4-16-1984

Flood Insurance Study

City of Cedar City, Utah, Iron County

FLOOD INSURANCE STUDY

CITY OF CEDAR CITY, UTAH

IRON COUNTY

APRIL 16, 1984

Federal Emergency Management Agency

COMMUNITY NUMBER 490074

TABLE OF CONTENTS

TABLE OF CONTENTS - continued

FIGURES

TABLES

EXHIBITS

FLOOD INSURANCE STUDY
CITY OF CEDAR CITY, UTAH

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Cedar City, Iron County, Utah, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert Cedar City to the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these Federally supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 24 CFR, 1910.1 (d). In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgements

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by Rollins, Brown, and Gunnell, Inc., for FEMA under Contract No. H-4593. This study was completed in August 1982.

1.3 Coordination

A coordination meeting was held on August 2, 1979 with the FEMA consultation coordination officer, city officials, the study contractor, and interested members of the public. During this meeting, the Flood Insurance Program, Flood Insurance Study Guidelines, and the scope of this study were reviewed. Effective coordination efforts were established with the community, the Sacramento District office of the U.S. Army Corps of Engineers, other Federal agencies, and several private consultants in an effort to locate all existing hydrologic and hydraulic data. Meetings with the city engineering and planning staffs were held throughout the study period on an informal basis to review interim results, and provide relevant data for problem areas.

Requests for information were made to the U.S. Bureau of Reclamation, the U.S. Soil Conservation Service (SCS), the Sacramento District of the U.S. Army Corps of Engineers, and the Dixie National Forest. All these sources provided hydraulic or hydrologic data that were reviewed and incorporated into the engineering analysis. Requests for information from several local consultants also provided data on master plans of drainage and design plans of hydraulic structures. The State of Utah, Highway Department, District 5, provided construction plans for Interstate Highway 15 and U.S. Highway 91 which included hydraulic structure data.

Bulloch Brothers Engineering, representing the city, provided useful historic information, some cross sectional data, and development projections that were utilized as reference data presented in this report. The U.S. Army Corps of Engineers provided topographic mapping, their flood plain investigation of Coal Creek, HEC-II data, and related information from their study. They also reviewed the hydrologic analysis performed in this study and approved the discharges presented herein. Additional flood data were obtained from both the SCS and the U.S. Department of Agriculture Dixie National Forest.

On August 4, 1983, the results of the study were reviewed at the final meeting attended by representatives of the study contractor, FEMA, and community officials. The study was acceptable to the community.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Cedar City, Iron County, Utah. The area of study is shown on the Vicinity Map (Figure 1).

The areas studied by detailed methods were selected with priority given to all known flood hazard areas, and areas of projected development or proposed construction for the next five years, through August 1984. The flooding sources studied by detailed methods are listed below:

Fiddlers Canyon
Dry Canyon
Coal Creek
Cross Hollow

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The areas studied by approximate methods include Coal Creek from the canyon mouth upstream to the city limits, Squaw Creek, and Stephens Canyon. The scope and methods of study were proposed to and agreed upon by the FEMA and the City of Cedar City.

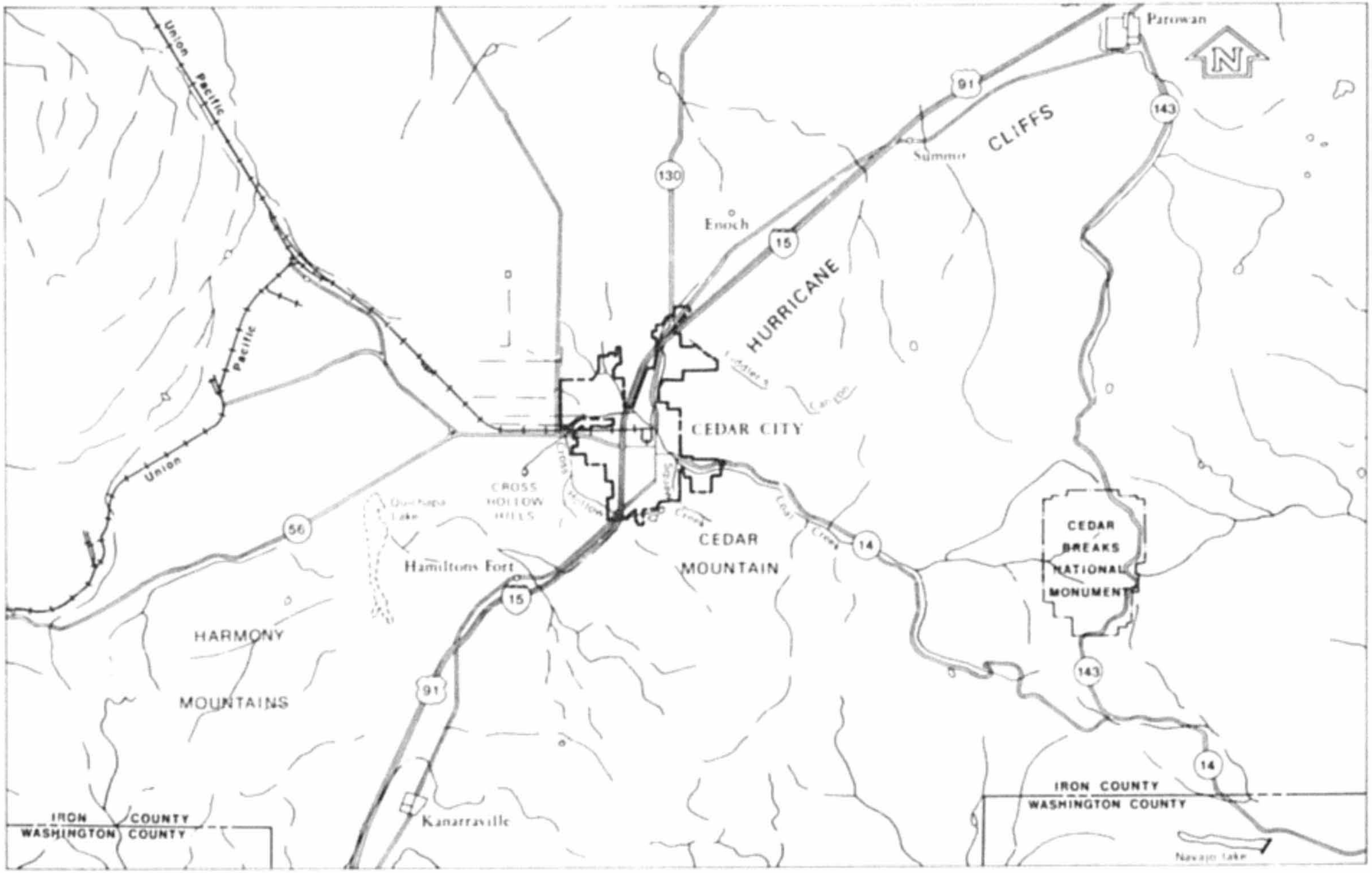


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF CEDAR CITY, UT
(IRON CO.)

APPROXIMATE SCALE
4 0 4 8 12 MILES

VICINITY MAP

2.2 Community Description

Cedar City is located in the southern portion of Iron County, in southwestern Utah, on Interstate Highway 15, approximately 175 miles northeast of Las Vegas, Nevada, and 265 miles south of Salt Lake City, Utah. Communities in the area include Enoch, Summit, and Parowan to the north, and Hamilton Fort and Kanarraville to the south. However, none of these communities share common borders with Cedar City.

Cedar City is situated in the Coal Creek drainage basin at the foot of the Hurricane Cliffs of the southern Rocky Mountains in the high desert plateaus of western Utah. It has an average mean winter temperature of 30° and a summertime average temperature of 74°.

Elevations of the Coal Creek drainage basin range from 10,000 feet on the plateau to approximately 5,500 feet in Cedar Valley. Most of the drainage basin is semiarid; however, the upper elevations support stands of pine and aspen forest. Vegetation in the lower elevations ranges from pinon and juniper in the foothills to sage and desert grassland in the valley. The foothills and lower mountain slopes directly north and east of Cedar City may be classified as badlands due to the large amount of rock-outcrop and sparse vegetation. These badland areas are a major source of the flooding potential which exists in the Cedar City area.

Cedar City was founded in 1853 as a mining colony by Mormon pioneers. Coal and iron deposits were opened and 2,500 pounds of iron were produced during the first year of development. This was the first iron produced west of the Mississippi River. The mining industry of this area still plays a very important part in the community's industrial base.

Cedar City has developed into a hub for the year round recreational activities of southwestern Utah. Zion National Park, Cedar Breaks National Monument, and major recreational areas of Dixie National Forest are less than 30 miles from Cedar City. Brian Head Ski Resort, located in Bear Valley at the base of Brian Head Summit, is only 13 miles east of Cedar City, and is reached by State Highways 14 and 143.

Cedar City's population is 10,972 based on the 1979 Bureau of Census estimates with a community population of nearly 18,000 within a 30 mile radius. Commercial development was tied to the iron and coal mining business, but rapidly expanding recreational activities have made a major impact on the retail trade segment of the commercial life of this community.

Commercial development has occurred along the north-south Main Street corridor, along 200 North Street from Main Street west to Interstate Highway 15, and along the access road (U.S. Highway 91) at the south end of the city.

Cedar City is supported by major transportation systems that include rail; bus, a regularly scheduled air carrier, State Highways 130, 56, and 14; Interstate Highway 15; and U.S. Highway 91.

The principal watercourse traversing the center of Cedar City is Coal Creek. Coal Creek, which has its origins high on the Markagunt Plateau, has a drainage area of 80 square miles, runs northwesterly from the eastern city boundaries through the northern half of the city and out into the agriculture areas of Cedar Valley to the northwest of the city's Metropolitan Airport. Here, the flow is generally lost to evaporation or infiltration. In very wet years, some runoff may reach Escalante Valley. Ashdown Creek, a major headwater tributary of Coal Creek, has its source in a spectacular soil and rock formation of the Markagunt Plateau set aside as Cedar Breaks National Monument. Floods often originate from this area due to the large amount of impervious area and very sparse vegetation. Large amounts of red-colored sediment are washed from this area with each flood.

2.3 Principal Flood Problems

The major flood threats to the City of Cedar City are of two similar types. Coal Creek, with a substantial drainage area, and several smaller, relatively sparsely vegetated drainages produce significant floodflows due to summertime thunderstorms of short duration, but high intensity. These storms traditionally occur in the summer months of July, August, and September. In addition, Coal Creek, with its large drainage area that extends into the alpine areas of the Markagunt Plateau, is subject to significant spring snowmelt runoff.

Records kept from the earliest days of settlement show the area is subject to periodic flooding from Coal Creek, and some of the smaller drainage basins immediately west and south of the city. As early as 1853 floods in Coal Creek were reported with major flooding events occurring in 1907, 1915, 1921, 1936, 1959, 1965, 1967, 1969, and 1975.

On Coal Creek, the floods of July 22, 1921, and August 20, 1921 with estimated peak discharges of 4,500 cubic feet per second (cfs) and 4,000 cfs represent estimated return periods of 20 years and 15 years, and resulted in estimated damages in excess of $387,000. On July 23, 1969, and July 12, 1975, Coal Creek sustained major floodflows estimated at 4,620 cfs and 4,440 cfs, respectively. The estimated return interval for these floods is 20 years and 19 years, respectively. The July 1969 flood is the maximum flood on record. On August 21, 1907, a relatively large amount of damage was caused by a flood in Coal Creek with a discharge of 3,650 cfs, and a return interval of approximately 15 years. Damage was estimated in excess of $139,000.

Summer thunderstorms have also caused major damage from floodflows in the smaller drainage basins of the Hurricane Cliffs immediately to the west and south of the city. On August 17, 1965, an estimated 2,500 cfs or a flood in excess of the estimated 100-year flood occurred in Fiddlers Canyon. Previous to the 1965 flood, major events were recorded in August 1921 and July 1936, with estimated peak discharges of 1,900 cfs and 1,650 cfs and estimated return intervals of 80 years and 50 years, respectively. During the August 1965 flood, it was reported that a wall of water four feet deep swept out of Dry Canyon causing considerable damage to U.S. Bureau of Land Management buildings and equipment, taking out a 40-foot section of the east rock wall of the city cemetery and spreading sediment and debris over a large area of this alluvial fan. No estimate of peak discharge or return interval are available.

The flood of July 26, 1959, originated from the mountain slopes southeast of Cedar City, in the Cross Hollow watershed. A peak discharge of 3,000 cfs was estimated above the residential areas and a peak of 1,200 cfs was reported to have passed through residential areas. These peaks represent return intervals of 125 years and 30 years, respectively. This flood promoted the SCS to construct the Greens Lake Watershed Project.

There is no information available concerning historical floods from Squaw Creek or Stephens Canyon.

2.4 Flood Protection Measures

The major flood protection measure that affects Cedar City is the Greens Lake Watershed Project, designed and built in 1957 by the SCS. This system is regulated by two sediment debris basins, two floodwater detention basins, and a floodway channel in the upper portion of the drainage basin. These facilities should provide adequate protection even from the 500-year flood in the upper areas of this basin. However, the lower areas, especially on the west side of the city and just south of the airport are still subject to flooding.

The majority of the other flooding sources have no existing flood protection systems with the exception of some diversion works and natural material levees along some reaches of Coal Creek. Neither of these improvements provides adequate flood protection from this watercourse.

Non-structural measures of flood protection are being utilized to aid in the prevention of future flood damage. These are in the form of land use regulations adopted from the code of Federal Regulations which control building within areas that have a high risk of flooding.

3.0 <u>ENGINEERING METHODS</u>

For the flooding sources studied in detail in the City of Cedar City, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded <u>once</u> on the average during any 10-, 50-, 100-, or 500-year period (recurrence intervals), have been selected as having special signi-

ficance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term <u>average</u> period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (one percent chance of annual occurrence) in any 50-year period is about 40 percent (four in 10), and for any 90 year period, the risk increased to about 60 percent (six in ten). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for floods of selected recurrence intervals for each flooding source studied in detail affecting the community.

Only one gaging station exists in the study area and it is located on Coal Creek near the mouth of Cedar Canyon. Discontinuous streamflow records exist for this site for the period of 1915 to 1937. Continuous records extend from 1938 to the present. A number of peak discharge estimates of unrecorded historic events are available dating as far back as 1886; however, recurrence intervals were hard to establish and the estimates were not felt to be reliable enough to include in a frequency analysis.

Since there are three types of events which may produce floods on Coal Creek, namely snowmelt runoff, cloudburst storms, or general rainstorms, it was necessary to determine if these events should be considered separately in the flood frequency analysis. The streamflow record for the gage on Coal Creek was examined and the annual flood peaks were separated into the three types of flood events. It was found that general rainstorms had never produced any recorded annual flood peak and thus needed no further consideration. A statistical test was then applied to the data for the other two types of annual flood events. This statistical test indicated, within a 99 percent confidence interval, that the two types of events do arise from different probability distributions, therefore, cloudburst and snowmelt floods were considered separately in the flood-frequency analysis. The probability distribution for the frequency analysis was assumed to be the log-Pearson Type III distribution and flood-frequency curves were developed according to U.S. Water Resources Council Guidelines, Bulletin 17A (Reference 1). The regional skew value of 0.0 was obtained from Plate No. 1 of the above report and used in the frequency analysis. Finally, a combined frequency curve, based on the snowmelt and cloudburst curves, was developed.

Discharge-frequency estimates were established downstream at Center

Street and Interstate Highway 15 using Modified-Puls storage routing techniques utilizing storage-discharge relationships developed for the stream by the U.S. Army Corps of Engineers in a previous study completed in 1979 (Reference 2). A decrease in discharge occurs downstream from the streamgage owing to overbank storage effects. Floods caused by cloudbursts have a relatively small volume and often attenuate as they proceed downstream.

The remaining streams included in the study do not have streamgaging records available. The drainage areas for these streams are small enough to render it inappropriate to use available regional methods for flood-frequency estimation. The SCS Curve Number Method (Reference 3) was used to estimate the 25-, 50-, and 100-year floods on these streams. These estimates were plotted on log-normal probability paper and a frequency curve was drawn (assuming a regional skew of 0.0) for extrapolation to the 10-, and 500-year floods. Precipitation-frequency estimates were obtained from a precipitation-frequency atlas (Reference 4).

A summary of drainage area-peak discharge relationships for each stream studied in detail is shown in Table 1.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail in the City of Cedar City were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of these flood sources.

The U.S. Army Corps of Engineers HEC-II computer program was utilized to estimate flood elevations for Coal Creek from Interstate Highway 15 to the mouth of the Cedar Canyon. The cross sectional information used to develop the computer model for Coal Creek was provided by the U.S. Army Corps of Engineers in card deck form. These cross sections were based on 1:2,400, 2-foot contour interval topographic mapping dated 1979 (Reference 5). These data were transcribed to provide computer analysis of Coal Creek consistent with the requirements of the Flood Insurance Study Guidelines and Specifications. Locations of selected cross sections used in the hydraulic analyses are shown on the flood profiles.

In the overflow areas above Interstate Highway 15 where shallow flooding occurs, normal depth calculations, based on the same 1:2,400 topographical mapping (Referrence 5), were compiled to determine the depths of flooding to be expected from the 100-year flood. Below Interstate Highway 15, the normal depth calculations were based on 1:24,000 U.S. Geological Survey (USGS) Quadrangle maps (Reference 6).

Dry Canyon and Fiddlers Canyon are active alluvial fans and the flood hazards associated with these flooding sources were determined by application of the methodology established by the FEMA and presented in the Flood Insurance Guidelines and Specifications, thereby identifying depth and velocity zones resulting from the 100-year discharges.

TABLE 1
SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ. MILES)	PEAK DISCHARGES (cfs)			
		10-Year	50-Year	100-Year	500-Year
COAL CREEK					
Near Cedar City gaging station	80.9	2,900	6,500	8,500	14,000
At Center Street	83.9	2,320[1]	5,305[1]	6,970[1]	11,860[1]
At Interstate Highway 15	86.7	1,410[1]	3,590[1]	4,760[1]	8,740[1]
FIDDLERS CANYON					
At Canyon Mouth	7.54	920	1,720	2,150	3,350
STEPHENS CANYON					
At Canyon Mouth	0.80	275	540	670	1,100
DRY CANYON					
At Canyon Mouth	1.23	370	700	870	1,350
SQUAW CREEK					
At Canyon Mouth	1.50	320	600	750	1,200
CROSS HOLLOW					
At State Highway 56	4.77	70	190	275	590

[1]The decrease in discharge with the increase in drainage area is due to overbank storage effects.

Flood boundaries and resulting shallow flooding depths for Cross Hollow were determined based on cross sections taken from 1:24,000 USGS quadrangle maps (Referrence 6) and normal depth calculations as they join the overflow areas of Coal Creek at State Highway 56.

Squaw Creek flood boundaries were found to be less than 200 feet wide and this study was reduced in scope to show approximate 100-year boundaries based on normal depth calculations.

Roughness coefficients (Manning's "n") that were used in the computations were assigned on the basis of field investigation of the flood plain areas and previous studies by the U.S. Army Corps of Engineers and the SCS. Listed in Table 2 are those Manning's "n" values used in this analysis.

TABLE 2
SUMMARY OF MANNING'S "n" VALUES

STREAM	MANNING'S "n" CHANNEL	MANNING'S "n" OVERBANK
Coal Creek	0.070	0.080
Cross Hollow	0.050	0.050
Squaw Creek	0.050	0.050

Debris potential was considered throughout the general area. Although there is significant suspended solids carried in the major floodflows in this area caused by erosion of streambeds and banks, this analysis reflects a low debris potential classification for all streams studied. Therefore, no provision for debris was made in the hydraulic analysis.

All hydraulic structures, including bridges, channel improvements, and retention systems were field investigated and current geometric data were obtained by field surveys. Copies of the as-built design drawings of the structures were also obtained and checked.

Flood profiles were drawn for Coal Creek showing computed water surface elevations for floods of selected recurrence intervals. All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). The location of the elevation reference marks used in the study are shown on the Flood Boundary and Floodway Maps and on the separately printed Flood Insurance Rate Maps.

Beginning water-surface elevations were determined by utilizing the data provided by the Sacramento District of the U.S. Army Corps of Engineers. The discharge for the watercourse was applied to a significant number of cross sections downstream of the beginning of each study reach and checked for consistency with known high water marks of previous flooding events to provide accurate beginning water-surface elevations.

For areas studied by approximate methods, flooding depths were determined from normal-depth calculations and examination of local topography. For Stephens Canyon, the approximate 100-year flood boundaries were determined using the alluvial fan methodology.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination the 100-year flood has been adopted by FEMA as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps. Approximate flood boundaries were delineated on a USGS quadrangle map, at a scale of 1:24,000 quadrangle map with a 40 foot contour interval and 10 foot supple-mental contours (Reference 5). Detailed flood boundaries were delineated using the above cited USGS quadrangle maps west of Interstate Highway 15 and using 1:2,400, 2 foot contour topographic maps (Referrence 5) east of Interstate Highway 15. In cases where the 100- and 500-year boundaries are close together, only the 100-year boundary has been shown.

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Flood Map. Small areas within the flood boundaries may lie above the flood elevations, and therefore, may not be subject to flooding. Owing to limitations of the map scale and/or lack of detailed topographic data, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this report are presented to local agencies as minimum standards that can be used as a basis for additional studies.

The floodways presented in this study were computed on the basis of equal-conveyance reduction from each side of the flood plain. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed (Table 3).

As shown on the Flood Boundary and Floodway Map, the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY	INCREASE (FEET)
COAL CREEK								
A	3,500	497	1,413	3.7	5,712.0	5,712.0	5,713.0	1.0
B	6,600	67	526	11.1	5,769.0	5,769.0	5,769.0	0.0
C	9,500	388	1,199	5.5	5,823.6	5,823.6	5,824.6	1.0
D	11,600	56	522	13.4	5,863.7	5,863.7	5,864.0	0.3

[1] Feet above east side of Interstate Highway 15

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF CEDAR CITY, UT

(IRON CO.)

FLOODWAY DATA

COAL CREEK

collinear, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

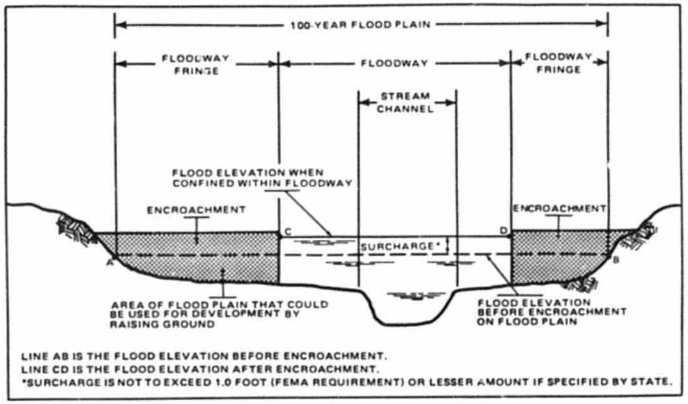


Figure 2. Floodway Schematic

In the case of shallow flooding on debris cones such as exist at the mouth of Fiddlers, Stephens, and Dry Canyons, and transitional areas of the alluvial plain below Interstate Highway #15, flow paths are highly unpredictable and subject to sudden changes in direction. Because this type of flooding is overland without a stable and consistent flow path to serve as a point of orientation around which to establish landuse control areas, delineation of floodways meeting FEMA criteria is impossible. Therefore, no floodways were developed for these areas.

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, FEMA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each flooding source affecting the City of Cedar City.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot

The locations of the reaches determined for the flooding sources of the City of Cedar City are shown on the Flood Profiles and are summarized in Table 4.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their assigned FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest one-half foot and shown as a three-digit code. For example, if the difference between the water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, the accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of the City of Cedar City was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A: Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
COAL CREEK							
Reach 1	03, 04	-0.2	0.0	0.0	005	A1	Varies - See Map
Reach 2	03, 04	-3.3	-0.9	1.8	035	A7	Varies - See Map
Reach 3	04	-0.8	-0.1	0.4	010	A2	Varies - See Map
Reach 4	04	-2.9	-0.8	1.3	030	A6	Varies - See Map
Reach 5	04	-5.0	-1.8	3.3	050	A10	Varies - See Map
Reach 6	04	-3.2	-0.9	2.2	030	A6	Varies - See Map
Shallow Flooding	01, 02, 03, 04	NA	NA	NA	NA	A0	Varies - See Map
CROSS HOLLOW							
Shallow Flooding	03	NA	NA	NA	NA	A0	Depth = 1 foot
DRY CANYON							
Shallow Flooding	04	NA	NA	NA	NA	A0	Depth = 2 foot
Alluvial Fan Flooding	04	NA	NA	NA	NA	A0	Depth = 3 foot Velocity = 8 fps
Alluvial Fan Flooding	04	NA	NA	NA	NA	A0	Depth = 2 foot Velocity = 7 fps
Alluvial Fan Flooding	04	NA	NA	NA	NA	A0	Depth = 2 foot Velocity = 6 fps

[1] Flood Insurance Rate Map Panel

[2] Weighted Average

[3] Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF CEDAR CITY, UT

(IRON CO.)

FLOOD INSURANCE ZONE DATA

COAL CREEK, CROSS HOLLOW, & DRY CANYON

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
FIDDLERS CANYON							
Alluvial Fan Flooding	02	NA	NA	NA	NA	AO	Depth = 2 foot Velocity = 6 fps
Alluvial Fan Flooding	02	NA	NA	NA	NA	AO	Depth = 1 foot Velocity = 5 fps
Alluvial Fan Flooding	02	NA	NA	NA	NA	AO	Depth = 1 foot Velocity = 3 fps

[1]Flood Insurance Rate Map Panel

[2]Weighted Average

[3]Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF CEDAR CITY, UT

(IRON CO.)

FLOOD INSURANCE ZONE DATA

FIDDLERS CANYON

methods, no base flood elevations shown or FHFs determined.

Zone AO: Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; depths are shown, or for areas of 100-year alluvial fan flooding, depths and velocities shown, but no Flood Hazard Factors are determined.

Zones A1,A2,A6, A7, and A10: Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones assigned according to Flood Hazard Factors.

Zone B: Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; or areas subject to 100-year flooding from sources with drainage areas of less than one square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

Table 4, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map of Cedar City is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineations of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by FEMA.

6.0 OTHER STUDIES

A flood plain study was prepared in October 1979, by the U.S. Army Corps of Engineers, Sacramento District, for Coal Creek (Reference 5). This study evaluated the same reaches of this flooding source as undertaken by the U.S. Army Corps of Engineers study. There are small differences between this study and the U.S. Army Corps of Engineers flood plain study. It provided the basis of the analysis of Coal Creek; however the flood discharges used in this study were slightly lower than that used by the U.S. Army Corps of Engineers. Therefore, flood boundaries along Coal Creek are slightly more narrow than those shown by the U.S. Army Corps of Engineers in their study.

Additionally, the U.S. Geological Survey has published flood-prone area maps for the Cedar City area (Reference 7). The 100-year frequency flood boundaries indicated in this report are in general agreement with those maps. The U.S. Geological Survey analysis was not as detailed as the analysis for this study and thus cannot be expected to be as accurate.

A report, Greens Lake Watershed Project, 1957 (Reference 8), was prepared by the SCS and gives background information concerning the hydrologic and hydraulic data of the area, and discusses the history of flooding in the southern Utah area. It also provided design plans of existing facilities and the designated floodway as constructed.

More recently, the SCS conducted a comprehensive study of the Beaver River Basin (Reference 9). This study included an analysis of flood problems in the basin and provided flood frequency estimates for several drainages included in the present study. The peak discharges presented in this Flood Insurance Study are in agreement with those presented in the SCS report.

The Utah Water Research Laboratory at Utah State University, prepared a report in January 1980, Flood Damage Mitigation in Utah (Reference 10), under the Water Resources Planning Series. This was a statewide comprehensive study of flood hazards, flood damage, and mitigation measures taken. Iron County is only one small segment of this report. The data presented is very general in nature and is not in conflict with data presented in this report.

The U.S. Bureau of Land Management (Reference 11) prepared a report and design plans for a flood control basin for Dry Canyon. This report provided hydrological data that was consistent with that presented in this report. The facility has never been constructed.

This study is authoritative for purposes of the National Flood Insurance Program; data presented herein either supersedes or is compatible with all previous determinations.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the Natural and Technological Hazards Division, Federal Emergency Management Agency, Building 710, Denver Federal Center, Lakewood, Colorado 80225.

8.0 BIBLIOGRAPHY AND REFERENCES

1. U.S. Water Resources Council, Guidelines for Determining Flood Flow Frequencies, Bulletin 17A, 1977.

2. U.S. Department of the Army, Corps of Engineers, Sacramento District, Coal Creek, Cedar City, Utah Hydrology, Office Report, 1979.

3. U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, 1972.

4. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Precipitation Frequency Atlas of the Western United States, Volume VI, Utah, 1973.

5. U.S. Department of the Army, Corps of Engineers, Sacramento District, Cloudburst Floodplain Area Cedar City and Vicinity, Coal Creek, Iron County, Utah, Map panels 1 through 4, Scale 1:2,400, Contour Interval 2 feet, 1979.

6. U.S. Department of the Interior, Geological Survey, Quadrangle Maps, Scale 1:24,000, Cedar City, Utah, 1971.

7. U.S. Department of the Interior, Geological Survey, Flood-Prone Area Maps, Scale 1:24,000, Contour Interval 20 or 40 feet: Cedar City, Utah, 1971.

8. U.S. Department of Agriculture, Soil Conservation Service, Watershed Work Plan, Greens Lake Watershed, Iron County, Utah, 1957.

9. U.S. Department of Agriculture, Economic Research Service-Soil Conservation Service and Forest Service, Beaver River Basin, Resource Related Problems, Appendix III, 1973.

10. James, et. al., Flood Damage Mitigation in Utah, Utah Water Research Laboratory, 1980.

11. U.S. Bureau of Land Management, Dry Canyon Detention Dam Design Data, Cedar City District, Utah, 1967.

Berwick, V.K., Floods in Utah, Magnitude and Frequency, U.S. Geological Survey Circular 457, 1962.

Butler, Elmer and J.C. Mundorff, Floods of December 1966 in Southwestern Utah, U.S. Geological Survey Water Supply Paper Number 1870-A, 1970.

Butler, E. and R.W. Cruff., Floods of Utah, Magnitude and Frequency Characteristics Through 1969, U.S. Geological Survey Open File Report, 1971.

Butler, Elmer, Developing a State Water Plan, Cloudburst Floods in Utah 1939-69, U.S. Geological Survey - Utah Division of Water Resources Cooperative Investigations Report No. 11, 1972.

Dawdy, David R., Flood Frequency Estimates on Alluvial Fans, Journal of the Hydraulics Division, ASCE, November, HY11, pp. 1407-1413, 1979.

Eychaner, James H., Estimating Runoff Volumes and Flood Hydrographs in the Colorado River Basin, Southern Utah, U.S. Geological Survey Water Resources Investigation, 76-102, 1976.

Federal Highway Administration, Runoff Estimates for Small Rural Watersheds and Development of a Sound Design Method, Volumes I and II, Prepared by Utah Water Research Laboratory, Utah State University, 1977.

Fields, Fred K., Estimating Streamflow Characteristics for Streams in Utah Using Selected Channel-Geometry Parameters, U.S. Geological Survey Water Resources Investigations, 34-74, 1975.

Jeppson, R.W., et. al., Hydrologic Atlas of Utah, Utah Water Research Laboratory, 1968.

Richardson, E. Arlo, Estimated Return Periods for Short-Duration Precipitation in Utah, Department of Soils and Biometeorology, Utah State University, 1971.

U.S. Bureau of the Census - 1980 Estimates, provided by the Cedar City Chamber of Commerce.

U.S. Department of Agriculture, Economic Research Service - Soil Conservation Service and Forest Service, Beaver River Basin, Natural Resource Inventory (Soils Supplement), Appendix I, 1972.

U.S. Department of the Interior, Geological Survey, Compilation of the Records of Surface Waters of the United States through 1950 to September 1960, Part 10, Colorado River Basin, Water-Supply Paper No. 1734, 1964.

U.S. Department of the Interior, Geological Survey, Water Resources Data for Utah, separate books for each year, 1961-1978.

U.S. Department of Agriculture, Soil Conservation Service, Sevier Lake Survey Report, 1950.

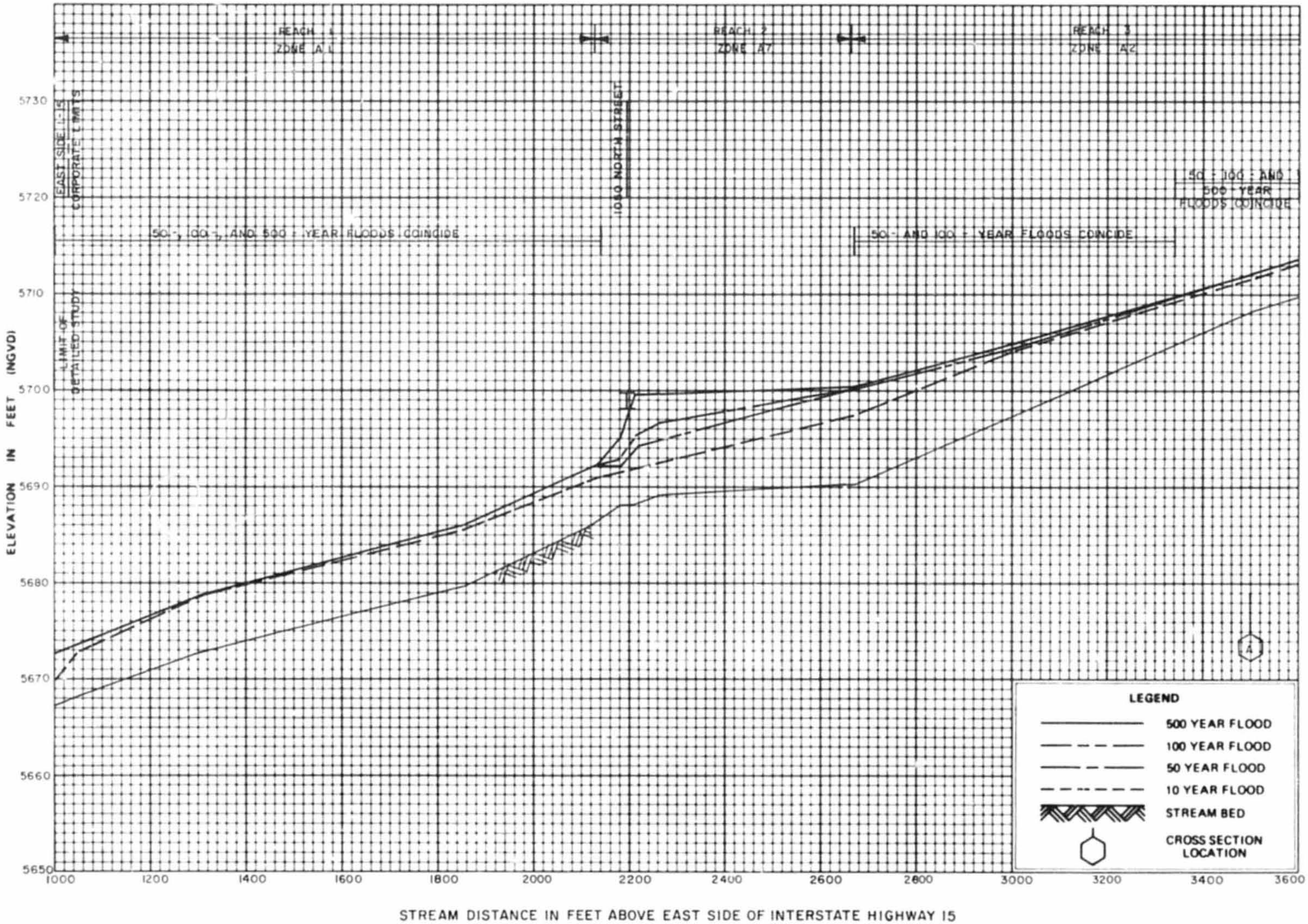
U.S. Department of Agriculture, Soil Conservation Service, Virgin River Study, 1951.

U.S. Department of Agriculture, Soil Conservation Service, Utah Floods File.

U.S. Water Resources Council, Pacific Southwest Inter-agency Committee, Great Basin Region Comprehensive Framework Study, Appendix IX, Flood Control, 1971.

Whitaker, G.L., Summary of Maximum Discharges in Utah Streams, State of Utah Technical Publication No. 21, 1969.

Wooley, R.R., Cloudburst Floods in Utah 1850-1938, U.S. Geological Survey Water-Supply Paper No. 994, 1946.



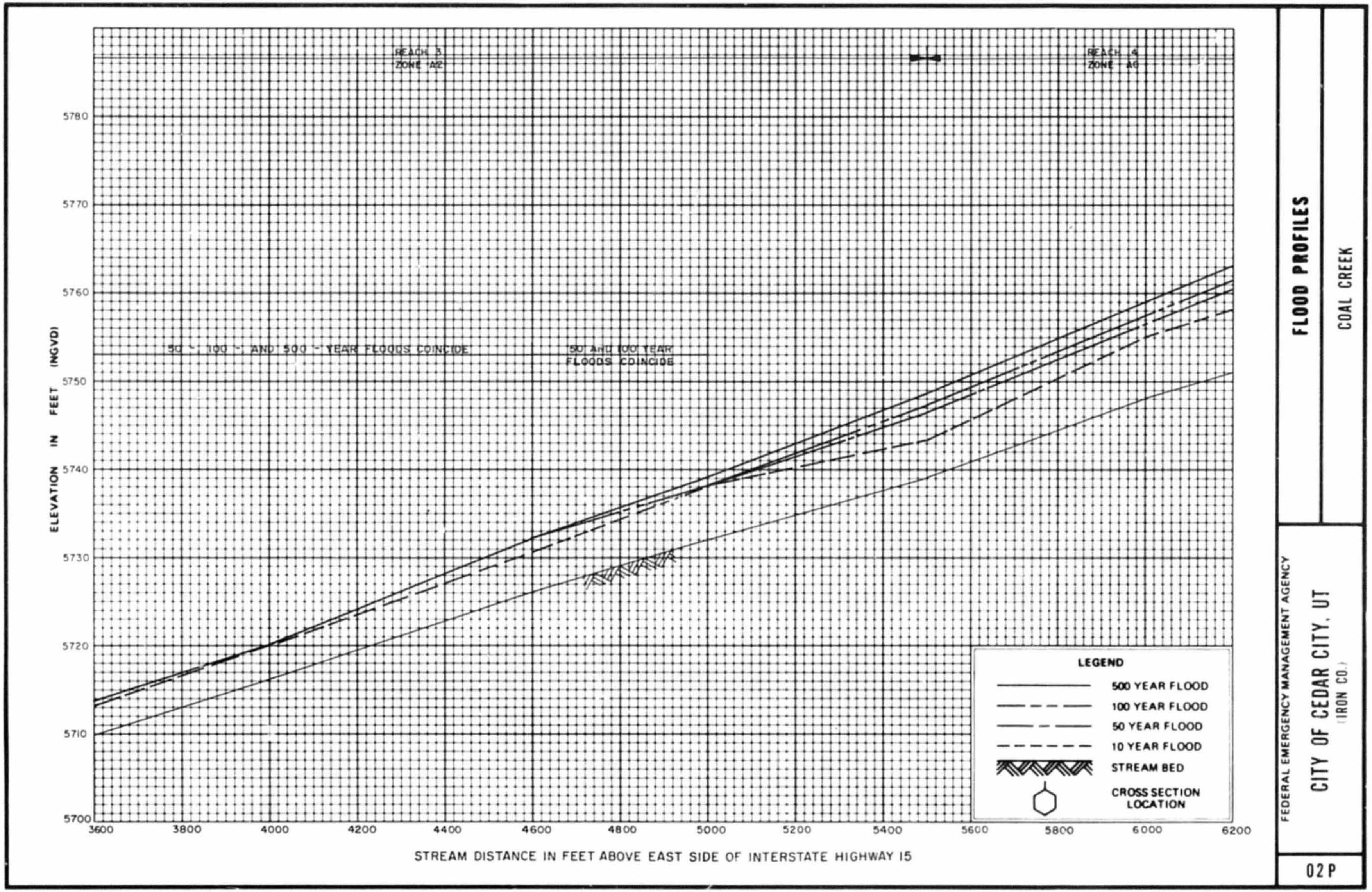
FLOOD PROFILES

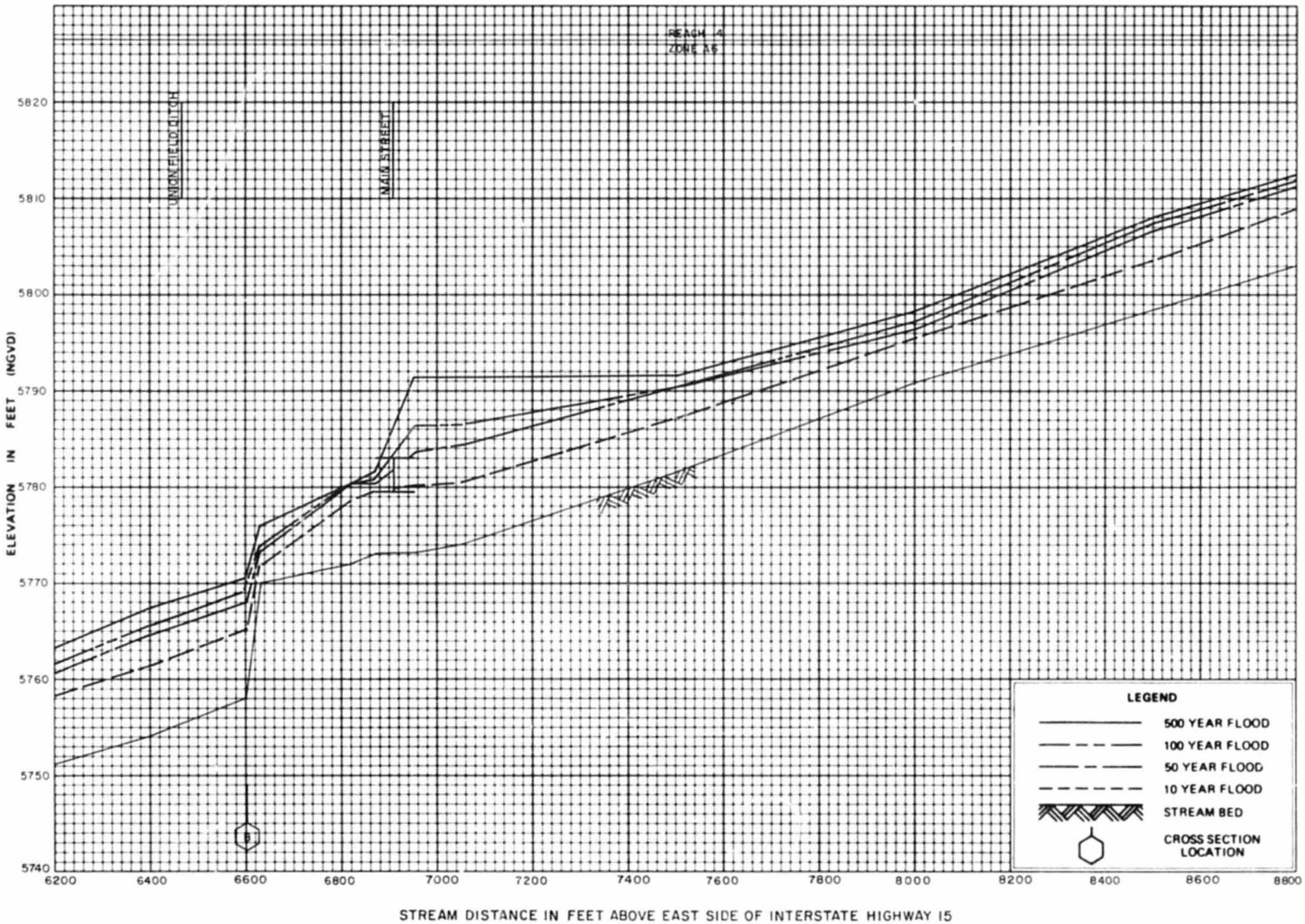
COAL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF CEDAR CITY, UT
(IRON CO.)

01P


REACH 3
ZONE A2
REACH 4
ZONE A6
50-, 100-, AND 500-YEAR FLOODS COINCIDE
50 AND 100 YEAR FLOODS COINCIDE
ELEVATION IN FEET (NGVD)
5700
5710
5720
5730
5740
5750
5760
5770
5780
3600
3800
4000
4200
4400
4600
4800
5000
5200
5400
5600
5800
6000
6200
STREAM DISTANCE IN FEET ABOVE EAST SIDE OF INTERSTATE HIGHWAY 15
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
COAL CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY OF CEDAR CITY, UT
(IRON CO.)
02P



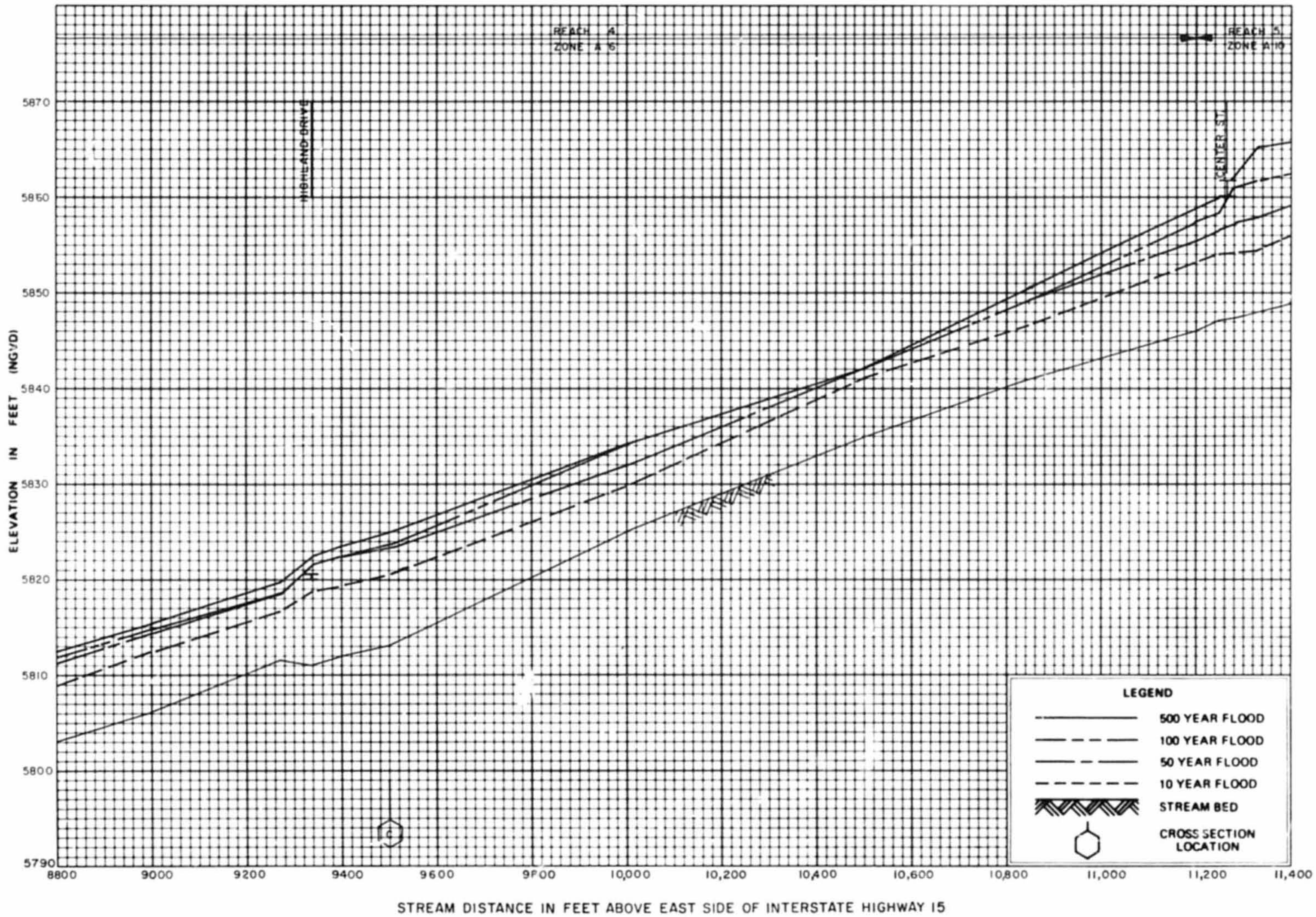
FLOOD PROFILES

COAL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF CEDAR CITY, UT
(IRON CO.)

03P



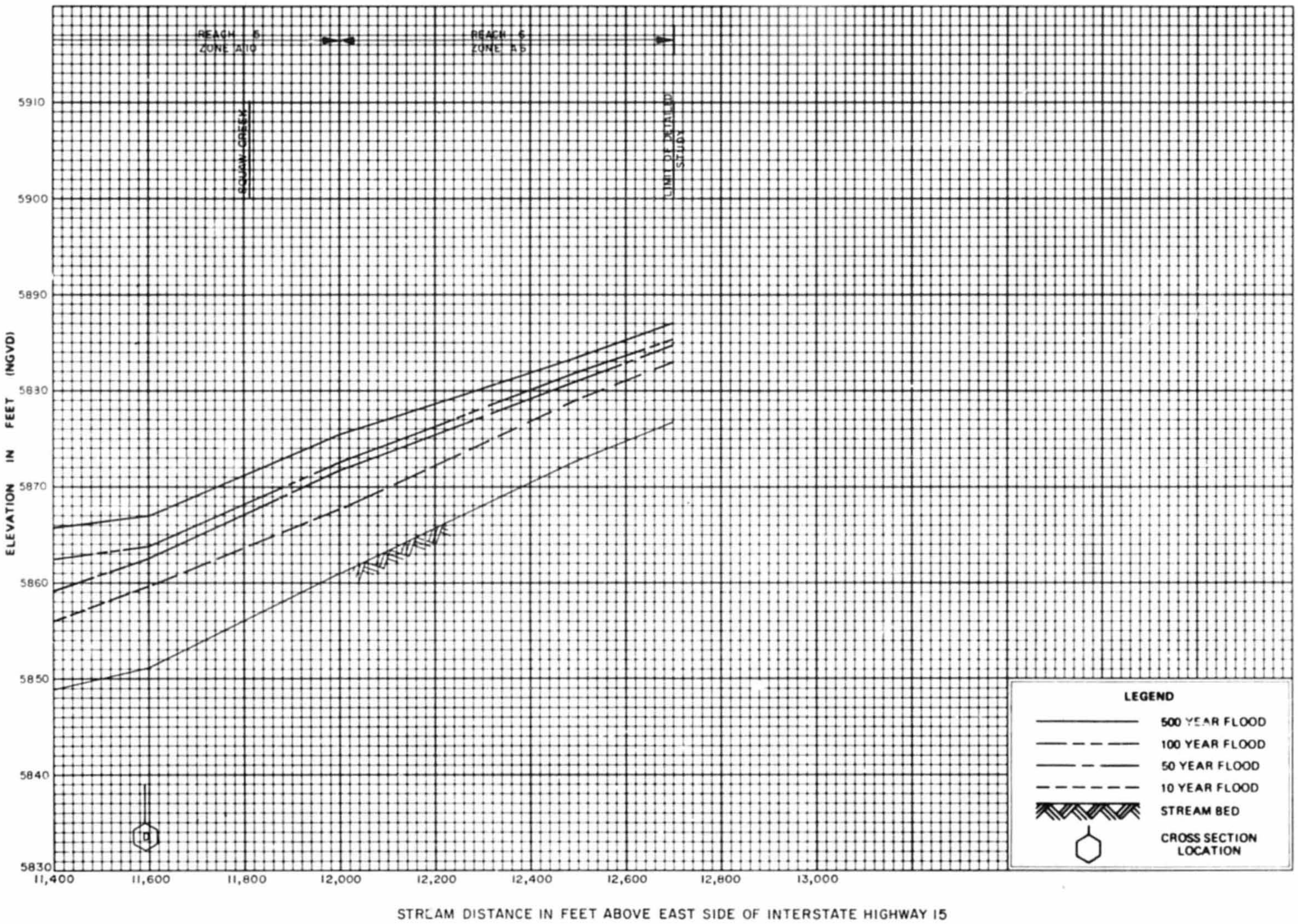
FLOOD PROFILES

COAL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF CEDAR CITY, UT
(IRON CO.)

04P



FLOOD PROFILES

COAL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF CEDAR CITY, UT
(IRON CO.)

05P