 individuals per square mile [Todd, 1976].

Elk and deer movements in the Big Thompson Canyon generally parallel the canyon and no major crossings occur. Movements in the North Fork Canyon also generally parallel the canyon but due to the smaller stream width and gentler topography in some areas, some cross-canyon movement does occur.

A major elk migratory corridor is present within the study area as demarcated in Map 10. Herds typically move from the higher elevations of Rocky Mountain National Park and the Storm Mountain area into the lower elevations of the Crosier Mountain area to forage when heavy snows set in at higher altitudes. These movements normally occur during September through December, depending upon snowfall, and returns begin with spring thaw. Development, particularly fencing, in the migratory corridor area constitutes a barrier to the movement of elks into their important winter foraging grounds, and may result in the starvation of individuals, particularly small juveniles which experience difficulty crossing fences.

Game birds occurring in the study area include the bard-tailed pigeon, mourning dove, blue grouse, and Merriam's turkey. Huntable populations of pigeons and doves migrate through the Big Thompson drainage area yearly, and huntable populations of grouse are present in the area year-round [DOW, 1976]. Turkey populations are present only on the North Fork, barely entering the study area as shown in Map 9, and are not presently hunted.

Four species of mammals occurring within the flood impacted area are considered small game. The three that are present in huntable population sizes are the snowshoe hare, cottontail rabbit, and pine squirrel. Although Abert's squirrel is designated small game, its limited numbers and restricted range do not support huntable populations and hunting is prohibited.

COMMUNITY DESCRIPTIONS

The purpose of this section is to provide a description, in textual and graphic form, of the communities within the study area that have been designated for detailed planning. Table 5 presents a summary of the information included in this section.

GLEN HAVEN

Glen Haven is located approximately 7 miles northeast of Estes Park on the North Fork of the Big Thompson River. This is the only community located along the North Fork that has been designated for detailed planning within the scope of this project. The community is situated in a deep gorge of the North Fork surrounded by steep slopes rising high above the valley floor. Three tributaries of the North Fork converge at Glen Haven, each arriving through small canyons into which development has thrust.

TABLE 5. SUMMARY OF EXISTING CHARACTERISTICS OF BIG THOMPSON PLANNING COMMUNITIES

	GLEN HAVEN	LOVELAND HEIGHTS/ GLEN COMFORT	WALTONIA	DRAKE/ MIDWAY	CEDAR COVE	SYLVAN DALE	BIG THOMPSON VALLEY EAST
RESIDENTIAL [a]							
Structures	226	275	55	115	92	77	305
Acreages	170 ac	110 ac	18 ac	65 ac	57 ac	43 ac	212 ac
COMMERCIAL [a]							
Structures	12	71	1	35	40	9	38
Acreages	6 ac	18 ac	.25 ac	9 ac	36 ac	6 ac	17 ac
FLOODWAY (FW) [b]	40 ac	50 ac	17 ac	23 ac	70 ac	79 ac	271 ac
FLOODFRINGE (FF) [b]	5 ac	5 ac	1 ac	2 ac	2 ac	7 ac	30 ac
RESIDENTIAL IN FW[a]							
Structures	61	36	6	19	39	12	41
Acreages	35 ac	12 ac	1.5 ac	6 ac	14 ac	10 ac	23 ac
COMMERCIAL IN FW [a]							
Structures	9	27	0	1	14	0	11
Acreages	2 ac	7 ac	0 ac	2 ac	4 ac	0 ac	5 ac
PUBLIC FACILITIES IN FW [a]	1	0	0	0	0	1	0
RESIDENTIAL IN FF [a]							
Structures	3	10	3	3	1	8	12
COMMERCIAL IN FF [a]							
Structures	0	2	0	6	2	0	2
PUBLIC FACILITIES IN FF [a]	0	0	0	0	0	0	0
GEOLOGIC HAZARDS [c]							
Landslide Areas	2	4	0	7	4	-	-
Debris Fans	13	22	13	32	24	-	-
Rockfall Areas	5	28	4	15	12	-	-

[a] Toups Corporation, 1977. [b] GAI, 1976. [c] Soule, et. al., 1977.

The location of the geologic hazards within Glen Haven are indicated in Map 11. Table 5 summarizes the number of these hazards. The town of Glen Haven is located on a section of the North Fork that is relatively straight. High velocity ripple flows are typical of the reach passing through town, with a sharp meander on the east end of the town tending to slow the river before it continues downstream. The narrow canyon walls restrict the residential structures and thoroughfares to localities adjacent to the river.

There are approximately 170 acres of residential development in the Glen Haven area. However, only 6 acres of commercial development are present. Unlike the communities located along the main body of the Big Thompson River, commercial development in Glen Haven generally services residents of the area. The county road that runs along the North Fork is not a heavily traveled road and only a few tourists wander off U.S. Highway 34 on their way to Rocky Mountain National Park to enjoy the scenic drive along the North Fork. The small commercial areas indicated on Map 12 include a restaurant, saloon, country store, gift and pantry shop, a firehouse, and a post office.

There are 238 structures, 226 residential and 12 commercial, remaining in the Glen Haven area. As portrayed in Map 13, of the residential structures, 61 are located in the floodway area and 3 are located in the flood fringe. Of the commercial structures, 9 are located in the floodway. In general, the structures still remaining in the floodway and flood fringe are considered damaged less than 50 percent and could be rehabilitated.

Map 14 indicates the ownership patterns in the Glen Haven community. As indicated, the majority of the area is divided into small private parcels. The large area in the middle of the community west of the residential development is a privately owned parcel. The U.S. Forest Service owns the land to the southwest and northeast of the community. Unfortunately, right-of-way information for the county roads in the area was not available. Therefore this information is not indicated on the ownership map as it is on the ownership maps for the other communities.

Map 15 indicates the location of the county and private roads that provide access to and within the Glen Haven area. This figure also indicates the location of the private access bridges within the community. There were 24 private bridges in Glen Haven and along the North Fork destroyed by the flood. This area has not been included in the bridge district established by the Larimer County Board of Commissioners. Reconstruction of private bridges will proceed at the discretion of individuals. At the present time 15 of the bridges are planned to be replaced. The remaining bridges provided access to single homes and were not eligible for Federal assistance. These will only be rebuilt if the individual homeowners choose to do so. Information regarding the location of proposed bridges in the Glen Haven area is indicated on Map 15.

LOVELAND HEIGHTS/GLEN COMFORT

The community of Loveland Heights/Glen Comfort is located approximately 4 miles east of Estes Park and exhibits the least severe topographic relief of any community within the canyon. The river channel is relatively wide and the canyon walls, though steep in some areas, generally rise gradually from the riverbed. In addition, the height of the canyon walls is considerably less than it is in the other communities. The head of the Big Thompson Canyon proper lies at the western end of this community.

The location and extent of geologic hazards occurring within Loveland Heights/Glen Comfort are indicated in Map 16. Table 5 summarizes the number of geologic hazards within this community. Upstream from the Loveland Heights/ Glen Comfort area the river is fairly straight as it approaches the community. This reach is followed by two sharp bends within the area. Gentler meanders throughout the area account for sediment deposition sufficient to allow settlement. Flow is rapid with meanders adsorbing much of the flow energy. In places, construction of U.S. Highway 34 has forced narrowing of the channel within the town and increased stream velocity with reduced capacity.

Loveland Heights/Glen Comfort contains the most development of any community within the main canyon, with approximately 110 acres of residential development and 18 acres of commercial development. Primarily responsible for this level of commercial use is the proximity of Loveland Heights/ Glen Comfort to the tourist community of Estes Park. As indicated in Map 17, development generally follows the river; however, where topography permits, development does extend up smaller canyons and gorges primarily on the northern side of the river and U.S. Highway 34.

Residential development occurs throughout the Loveland Heights/Glen Comfort community. The major commercial area is located roughly in the center of the community. The other commercial areas are located at the eastern and western ends of the community.

Most of the commercial activities within Loveland Heights/Glen Comfort are tourist-oriented. There are numerous motels and gift shops located adjacent to U.S. Highway 34 in the commercial areas that cater to the tourist driving through the canyon enroute to Rocky Mountain National Park.

One large area located at the western end of the community, approximately 9 acres in size, has been designated as an active recreation area. This area is owned by the U.S. Forest Service and provides opportunities for stream fishing and picnicing due to the relatively gentle sloping areas adjacent to the river.

Within Loveland Heights/Glen Comfort there are approximately 346 structures standing today, 71 commercial and 275 residential. Of the total 346 structures, 36 residential and 27 commercial structures are located in the floodway (see Map 18), but are considered suitable for rehabilitation because they were less than 50 percent damaged by the flood. An additional 12 residential and commercial structures are located in the areas designated as flood fringe.

The ownership patterns within Loveland Heights/Glen Comfort are depicted in Map 19. As indicated, the majority of the land is privately owned and divided into relatively small parcels. However, there are several large parcels of privately owned land scattered throughout the community.

The U.S. Forest Service owns most of the land south of the community and some of the lands to the northeast.

Map 20 indicates the major public and private roads that provide access to and within the community. Also, as indicated, there are 8 existing temporary bridges within this community, all of which will be replaced by permanent structures that will be built by the bridge district established by the Larimer County Board of Commissioners.

WALTONIA

The community of Waltonia is located approximately 10.5 miles east of Estes Park. Throughout the community, as defined in this study, the river channel is relatively narrow with steep canyon walls extending up the northern and southern banks. There are a few relatively isolated spots where the riverbed widens enough to allow the presence of development. Throughout most of the community U.S. Highway 34 constricts the river channel.

Map 21 portrays the location of the geologic hazards within Waltonia. Table 5 summarizes the number of these hazards. As indicated, there are no landslide areas in Waltonia; this is due to the extensive bedrock formation comprising the canyon walls in this area.

In comparison to the other planning communities, Waltonia has the least amount of development, with only 18 acres of residential development. Map 22 indicates that the majority of this development is located on the south side of the Big Thompson River and extends up a steep tributary canyon approximately one-half mile. There are two smaller

residential areas located approximately 1/4 and 3/4 of a mile downstream from the main portion of Waltonia. Both of these areas are also on the southern side of the river. The three other areas designated as residential on the north side of U.S. Highway 34 are areas where individual houses are located. The only commercial area remaining in Waltonia is a motel located approximately 1/2 mile downstream of the main community. There is one small area designated as active recreation located adjacent to the easternmost residential area. This area was designated as active recreation because there is public access to the river for fishing.

Within the community of Waltonia, there are approximately 55 residential and one commercial structure standing today. Of these, 6 residential structures are located in the floodway and 3 are in the flood fringe (see Map 23), but are considered suitable for rehabilitation because they were less than 50 percent damaged by the flood.

The ownership patterns within Waltonia are indicated on Map 24. The majority of the land is privately owned and divided into large parcels. The U.S. Forest Service owns the lands bordering Waltonia on the north and south. The areas where development has occurred are divided into small private parcels.

Map 25 indicates the major public and private roads that provide access to and within Waltonia. As indicated, U.S. Highway 34 runs east and west through the entire community. At the present time there are four temporary bridges providing access to the residential areas on the south side of the river. The bridge district established by the Larimer County Board of Commissioners has determined that new bridges should be built at all the locations where the temporary bridges exist and will have county bridges constructed in the near future at the designated locations.

DRAKE/MIDWAY

Drake/Midway is located approximately 13 miles east of Estes Park at the confluence of the Big Thompson River and the North Fork. Topographic characteristics of the Drake/Midway community are varied. The eastern and western ends of the community are defined by very steep canyon walls. In the areas within Drake/Midway where development has occurred, the river bed widens forming relatively level areas adjacent to the river and to U.S. Highway 34. The slope of the canyon walls adjacent to these areas along the river exhibits less severity than those in the other areas. The widest portion of the Drake/Midway community exists near the confluence of the North Fork and the Big Thompson River. This is also the area of the community that experienced the most flood damage.

Map 26 indicates the location of the geologic hazards within this community. Table 5 summarizes the number of these hazards within the Drake/Midway area. Drake/Midway is uniquely located hydrologically. At the confluence of the Big Thompson and North Fork of the Big Thompson River the character of the channel tends to favor dissipation of a portion of the energy of both rivers. The North Fork passes through the town with a high velocity and little deviation from a direct course. The Big Thompson also approaches Drake with a relatively high velocity. However, a sharp bend slows it somewhat before it joins the North Fork at a perpendicular angle. Downstream from the confluence, constriction by U.S. Highway 34 results in higher velocities and a narrower channel. The eastern end of the community is typical of downstream conditions of the Big Thompson River, a general meandering pattern with occasional channel narrowing by the highway. A sharp bend is located at the end of town which results in a slower river velocity.

There are approximately 65 acres of residential and 9 acres of commercial development within Drake/Midway generally located in three separate areas. As shown in Map 27, the most extensive residential area is located roughly in the middle of the community in the area commonly known as Midway. Development in this area occurs on both the northern and southern sides of the river. Approximately three-fourths of a mile downstream from this area is another relatively large area of residential development. These two areas are separated by an area designated as active recreational due to the public accessibility to the river for fishing. The third major area of residential development is located north of U.S. Highway 34 at the point where the North Fork enters the Big Thompson. Just south of this area and across the main river channel several additional residential structures are located at the western extreme of the community.

Each of the major residential areas also embrace some commercial activities. The commercial area near the confluence of the Big Thompson and the North Fork includes a post office, a grocery store, and a souvenir shop. There is a motel and gas station located at Midway and an Indian jewelry store located in the commercial area at the eastern end of the study area. The public facility located in the center of Drake/Midway is the Big Thompson Community Building. The other public facility is the Colorado Division of Highways maintenance yard.

Drake/Midway experienced some of the worst damage as a result of the Big Thompson flood. Notwithstanding, 150 structures remain standing within the community. Of these, 35 are designated as commercial. There are 19 residential structures and 1 commercial structure located in the floodway (see Map 28). There are 3 residential structures and 6 commercial structures located in the flood fringe areas.

Map 29 depicts the ownership patterns within the community. As indicated, the majority of the land is in private ownership either in small parcels in the developed areas or large parcels on the perimeters of development. The U.S. Forest Service owns most of the land north and south of Drake/Midway and also owns the parcel of land designated as active recreation in Map 30. The State of Colorado owns the parcel of land where the Department of Highways maintenance yard is located.

U.S. Highway 34 provides the primary access to and from the Drake/Midway area. Access to the residential and commercial areas across the river from U.S. 34 is presently provided by five temporary culvert bridges, one temporary steel bridge, and a foot bridge. The bridge district established by the Larimer County Board of Commissioners is planning to build five automobile bridges and one foot bridge to replace those destroyed by the flood. In addition, the Colorado Highway Department is rebuilding the bridge that previously provided access to their maintenance yard and residences in the vicinity of the maintenance yard. The location of existing bridges and proposed access points, the alignment of U.S. 34 and the county road ascending the North Fork, and the location of private access roads are all portrayed on Map 30.

CEDAR COVE

Cedar Cove is located approximately 17 miles east of Estes Park. The eastern end of the community is adjacent to the western end of the portion of the Big Thompson Canyon known as the "Narrows". The community exhibits a relatively wide river bed area clearly defined by steeply rising slopes on

the northern and southern sides of the river. These characteristics are relatively consistent throughout the community; however, at the western end of the community the river channel narrows and the canyon walls steepen.

The relatively consistent slight meandering pattern of the Big Thompson River is altered at Cedar Cove. Upon entering the area, the river assumes a relatively straight course that results in increased velocity and energy that is dissipated by a sharp right bend. The sharp bend and wide alluvial area are capable of slowing flood waters, and a large flood plain has been formed.

Map 31 indicates the location and occurrence of the geologic hazards within this community. Table 5 summarizes the number of the geologic hazards in the Cedar Cove area.

There are approximately 57 acres of residential and 36 acres of commercial development in the Cedar Cove area. As indicated in Map 32, the majority of the commercial and residential development is located in the eastern half of the community. However, there are a few isolated areas of residential development located adjacent to and within the Loveland Mountain Park, which encompasses most of the 203 acres of land designated as active recreation. The commercial area adjacent to Loveland Mountain Park is a motel. Motels, a restaurant, and other businesses are located in the other commercial areas. As indicated in Map 32, development generally follows the river bed and tributary canyons or the alignment of U.S. Highway 34 as it traverses the area.

There are 132 structures presently standing in the Cedar Cove community. Of these, 92 are classified as residential and 40 as commercial. There are 39 residential structures and 14 commercial structures still standing in the areas designated as the floodway (see Map 33). One additional residential structure and 2 commercial structures are located in the flood fringe area.

Map 34 indicates the ownership patterns in the Cedar Cove area. The city of Loveland is clearly the biggest land owner in this area. Loveland Mountain Park is located on city lands within Cedar Cove. This area was also, and will be upon reconstruction, the location of the Loveland hydroelectric powerplant. Larimer County owns some land in the central portion of the community. Most of the private property in the eastern portion of the area is divided into small parcels; however, there are a few very large private parcels in the area. As with most of the communities within the Big Thompson Canyon, the U.S. Forest Service owns the majority of the land to the north and south of the Cedar Cove area.

Map 35 indicates the major public and private roads within the Cedar Cove area. This figure also designates the location of two existing temporary access bridges and the location of three places where new bridges will be built by the locally formed bridge district. These new bridges will provide access needed by residents living across the river from U.S. Highway 34.

SYLVAN DALE

The community of Sylvan Dale is located approximately 21 miles east of Estes Park and just east of the mouth of the Big Thompson Canyon. The community is of uniformly low relief. As the Big Thompson River leaves the mouth of the canyon, it meanders gently through the foothills and hogbacks located in this portion of the study area. The river channel is relatively wide in this area and characterized by shallow banks and broad valleys along both sides.

There are approximately 43 acres of residential development and 6 acres of commercial development in Sylvan Dale. Map 36 indicates that the majority of the residential development is located adjacent to the Big Thompson River as it meanders through the area. The largest residential area is located just east of the mouth of the canyon. The Dam Store and Sylvan Dale Ranch are the two most distinct commercial activities within the community. The Big Thompson School, located at the eastern end of Sylvan Dale, and the Loveland Municipal Water Filtration Plant, located in the center of the community, are the major public facilities designated in Map 36. The other designated public facility is a small hydroelectric power plant.

At the present time there are 86 structures in the community of Sylvan Dale. Of these, 77 are residential and 9 are commercial. There are 12 residential structures in the floodway (see Map 37) and 8 in the flood fringe area. All of these structures are generally considered suitable for rehabilitation since they were less than 50 percent damaged by the flood.

Map 38 illustrates ownership patterns within the community. With the exception of the land owned by the city of Loveland and the Big Thompson School property, all of the land within Sylvan Dale is privately owned. By far the largest land owner is Sylvan Dale Ranch which owns several large parcels on both sides of the river.

Map 39 depicts the major public and private roads that provide access to and within Sylvan Dale. As shown, U.S. 34 traverses the eastern portion of the community and then reenters the community in its western portion.

BIG THOMPSON VALLEY EAST

The community designated as Big Thompson Valley East, for purposes of this study, is located approximately 24 miles east of Estes Park and 2 miles west of the city of Loveland. As the Big Thompson River enters Big Thompson Valley East, the topography of the study area becomes less and less varied. At the eastern end of Big Thompson Valley East, the river flows along its natural course across the plains of Larimer County. As in Sylvan Dale, the river channel is relatively wide and characterized by broad, gently sloping banks and gentle valleys along both sides.

Map 40 indicates land use patterns within this community. There are approximately 212 acres of residential development and 17 acres of commercial development within this area. Due to the proximity of the community to Loveland, much of the development is oriented in character toward that city. In general, the commercial development is located along U.S. Highway 34 which passes through the middle of the area.

There are 305 residential and 38 commercial structures within the community. Of the residential structures, 41 are located in the floodway (see Map 41) and 12 are located in the flood fringe. Of the commercial structures, 11 are located in the floodway and 2 are located in the flood fringe. All of the structures in the floodway and flood fringe are considered suitable for rehabilitation since they were generally less than 50 percent damaged by the flood.

Map 42 indicates ownership patterns within this community. As shown, the majority of land is in private ownership and divided into small parcels. This further indicates the relationship of this part of the study area to the city of Loveland. There is one small parcel of land owned by Larimer County located in the center of the community. There are no other public lands within Big Thompson Valley East.

The private and public street network that provides access to and within the community is portrayed in Map 43. As shown, U.S. Highway 34 bisects the entire community and serves as the major access route to and from the area.

V

ENVIRONMENTAL IMPACT OF THE FLOOD

Primary, secondary, and tertiary impacts of the Big Thompson flood are discussed within this chapter. As indicated previously, the information presented is not intended to constitute a thorough environmental impact assessment of the flood. Rather, it is intended to indicate the most significant social, economic, and physical consequences of the flood. The impacts discussed below indicate considerations that will be addressed during the development of the comprehensive land use plan for the Big Thompson study area.

PRIMARY IMPACTS

Primary impacts of the July 31, 1976, disaster are those that occurred as a direct result of the flood within the planning study area.

SOCIAL CONSEQUENCES

On the evening of July 31, 1976, at least 139 people were killed in a devastating flood and at least six people are still missing. As indicated in Table 10, less than 30 percent of the flood victims were residents of Big Thompson Canyon. Approximately 33 percent of the people killed lived outside the state of Colorado. This fact reflects the significance of the Big Thompson Canyon as a national scenic and recreation area.

TABLE 6

RESIDENTIAL LOCATION OF PERSONS
KILLED BY THE JULY 31, 1976 FLOOD [a]

AREA	NUMBER KILLED	PERCENT OF TOTAL
Big Thompson Canyon	41	29
Loveland	10	7
Other portions of Larimer County	7	5
Greeley	6	4
Denver	17	13
Other portions of Colorado	11	8
Portions of United States outside Colorado	46	33
Foreign	1	1
TOTAL	139	100%

[a] Wright-McLaughlin Engineers, November, 1976.

As indicated in Table 7, 44 percent of those persons killed during the flood were over 50 years of age. Due to the retirement community nature of the permanent canyon residents, it is reasonable to assume that a substantial portion of the older persons killed were permanent residents. The high percentage of these persons killed also reflects the high flood hazard in the canyon created by the steep canyon walls that are extremely difficult to climb, especially when they are rain-soaked. Approximately 45 percent of the persons killed in the flood were men and 55 percent were women.

As a result of the flood, the majority of the people that lived in the canyon were forced to find alternative housing, at least until a temporary road was built through the canyon. As soon as the temporary road was completed, people began moving back into the canyon. The flood totally destroyed or damaged approximately 450 structures (residential and commercial) [BTRPO and Inter-Faith, 1977]. People previously living in these structures were temporarily or permanently displaced from their homes and forced to find other housing opportunities.

It has been estimated that approximately 190 full-time resident families were displaced because their homes were damaged or destroyed as a result of the flood. Of these, 100 full-time resident families were permanently displaced because their homes were destroyed by the flood [HUD, 1977].

Due to a housing shortage in the Loveland and Fort Collins areas prior to the flood, temporary housing was extremely difficult to find. People were housed throughout the area in every conceivable hotel, motel, house, apartment, room

TABLE 7

AGE BREAKDOWNS OF PERSONS KILLED
BY JULY 31, 1976 FLOOD [a]

AGE CATEGORY	NUMBER OF PEOPLE KILLED	PERCENT OF TOTAL
0-10	10	7
11-20	19	14
21-30	23	17
31-40	7	5
41-50	12	9
51-60	25	18
61-70	25	18
71-Over	11	8
Unknown	7	4
TOTAL	139	100%

[a] Wright-McLaughlin Engineers, November, 1976.

and basement [Holman and Shellhart, 1977]. The other structures that were damaged or destroyed by the flood were either commercial buildings or buildings belonging to temporary canyon residents.

It has been estimated that in addition to the number killed, 568 full and part time canyon residents were affected by the flood. Table 8 indicates the age breakdowns of these flood victims. As indicated, 58 percent of these victims are over the age of 50 [BTRPO and Inter-Faith, 1977]. Many of these victims are retired and living on fixed incomes as reflected by the average income of the canyon residents--$9,000 per year--compared to the Larimer County and national averages, $10,800 and $14,500, respectively.

ECONOMIC CONSEQUENCES

This section summarizes some of the estimates of damage to residences, businesses, and public facilities in the flood impacted area. Numerous dollar estimates of the total flood-related damages have been ventured during the nine months that have elapsed since the flood occurred [USCE, 1976; Larimer County, 1976; Inter-Faith, 1977]. The most complete estimate of the overall economic consequences of the flood concludes that the total economic loss in Larimer County was $35,498,100 with an estimated additional loss of $45,000 in Weld County [USCE, 1976]. Roughly half of this loss was due to damage to U.S. 34, U.S. Forest Service roads, and public and private bridges. The other significant loss reflects damage to public and private structures and facilities.

The U.S. Army Corps of Engineers has broken down some of these estimates of the economic consequences of the flood [USCE, 1976]. Personal property damages were estimated at $5,036,000 with an additional $8,928,500 estimated damage to structures. Cleanup operations to remove debris potentially

TABLE 8

AGE BREAKDOWN OF SURVIVING
FLOOD VICTIMS [a]

AGE CATEGORY	NUMBER OF PERSONS	PERCENT OF TOTAL
0-10	31	5
11-20	72	13
21-30	25	4
31-40	39	7
41-50	75	13
51-60	138	24
61-70	121	22
71-Over	68	12
TOTAL	569	100%

[a] BTRPO, 1976, Revised.

hazardous to public health and welfare cost approximately $1,611,000. Emergency efforts and assistance rendered by the Red Cross, Colorado National Guard, and local governments has been estimated at $656,000. The original estimate for repairing U.S. Highway 34 was $14,800,000. This has been revised by the Colorado Division of Highways to $16,500,000 [Atkins, 1977]. Estimated cost for future repair and reconstruction of the county road through the North Fork, the public and private access bridges that were damaged or destroyed, and U.S. Forest Service roads in the area is $2,620,000. Damage to irrigation structures and equipment owned by the Northern Colorado Water Conservancy District has been estimated at $538,000, while damage to the U.S. Bureau of Reclamation facilities is estimated at $300,000. These figures are all simply estimates of damage. The real cost of the damage can be calculated only subsequent to repair and reconstruction of the facilities that were damaged or destroyed. Post-construction surveys should be conducted to fully document the direct economic consequences of the flood.

The Larimer County Assessor's Office has prepared a computer printout indicating pre- and post-flood assessed valuation of the land and improvements that were affected by the flood. Pre-flood assessed valuation of land and improvements for the parcels was prepared in 1976 and based upon 30 percent of assessor's actual value and 24 percent of assessor's market value. Assessor's actual value equals 80 percent of assessor's market value. Post-flood assessed valuation of land was based upon a formula reflecting the adoption of floodplain zoning regulations in the county that decreased the value of land in the floodway and flood fringe areas but increased the value of lands adjacent to the flood fringe.

The land in parcels located in the floodway was assessed at 10 percent of pre-flood assessor's actual value, land in the flood fringe was assessed at 20 percent of assessor's actual value, and the land adjacent to the flood fringe was assessed at 35 percent of assessor's actual value. Post-flood assessment valuation of improvements was based on reevaluation of each structure and improvement within the flood impacted area by the Assessor's Office. Based upon the information in the computer printout, the total assessed valuation of the flood impacted area was reduced by $1,580,340 as a result of the flood. Approximately 23 percent of this reduction, or $304,000, resulted from damage to parcels under commercial use. The remaining $1,216,340 loss was to residential parcels. These figures represent losses to both land and improvements. Assessor's pre- and post-flood market value generally equals 50 percent of real market value as reflected in land sales [BTRPO, 1977]. Therefore, the full impact of the flood on land and improvements is estimated at $13,169,500 (roughly $4,241,000 higher than the original estimate in USCE, 1976).

Larimer County Assessor information was also used to calculate flood-caused damage, in terms of reduction in assessed valuation, for each of the seven communities within the canyon designated for detailed planning. Table 9 presents the results of these calculations. Detailed parcel by parcel damage information by communities is available from Toups Corporation and the BTRPO, but is not included in this report due to the bulk of the recorded information.

The primary impact of this reduction in property value is felt by individual property owners. The reduction in assessed valuation also reduces the county's tax base. Although the reductions in assessed valuations of improvements can be directly attributed to the flood, the reductions in land value are due to the adoption of flood plain zoning regulations which reduced post-flood assessed valuations of land as indicated above.

TABLE 9

PRE- AND POST-FLOOD ASSESSED VALUATION OF PROPERTIES WITHIN PLANNING COMMUNITIES [a]

COMMUNITY	PRE-FLOOD ASSESSED VALUATION [b]	POST-FLOOD ASSESSED VALUATION [b]	REDUCTION IN ASSESSED VALUATION	ACTUAL LOSS [c]
Glen Haven	$141,640	$ 87,540	$ 54,100	$450,833
Loveland Heights/ Glen Comfort	305,880	222,200	83,680	697,333
Waltonia	160,470	65,590	94,880	790,666
Drake/Midway	347,560	135,290	212,270	1,768,916
Cedar Cove	378,650	158,080	220,570	1,838,083
Sylvan Dale	210,790	112,270	98,520	821,000
Big Thompson Valley East	402,610	261,810	140,800	1,173,333

[a] Larimer County Assessor's Office, Toups Corporation.
[b] Reflects only assessed valuation of properties experiencing damage during the July 31, 1976 flood, not total assessed valuation of community.
[c] BTRPO, 1977, and Toups Corporation.

PHYSICAL CONSEQUENCES

A series of maps have been prepared that portray some of the physical consequences of the flood. These maps, included as Maps 44 through 50, indicate the following information for each of the seven communities designated for detailed planning:

1. Boundary of July 31, 1976 flood;
2. Bridges that were destroyed;
3. Structures that were removed as a result of the flood;
4. Damage to U.S. Highway 34;
5. Geologic events that occurred during the flood.

Table 10 summarizes the information portrayed on the community impact maps (Maps 44-50).

The delineation of the flood boundary has been transferred from information included in USGS and CWCB [1976]. Information pertaining to the number and location of bridges and structures destroyed and the damage to U.S. Highway 34 is based upon interpretation of pre-flood aerial photographs compared with the post-flood base maps. The number and location of geological events were taken from Soule, et. al., [1976] and photographically enlarged from the original presentation scale of 1" = 1000' to 1" = 200'. Therefore, the geological information presented is accurate to only 1" = 1000' scale. The maps reflecting geological information are under review by the Colorado Geological Survey (CGS) to check accuracy. Any changes suggested by the CGS will be incorporated into the maps during Phase B of this program.

TABLE 10. SUMMARY OF PHYSICAL IMPACTS OF JULY 31, 1976 FLOOD [a]

	GLEN HAVEN	LOVELAND HEIGHTS/ GLEN COMFORT	WALTONIA	DRAKE/ MIDWAY	CEDAR COVE	SYLVAN DALE	BIG THOMPSON VALLEY EAST
STRUCTURES							
Removed [a]	10	14	20	83	45	15	25
BRIDGES							
Destroyed [a]	24	4	4	7	5	4	4
U.S. HIGHWAY 34							
Destroyed [b]	-	5,280'	14,678.4'	14,889.6'	2,798.4'	4,382.4'	-
Damaged [b]	-	15,840'	1,500.0'	5,300.0'	5,300.0'	600.0'	13,200'
GEOLOGIC IMPACTS [c]							
Debris Fans	12	21	4	-	-	-	-
Rockfalls	-	3	2	-	-	-	-
Landslides	2	2	1	1	2	-	-
Downcut Stream Channels	10	12	3	-	-	-	-
Sheet Erosion	4	3	-	-	-	-	-

[a] Toups Corporation, 1977.
[b] Adkins, 1977.
[c] Soule, et. al., 1977.

Property Damage

It has been estimated that 250 structures within the study area were completely destroyed by the flood, and that an additional 200 structures, residential and commercial, were damaged but are amenable to restoration [BTRPO & Inter-Faith, 1977]. The results of a post-flood land use survey conducted as a component of this study are presented in Chapter IV of this report (pages 63-78). This survey documented the number and use of structures that are currently present in the flood impacted area. No detailed land use surveys of pre-flood conditions exist. Therefore, at this time is is not possible to document the use of the structures that were destroyed by the flood. During interviews with canyon residents that will be conducted during Phase B of this program, information pertaining to the use of the structures removed during the flood will be collected. Table 10 indicates the number of structures that were removed as a result of the flood in each of the planning communities. These numbers include structures that were destroyed by the flood as well as those that were torn down subsequent to the flood due to the extensive damage they received during the flood. The data in the table is based upon the information reflected on the impact maps for each of the planning communities.

With the exception of one private access bridge located in the Loveland Heights/Glen Comfort community, all of the private bridges within the study area along the Big Thompson River and the North Fork were destroyed by the flood. This includes approximately 23 bridges along the main channel of the Big Thompson River and 24 bridges along the North Fork. Table 10 indicates the number of bridges removed in each of the planning communities based upon the information portrayed on the community impact maps (Maps 44 through 50).

Damage to Roads and Highways

The flood completely destroyed approximately 9.5 miles of U.S. Highway 34 within the 23 mile extent of the Big Thompson study area. In addition, approximately 10.5 miles of the highway were severely damaged as a result of the flood. Due to the extensive damage to U.S. 34, the Colorado Highway Department has repaired in excess of 20 miles of the road. Table 10 indicates the degree of damage to U.S. 34 occurring in each of the seven planning communities. Most of the areas where the highway was completely washed away occurred where the road severely constricted the river channel or where the road was located on the outside, or high velocity side, of a bend in the river. In both cases the extremely high flows and velocities of the flood could not be contained within the river channel and the road was destroyed. Approximately 10 miles of the county road through the North Fork of the Big Thompson River between Drake and Devil's Gulch and 4 miles between Devil's Gulch and Dry Gulch was completely washed out by the flood. The reason for this is that the road closely followed the river bed and as flows increased they could not be accomodated by the natural channel, hence the road was undercut and eventually washed away.

Geological Impacts

As indicated earlier in Chapter IV (Pages 33 through 40), CGS has mapped for the entire study area geomorphic features resulting from the Big Thompson flood. The severe flooding and high intensity rainfall promoted and/or accelerated several dynamic processes including erosion, deposition, and stream channel alteration. These geomorphic processes and resulting features greatly influenced the damage wrought by the flood and consideration of their implication is required in planning the reconstruction of the area.

The high intensity rainfall that produced severe damages during the storm involved a relatively small (15 to 20 percent) portion of the total Big Thompson drainage basin area west of the mountain front [Soule, et. al, 1977]. Because of this, many potentially hazardous areas were only slightly affected. CGS studies indicate that such violent meterorological processes have occurred many times and at many places in the past; accordingly, it is a reasonable conjecture that future cataclysmic events may occur in different parts of the area. Moreover, evidence indicates that most of the mapped geomorphic features can also be caused by localized intense thunderstorms such as occur much more frequently in the area than do storms of the magnitude producing the subject Big Thompson flood. Thus it is important to realize that although geologic impact maps presented in this chapter document actual flood-produced geomorphic features, and geologic hazard maps of the foregoing chapter delineate potentially hazardous areas, in reality both series of maps portray locations where adverse geological events could reasonably be expected to occur sometime in the foreseeable future.

As already indicated, a variety of geomorphic processes that produced observable features were associated with the flooding of the lower Big Thompson River. As with the potential geologic hazards discussed in Chapter IV, these flood impact features are displayed herein both on a canyon-wide basis (Maps 4 and 5) and on an individual community basis (Maps 44 through 50) for those seven communities receiving concerted focus in this report. The particular geomorphic features displayed on the maps have been selected for study due to their prominence and importance in determining future land use decisions.

The locations and rates of these processes change with time during a flood event causing changes in the locations and types of damage produced. Examination of these processes and the features produced conveys considerable insight into factors important for consideration in land use planning for flood prone areas. Flooding is a dynamic process during which changes occur in channel size, shape and location; water flow patterns; and damage patterns. It is critical to understand the interactions between man's use of land and these changing processes in order to accomplish safe and appropriate use of flood plains.

Flood-formed geomorphic features displayed in Maps 4 and 5 and Maps 44 through 50 are the following: (1) sheet erosion areas; (2) channel displacement; (3) stream bank erosion; (4) downcut stream channels; (5) debris fans; (6) flood deposits; (7) flood debris accumulation; (8) landslides; and (9) rockfalls. The flood limit as determined by USGS/CWCB [1976] is also delineated on all maps. It should be noted that a certain discontinuity exists in the reconnaissance conducted by CGS such that mapping of the study area segment below the Big Thompson Canyon mouth depicts channel displacement, stream bank erosion, flood deposits, and flood debris accumulation, while mapping of the remainder of the study area depicts the other features listed above.

Following is a description of the general types of geomorphic features examined and mapped as impacts of the flood. This discussion follows closely that appearing in Soule, et. al., [1977].

Flood Limit

The flood limit delineates the approximate extent of area inundated by flooding, rainstorms and resulting water runoff. Indicated are areas subjected to both water and debris movement and inundation. Recognition of the flood limit is accomplished by location of deposits of water-transported debris and sediment, by fluvially scoured and abraded bedrock adjacent to stream channels, and by other evidence recognized on aerial photographs of the area taken soon after the flooding.

As indicated earlier, the very intense rain which caused the Big Thompson flood occurred over less than 20 percent of the Big Thompson drainage basin west of the mountain front. Due to this rainfall pattern, there was a two-fold aspect to the flooding phenomenon and the resultant damages. In the areas of greatest rainfall intensity, flooding was characterized by spectacular flash-flood surges in relatively small and steep tributaries that also carried relatively large amounts of wood and rock debris. Those portions of the Big Thompson drainage basin that received moderate to no rainfall suffered little damage from local runoff. Damages in these areas were the result of main-stream flooding caused by heavy runoff and debris production in upstream areas.

The flash flooding during the subject rainstorms and the strong geologic evidence for many past flash-flood events at different places in the Big Thompson drainage basin indicate that all tributary drainage basins and dry-wash channels in this area are subject to periodic flash flooding.

This phenomenon may accompany a large regional rainstorm or may result from an isolated thunderstorm which produces only local effects. Though the frequency of flash flooding in a given dry wash is difficult to determine, it is clear that these local and potentially destructive events are much more frequent than larger events of regional impact.

Floodplain studies, whether routine or in the aftermath of a major flood, do not usually include all potential flood-hazard areas in a drainage basin such as the Big Thompson. Hundred-year floods and larger events are usually mapped only for selected reaches of the stream. These limits are then used as the principal basis for flood-hazard planning. As a consequence, "unexpected" flash flooding in smaller tributary drainage basins and ephemeral channels is common in the mountainous areas of Colorado and is usually not adequately considered in land use planning.

The CGS, based upon results of their geologic study, has formulated certain land use recommendations to be considered in assessing the safety of existing as well as future building sites in areas susceptible to flash flooding. It is emphasized that areas on the outside of sharp stream bends in any area not fully studied as to flash-flood potential are especially hazardous owing to possible superelevation of floodwater. Among the recommendations are that homes, sewer systems, vehicle parking areas, and other essential construction be located at least 12 feet above stream channels. Also advised is that man-made constrictions of stream channels be minimized or avoided since they can cause flooding by backwater upstream from the constrictions.

Sheet Erosion Areas

Sheet erosion areas are locations where large amounts of fine-grained surficial materials were removed and/or transported by sheet wash during the rainstorms producing the flood. Sheet erosion can occur during heavy rainstorms in essentially all parts of the Big Thompson Canyon area where vegetation is sparse, slopes are gentle to moderate, and fine-grained, poorly consolidated materials are present at the surface.

Sheet erosion, gully erosion, and sheet wash cause problems for residential developments because of undesireable erosion of the substrate under structures, deposition of eroded materials in natural and man-made drainageways; obstruction of drainage-control structures by sediment; and deposition of sediment on roads, building lots, and in buildings. Although threat to life and destruction of structures are unusual in these areas, erosion and deposition of fine-grained materials are usually a nuisance. Typically, the most desirable means of mitigating problems in sheet erosion areas is careful, well-planned control of surface drainage around roads and structures and avoidance of steeper cuts that are left barren of vegetation or other protective cover.

Stream Channel Displacement

Stream channel displacement by the flood occurred primarily where the pre-existing channel turned sharply; in many of these localities deep, high-velocity flood waters continued directly over the old bank and eroded a new channel. New channels formed outside the main channel resulted in changed

patterns of deep, high-velocity flooding and promoted increased damages. Stream channel displacement occurred along approximately 8700 feet of the Big Thompson River, predominantly in the section of the study area east of the canyon.

Debris Fans

A discussion of debris fans and their implications related to land use has already appeared in the previous chapter on Pages 35 and 36. The 75 debris fans depicted on the impact maps (Maps 4 and 5, and Maps 44 through 50) indicate areas where rock fragments, soil, and vegetation debris was transported down the associated lower-order drainage and moved across or was deposited upon the debris fan during the rainstorm.

Flood Deposits

Deposition of sediment was the most widespread flood-accelerated geomorphic process and cause of damage in the lower Big Thompson River flood plain. Significant deposition of sediment commonly occurred where there was a decrease in stream competence. This usually resulted from a velocity decrease caused by decrease in water depth or stream gradient, widening of the flood plain, a constriction, or a local variation of flood-plain geometry. Damages associated with these deposits included partial or complete burial of structures, roads, agricultural fields, and irrigation ditches. Locations of sediment deposition demarked on the maps include only those areas of relatively thick deposits. Deposition occurred to some degree throughout the flood plain except in those areas indicated as experiencing erosion.

Flood Debris Accumulation

Flood debris accumulations occur where floating material is caught on obstructions such as trees, bridges, buildings, and other structures. Smaller deposits of debris occur where depth of water decreases and can no longer carry its load. Damage patterns are altered due to the changes in flow depth and velocity. Debris caught in trees and in or on structures may protect an area immediately downstream by decreasing water velocity. In contrast, deflections of water by debris may locally increase velocity and cause severe damage. Accumulations of debris on bridges and houses may cause them to fail owing to the increased cross-sectional area upon which the flood water pushes. In the case of bridges, temporary damming followed by failure can cause flood surges that increase flooding and damage downstream.

Landslides and Rockfalls

Landslides and rockfalls that actually occurred during the flood-producing rainstorms usually occurred where slopes composed of relatively thick alluvium were eroded and undercut by flooding of the Big Thompson River or its tributaries. In a few localities debris slides and avalanches developed (see Maps 44-50 for specific locations). Localities where rockfalls occurred are shown separately from other landslides to demonstrate the similarity of these localities to many other places throughout the Big Thompson Canyon that are susceptible to rockfalls. Undoubtedly, many rockfalls that occurred during the storm have not been recognized since evidence thereof was probably removed by stream erosion or reconstruction before the CGS study was completed.

As already indicated in the previous chapter, potential hazards in landslides and rockfall areas cause severe problems for most construction. These areas are marginally stable at best and require site specific engineering analysis to determine whether they are at all suitable for development. It should be noted that during the recent flooding several structures slid into the Big Thompson River after the slopes where they were located were cut by erosion caused by flood flow.

Stream Bank Erosion

Stream bank erosion increased the area of flooding by widening the flood plain as the river eroded laterally. This process was especially severe on the outside of channel bends where flow was contained. Structures in such areas were damaged and destroyed by erosion and undercutting.

Downcut Stream Channels

Downcutting of stream channels occurred in portions of the Big Thompson watercourse which carried large volumes of high-velocity floodwater during the rainstorms which produced the flood. Flash floodwaters were sufficient to transport or remove some or all of the rocks and vegetation in these channels. Typically 1 to 3 feet of downcutting occurred in upper, steeper-gradient reaches of channels, whereas lower, lesser-gradient reaches saw transport of boulders 1 to 2 feet and occasionally larger in diameter. In some channels essentially all material was removed, leaving only a scoured bedrock surface. Channel downcutting is most pronounced in drainages that were subjected to the

highest rainfall intensities during the rainstorms. Essentially all channels, including small ephemeral drainageways in the Big Thompson Canyon area show evidence of similar flooding and downcutting having occurred in the past. Channels that were not downcut during the recent storm are not indicated on the impact maps; such mapping would merely produce a drainage net that can be easily deduced from the topography shown on the base map.

Hydrologic and Water Quality Impacts

The devastation caused by the Big Thompson flood illustrates that human encroachment and stream alterations can have dangerous repercussions. The flood severely altered the hydrologic and hydraulic characteristics of the river bed. Locations where water velocity was decreased served to collect major accumulations of debris while faster reaches of the river were scoured.

The U.S. Soil Conservation Service and the U.S. Forest Service are currently conducting a site by site analysis of the Big Thompson and North Fork channels for reconstruction purposes. Sites altered considerably by the flood will be rechanneled to protect property and maintain the hydraulic capacity of the channel. Special efforts will be directed toward reestablishment of the hydraulic capacity of the river by clearance, debris removal and rechannelization. Natural rock will be used wherever rip-rap is needed. Careful channel reconstruction may reestablish the ability of the natural channel to dissipate energy. This will contribute to preservation of life and property in the event of future flood occurrences.

Scouring of the stream bed and surrounding canyon area by high velocity flood waters resulted in the deposition of millions of cubic yards of sediment in and along stream beds. Reconstruction following the flood has increased the instability of soils and exacerbated sedimentation problems. Long range problems may be anticipated as a result of this sediment load. Beneficial stream uses which will be adversely affected include the coldwater fishery and associated recreational activities, water supply for agricultural irrigation, and water supply for municipal, industrial, and domestic use through both private and publicly owned water systems.

Sediment build-up at irrigation canal headworks is normally controlled by opening sluiceways to clear the sediment load once or twice a year. Sluicing on a weekly basis has become standard operating procedure since the occurrence of the flood. This increased maintenance expense may be expected to prevail for several years. Similar problems may be expected by the city of Loveland at its potable water treatment plant. Increased sediment build-up in the infiltration gallery, more frequent backwashing of sand filters, and higher turbidity levels resulting in increased chemical expenses should be anticipated.

As previously noted, the Big Thompson Siphon was demolished by the flood. This structure is an integral component of the system which transports water to Horsetooth Reservoir. Although the siphon was replaced as quickly as possible after the flood, several weeks passed during which water could not be furnished to Horsetooth Reservoir. Demand on the reservoir supply continued during this time and the water reached a

very low level. These events have been followed by a winter with very low precipitation; consequently the Horsetooth Reservoir water level is at present dangerously low.

Vegetation and Wildlife Impacts

Streambank vegetation along the various channels of the Big Thompson drainage suffered considerable damage from high intensity flows during the flood. These flows eroded root substrate and uprooted much of the low riparian vegetation associated with the channels. Several large trees were toppled and most of those that were not lost much of their root substrate and sustained injury from debris battering and abrasion. Trees thus weakened are particularly subject to pest attack and have therefore been designated for removal by the U.S. Forest Service.

The Big Thompson River fishery was a major recreational attraction for Larimer County prior to the flood. Physical conditions of the stream channel and hydrological conditions of the stream itself provided an ideal coldwater habitat for both stocked and indigenous trout. Bottom conditions in the stream were characterized by the presence of small boulders and cobble-sized rocks, and the absence of shifting silt. Flow conditions were well regulated from Olympus Dam to a constant flow of approximately 100 cfs throughout the canyon. The stable condition of the rocky stream bottom provided for development of a benthic faunal regime highly supportive of the stream fishery. Intermittent pools in the relatively steeply sloped canyon provided for a pool-to-riffle ratio ideal for trout habitation and reproduction.

These excellent fishery conditions have undergone radical alteration by the recent flood activity. This alteration has taken two principal forms: (1) channel scouring by high velocity flood waters, and (2) silt deposition in the former stream bed and surrounding canyon areas. This combination of events has essentially obliterated the highly conducive coldwater fishery conditions existing prior to the flood. Stream bed scouring has virtually eliminated the river's benthic invertebrate fauna, principal food source of trout. Deposition of silt from the canyon into the former stream bed is expected to cause especially troublesome adverse conditions as a result of the long-term instability of the canyon bottom. The shifting, unstable stream bed will discourage the development of a coldwater fishery in the canyon for some time to come. Sediment loads will vary seasonally and be considerably intensified during periods of spring runoff. Fisheries downstream of the canyon can also be expected to suffer from increased sediment loads and unstable bottom conditions.

The Colorado Division of Wildlife estimates that 80 to 90 percent of the previous Big Thompson drainage fish population was eradicated by flooding. Low flows, lack of food, and periodic stream freeze-up since the flood has likely resulted in death of most of the fish surviving the flood.

Stream rehabilitation has been strongly recommended by the Division of Wildlife and various other agencies. Even in the absence of rehabilitation measures, the stream will undergo a slow natural self-cleansing and rebuilding process leading to eventual return to pre-flood conditions. Such a process is quite slow and could be expected to take a number of years.

SECONDARY IMPACTS

The previous section discussed the consequences of the Big Thompson flood that were directly attributable to the physical event itself, such as destruction of property and loss of life. This section identifies some of the consequences indirectly resulting from the flood both within the planning study area and in the communities of Loveland and Estes Park. For the purposes of this study, the secondary impacts area has been generally limited to Loveland and Estes Park because these communities experienced the majority of the indirect consequences of the flood.

SOCIAL CONSEQUENCES

In terms of emergency housing provisions for the victims, the flood could not have occurred at a worse time. As indicated in the discussion of primary impacts, the flood temporarily or permanently displaced as many as 190 families living in the Big Thompson Canyon on a full-time basis. Although some of the people were able to return to the canyon within a relatively short period of time, many are still living in temporary housing and many will never be able or allowed to return to their homes in the canyon. The people that were dislocated were faced with an immediate serious relocation problem since housing opportunities in Loveland and surrounding communities were severely limited. In fact, according to the president of the Apartment Owners and Managers Association of Loveland, by the end of June, 1976, there were no vacancies in Loveland [Holman, 1977]. Therefore, the flood created an emergency need to house a large number of families thereby compounding a severe housing shortage in the Loveland area. Ironically, due to its tourist

nature, there was ample motel and hotel type housing available in Estes Park; however, because of flood-restricted accessibility and cost of this type of housing, most of these opportunities were not exploited.

A locally established HUD Disaster Office and the Apartment Owners and Managers Association set up a housing referral service on August 1, 1976. With the aid of local radio stations and newspapers, the service located over 80 temporary housing opportunities for the flood victims. Every possible housing opportunity was used including motels, old previously closed apartment complexes, and even basements of occupied residential dwelling units. When all possible opportunities in Loveland were exhausted, this referral service started locating flood victims in surrounding communities [Holman, 1977, and Shellhart, 1977].

ECONOMIC CONSEQUENCES

Businesses located along U.S. 34 and in other sections of Loveland and Estes Park experienced reduced revenues for the months of August and September over anticipated revenues due to the closure of U.S. Highway 34. Businesses in Estes Park were severely impacted by the closure of U.S. 34 especially since it occurred at the height of the tourist season. Based upon a survey conducted by the Estes Park Chamber of Commerce [Rogers, 1976], revenues for the month of August normally constitute an average 32 percent of annual revenues. Whereas 1976 retail sales within the city limits of Estes Park had increased by 26 percent over 1975 sales through the month of July, indicating a very good year, the sales for August decreased by 26 percent. During September, sales for 1976 were only 4 percent lower than 1975 primarily due to the reopening of U.S. Highway 34 as a temporary

facility. It has been conjectured that the losses experienced during the month of August in the Estes Park area may have exceeded $3,000,000. Total retail sales in Estes Park from January through September of 1975 were $18,836,050 compared with retail sales of $20,125,850 for the same period in 1976. Therefore, even though the flood reduced revenues during the months of August and September, the total annual revenues for the city increased by 6.8 percent and were not adversely affected. [Estes Park Chamber of Commerce, 1977].

The commercial establishments located along U.S. Highway 34 in Loveland also experienced significant reductions in business and loss of revenue during the period U.S. 34 was closed. Dennis Anderson of the Loveland Chamber of Commerce estimates that approximately $2,000,000 was lost by Loveland businesses as an indirect result of the flood. This figure reflects the Chamber's best estimate of flood-related business losses. However, as in Estes Park, the total retail sales increased by 25.9 percent from $73,861,000 in 1975 to $92,978,000 in 1976. This fact indicates that the flood did not adversely effect the economy of Loveland even though many businesses experienced lower than anticipated sales and revenues [Loveland Chamber of Commerce, 1977].

Though not confirmed by the surveys, it is common knowledge that numerous businesses were forced into closure during the time U.S. Highway 34 was closed. Therefore, employees were laid off and personal income in the Loveland and Estes Park areas was thereby affected by the flood.

TERTIARY IMPACTS

In addition to the primary and secondary impacts discussed above, the Big Thompson flood also affected the economy of the Larimer-Weld region. As a result of the flood a considerable amount of Federal and state monies have been channeled into the region. Probably the largest committment has been granted by the Department of Housing and Urban Development (HUD) to the Loveland Housing Authority. HUD has committed funds to the Loveland Housing Authority for construction of a 72-unit apartment complex and provision of rent subsidies to low-income elderly people displaced by the flood. To date, Loveland has received 140 applications for the 72 units available. Of these, 30 applications are from flood victims. When the project is complete, flood victims will be given priority over non-flood victims. It is apparent that only part of the 72 unit project will be used by flood victims and the project will not fully satisfy the housing requirements of those people displaced by the flood [Loveland City Manager's Office, 1977]. An additional $2,644,000 has been requested from HUD to aid in relocation of families displaced by the flood and rehabilitation of some of the lesser damaged homes and businesses in the flood impacted area [HUD, 1977].

The Federal Disaster Assistance Administration (FDAA) has allocated and spent in excess of $3,000,000 to repair and replace public facilities damaged or destroyed by the flood. Other significant expenditures include approximately $1,500,000 for rechannelization work to be accomplished by the U.S. Soil Conservation Service and the U.S. Forest Service, and an estimated $16,500,000 from the Federal Highway Administration for reconstruction of U.S. Highway 34 through the canyon [HUD, 1977].

The significance of these expenditures to the region is that a substantial portion of this money will flow directly to local contractors and businessmen, thereby acting as a stimulus to the regional economy. A detailed evaluation of the impacts of flood-related government spending upon the regional economy could be conducted by calculating the total amount of money expended and entering this figure into the Input-Output Computer Model developed for the region by the Larimer-Weld Regional Council of Governments. This would disclose the effect of the government spending upon different sectors of the regional economy. Such an exercise would not, however, indicate the impact of government spending upon the Big Thompson Canyon area, but would nevertheless be useful in documenting some of the regional impacts of the flood.

The result of the expenditure of Federal and state monies in the region at least partially, and may completely, offset the adverse economic consequences of the flood discussed in the primary impacts section of this Chapter (see pages 83 through 87). However, the people that suffered the direct economic losses are generally not the same people benefiting from the expenditure of government funds. Flood victims will benefit from the HUD funds allocated for the Loveland Housing Authority's project and requested for relocation and rehabilitation assistance. The remainder of the government funds will benefit people and businesses in the region other than flood victims, such as construction firms rebuilding U.S. 34 and the county road along the North Fork.

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