2130

FLOOD MITIGATION PLAN

for a

FLOOD CONTROL PROJECT

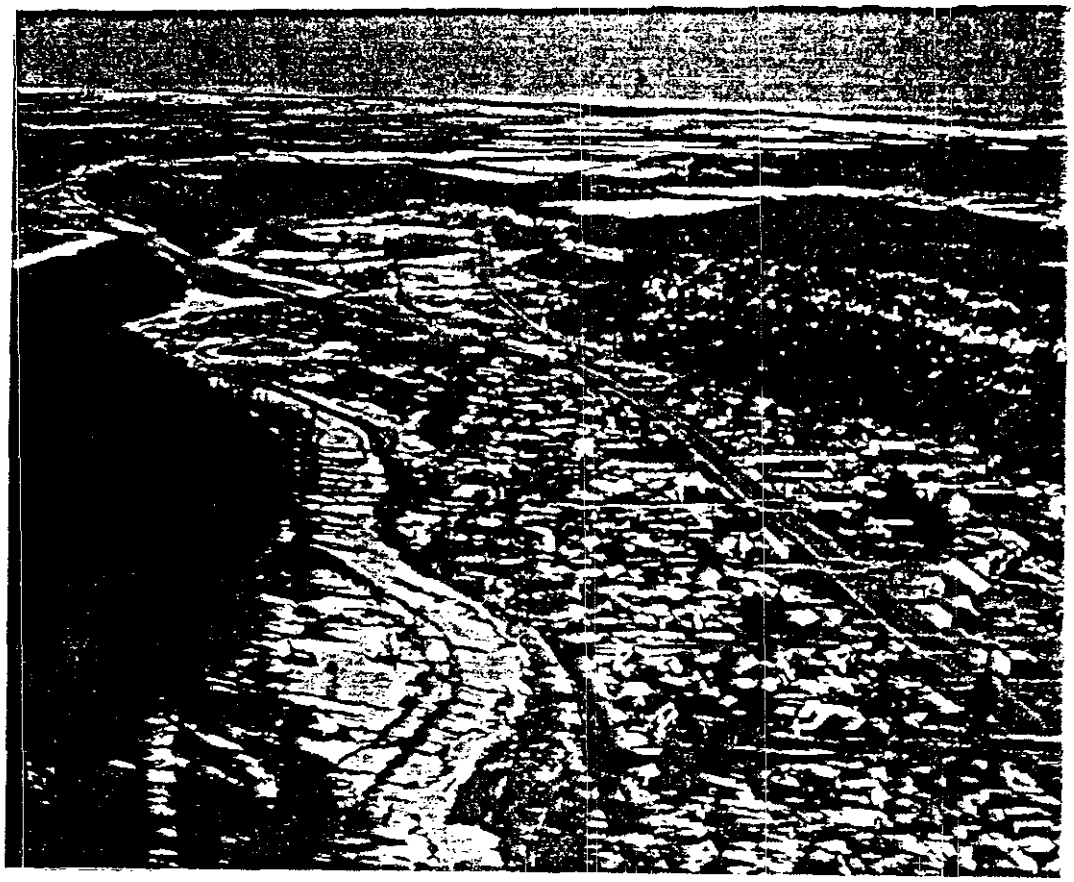
on the

DOLORES RIVER

at

DOLORES, COLORADO

ORIGINAL



by the

COLORADO WATER CONSERVATION BOARD

in cooperation with the

TOWN OF DOLORES, COLORADO

January, 1986

This Study was conducted under the direction of the
Colorado Water Conservation Board

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Flood Mitigation Plan
Town of Dolores

1. Introduction

1.1 Purpose and Scope of Report

A significant portion of the town of Dolores lies within the 100-year floodplain of the Dolores River. Portions of the town have recently received levee protection as a part of the U.S. Bureau of Reclamation's McPhee Reservoir project, immediately downstream of Dolores. There are, however, still several paths for floodwaters to overflow into town and flood much of Dolores. The purpose of this report is to review the current flood hazard in Dolores and to develop a means for addressing the threat posed to the town by a 100-year flood. The report reviews steps that have already been taken to reduce the flood threat and options for further reduction or elimination. The only type of long-term option is levee protection. Floodproofing or flood insurance will not prevent flooding, however, both flood mitigation measures will assist in lessening the economic impact of flood.

After the options have been discussed, and their estimated costs presented, the report recommends which options should be pursued. It describes possible phasing of the recommended course of action and potential funding sources. The report, therefore, provides the town of Dolores with a preliminary engineering analyses for the development of a flood hazard mitigation program. Final engineering design should be completed at such time as funding for a project has been secured.

1.2 Limits of Study

The study area is principally within the corporate limits of the town of Dolores. There is additional area in unincorporated Montezuma County. The downstream limit of

study is the newly constructed McPhee Reservoir, immediately west and north of the town of Dolores. All floodwaters will flow into this reservoir. The upstream limit of study is immediately east (upstream) of the town of Dolores water treatment facility, which is, in turn, east of the town of Dolores. It is a short distance west of the water treatment facility that floodwaters would first cross over Highway 145 and flow into town. To prevent waters from flowing into Dolores, a flood protection project would have to direct them into the river channel at this upstream point. Only then could protection at the other potential breakout points be justified. A structural mitigation project should, therefore, address the entire study area.

2. The Setting

2.1 Description of the Study Area

The town of Dolores is in the Dolores River basin in the Four-Corners area of Colorado. Upstream of Dolores the river basically flows from northeast to southwest. At Dolores it enters McPhee Reservoir, at which point the direction of flow changes to northwesterly. The river then flows to the Colorado River, joining that stream in eastern Utah about 100 airline miles northwesterly of Dolores. (See Plate 1.)

The Dolores River rises in the San Juan Range, in southwestern Colorado. In total, it drains about 870 square miles upstream from Dolores. Elevations range from about 6900 feet at Dolores to over 14,000 feet in the high headwater regions. Much of the higher drainage area is timbered with pine, fir, and spruce, while low brush dominates in the lower elevations in Dolores. Stream gradients upstream from Dolores average about 30 feet per mile.

The oldest known residents of the Dolores area were the Anasazi Indians who occupied the region until about 900 A.D. Particularly during the construction of the McPhee Reservoir, many artifacts of these people have been found by archaeologists. Several centuries later, in 1776, the

Dominguez-Escalante Expedition from the Spanish capitol in Santa Fe passed through the area.

About 100 years later, in 1878, interest in mining, livestock raising, and farming led to the establishment of a post office. The area's economy today revolves around ranching, farming, logging, mining, and tourism. It is expected that the completion and filling of McPhee Reservoir in the near future will increase tourist activity around Dolores.

2.2 Climate and Flooding Characteristics

Much of the annual precipitation in this region occurs as snow, and a deep snowpack usually accumulates in the high elevations. Convective type cloudbursts storms occur frequently in southwestern Colorado in the summer. General frontal type rainstorms approaching from the southwest can also occur over the Dolores River Basin from mid-June through December, but records show that they occur most often during September and October.

Snowmelt runoff in spring and early summer constitutes a frequent but comparatively moderate flood threat because high peak flows are not characteristics of snowmelt runoff on the Dolores River. Cloudburst storms produce high intensity rainfall but, due to the small areal extent of this type of storm, their short duration, and small volume of runoff, they constitute a significant flood threat only in the smaller drainage basins. General rains from fronts are the most serious flood threat in Dolores.

The largest flood of record, which occurred in October 1911, resulted from a frontal type of storm on the drainage areas of the Dolores and West Dolores Rivers. Much of the town of Dolores was flooded at that time. In May, 1973, snowmelt runoff damaged areas along the Dolores River upstream of Dolores and threatened other riverine areas. A bridge was washed out on Lost Canyon Creek. Large snowmelt flows also occurred on the Dolores River in May 1941 and June 1949. The largest recent flood on the Dolores River occurred in September 1970, but information other than

magnitude of flow for that flood is not available. Flood losses in the study area usually consisted of damage to bridges and irrigation structures. In a number of flood years, flood fighting was required to protect residential and commercial areas from rising water.

2.3 Stream Hydrology and Hydraulics

To determine peak flows of the 100-year flood, the U.S. Army Corps of Engineers made a flow-frequency analysis of flows recorded at the "below Rico" and "at Dolores" stream gaging stations on the Dolores River[1] according to guidelines established by the U.S. Water Resources Council. Snowmelt floods and rain floods at the Dolores gage were separated and statistically analyzed to determine the type of event that would cause the larger, less frequent floods. This type of analysis was not made for the Rico gage because the period of record is too short.

Unit hydrographs for the Dolores River were developed by the Snyder, s-curve, and optimization techniques, and were based on the flows of the September 1970 flood at the Rico and Dolores gages. Loss rates developed for this study were compared to and found basically the same as those from earlier studies made by the the Los Angeles District of the Corps of Engineers and the U.S. Bureau of Reclamation.

Peak flow-frequency values found for the 10-, 50-, 100-, and 500-year floods at selected index points are tabulated below.

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[1] Periods of record: 1914-15, and 1952-present, Rico gage; 1896-1903, 1911-12, and 1992-present, Dolores gage.

TABLE 1

Index Point	Drainage Area (Sq. Mi.)	Peak Flow (Cubic Feet per Second) 10-year Flood	50-year Flood	100-Year Flood	500-Year Flood
Dolores River above the mouth of the West Dolores River	270	3,700	6,000	7,500	20,000
West Dolores River at mouth	167	2,300	3,800	4,800	11,500
Dolores River below the mouth of Lost Canyon Creek	567	6,800	11,500	14,500	36,000

Using the discharges from Table I, flood elevations were computed with the Corps of Engineers' step-backwater program HEC-2. Basic cross section input was from surveyed cross section data furnished by the Colorado Water Conservation Board. The depth of water in the channel and adjacent flooded areas can be determined from the water surface elevations.

Plates 2a and 2b show the areas that would be inundated by the 100-year flood under present conditions. The 10-year flood would be contained within the stream channel, and the 50-year flood would closely follow the pattern of the 100-year food.

Velocity of flow during a 100-year flood on the Dolores River would average about 7-8 feet per second in the channel and 4 feet per second in overbank areas. Water flowing at about 2 feet per second or less will deposit sand, silt, and flood borne debris. Streambanks and the fill around bridge abutments may be eroded and large volumes of sediment transported by water flowing at a rate of 5-7 feet per second. Water flowing at 10 feet per second will cause severe erosion of channels, destroy low water crossings, and transport large boulders.

Substantial damage can be expected in the town of Dolores given the calculated velocities. In addition, any structural flood protection measures would need to include

riprap or other protection from erosion, so the flood protection structures themselves survive any flood.

2.4 Flood Damages

A preliminary count indicates between 80% and 90% of the town's structures would be flooded to varying degrees. At present the problem would begin with water breaking out just east of Dolores, crossing over Highway 145 and spreading out through town.

About 75% of the 100-year floodplain in town would experience flooding depths of 0 to 2 feet. Approximately 20% would experience flooding depths between 2 to 4 feet. About 5% would experience flooding depths over 4 feet.

Plate 3 shows the relationship between depth of flooding and the percent damage to a structure. The chart shows that slight damage due to seepage can be expected even in those buildings with their lowest floor somewhere between 0 and 1 foot above the 100-year flood elevations. These percentages of damage for each building can be combined with an assumed (or more accurately determined) dollar value for each building to calculate damages during a 100-year flood. By determining which buildings are in the 50-year floodplain, the 25-year floodplain, and the 10-year floodplain, and by using the same technique as for the 100-year floodplain, a curve showing estimated dollar damage versus the probability of flooding in any given year can be constructed. The area under that curve represents average annual damages. Over $100,000 in average annual damages was estimated for Dolores. Additional damages of major significance could be expected at the Water Treatment Facility. The ponds on the site would be destroyed and the buildings would experience substantial damage.

Other damages, such as transportation disruptions, closure of businesses, landscaping damage, cleanup costs infiltration into utilities, etc., were not accounted for in detail. Given the wide extent of the floodplain, those types of damages can be expected to be significant.

2.5 Existing Mitigation Measures

Almost all of the efforts carried out so far to reduce potential flood damages have consisted of levee construction. Prior to the McPhee Reservoir project levees were constructed locally. These are all too low to meet federal criteria. They are also in need of repair.

Within the past year the Bureau of Reclamation has constructed, as a portion of its McPhee Reservoir project, levees which provide flood protection. The primary purpose of these efforts was to eliminate potential backwater flooding from the new reservoir. Incidentally to this primary purpose, they protect certain portions of Dolores from a 100-year flood. Downstream of the 4th Street Bridge very little additional flood protection work is needed. Upstream of that bridge two sections of new levee have been completed. A part of one of these sections would meet federal freeboard criteria, but some raising of these new levee sections would be needed to meet the federal criteria.

The Bureau project also created a large park west of Dolores, between Highway 145 and the river. This area was formerly a low area, the site of more than 10 houses, almost entirely within the 100-year floodplain. It would now be subject to minor shallow flooding during a 100-year flood, something perfectly acceptable in a park. (See Plate 4.)

The final measure taken to date has been the purchasing of flood insurance. 8 NFIP policies were in effect as of November 25, 1985. Clearly that small number of policies is only addressing a small part of the flood threat in Dolores.

3. Alternatives for Flood Hazard Mitigation

A substantial part of Dolores lies in the 100-year floodplain. Within the area of concern in this report there are approximately 175 structures in the 100-year floodplain. The options discussed in the following section

are intended to address the question of protecting these 75 structures.

3.1 Flood Insurance

Given the small number of flood insurance policies in effect in Dolores, consideration should be given to encouraging more property owners to purchase flood insurance as long as portions of the town remain in the 100-year floodplain. Using maps and brochures, property owners could be notified of the hazard they face and of the availability of flood insurance. Ultimately the purchase of flood insurance is decided by property owners and lenders; the town can only inform people of the situation.

3.2 Floodproofing

In October 1983, the Colorado Water Conservation Board completed the Colorado Floodproofing Manual. The material in that manual could guide individual property owners on how to protect their buildings or, at least, how to reduce damages. Given the relatively large number of structures involved if total floodproofing were pursued, however, it appears that a structural flood protection project could be far more cost effective than floodproofing. It should also be noted that floodproofing would not protect streets, utilities, or landscaping or reduce outdoor clean up costs.

3.3 Structural Flood Control Measures

As shown on Plate 4, the Bureau of Reclamation has already constructed some levees in Dolores. These essentially stop at the 4th Street Bridge. Upstream of 4th Street there are two short sections of levee that were constructed by the Bureau. Parts of these levee sections are not high enough to meet the National Flood Insurance Program (NFIP) criterion of 3 feet of freeboard above the 100-year flood elevation (4 feet for the first 100 feet upstream of bridges). In addition, there are several gaps where there is not levee protection to keep 100-year flows out of the town.

Given the facts that the town is already substantially built out, that much of the town is in the 100-year floodplain, and that a partial network of levees already exists, the only feasible structural flood control alternatives for Dolores involve levee construction. For the north side of the river where the town is located, two alternatives are feasible. They both involve construction of new levees in combination with the improvement of existing levees from the 4th Street Bridge upstream approximately 3/4 mile to Station 66+00, directly opposite the eastern boundary of the Dolores High School. One alternative, Alternative A, would then turn north for 200 feet to Highway 145, then turn east for 300 feet along the south edge of the highway to tie into high ground. The second alternative, Alternative B, would continue along the north bank of the river for about 1250 feet, at the eastern boundary of the Dolores Water Treatment Facility, then turn north for approximately 400 feet to Highway 145.

As mentioned above, the two alternatives are identical from the 4th Street Bridge to Station 66+00. That portion of the project has been divided into 5 distinct sections. These are described below. The remaining portions, where there truly are two alternatives, will be described immediately after these 5 sections. Plates 5a and 5b show a map view of the levee alternatives. Cross-section drawings are also included on plates 6a and 6b, and profiles are shown on Plates 7a and 7b.

Two levee alternatives are considered in this report for the south side of the river, essentially between the alignments of 5th Street and 7th Street, where some existing homes are in the 100-year floodplain. These alternatives are also illustrated on Plates 5a and 5b, Plates 6a and 6b, and Plate 7a.

4. Plan Formulation

The structural plan of-improvement that has been selected for the study reach is one that considers levees on the right (North) bank and left (South) bank. The plan is described by a station reference. The levee stationing

used for the plan description is an extension of the Bureau of Reclamation project stationing for the McPhee Reservoir project. The Bureau levees between Highway 145 and the 4th Street Bridge provide 100-year flood protection. The proposed plan extends upstream of the 4th Street Bridge (Station 28+80).

4.1 Descriptions of Right (North) Bank Levees

4th Street to 6th Street - (Stations 28+80 to 36+40)

This section lies between the 4th Street Bridge and the first section of new Bureau of Reclamation levee. The majority of the section can be protected through the construction of a new levee. One portion, however, will require construction of a concrete flood wall because there is not enough room between the river and two existing houses for a levee.

Stations 28+80 to 34+10 - 530 feet of new levee construction. Of the 530 feet, approximately 240 feet would be about 2 feet high, while approximately 290 feet would need to be about 6 feet high. (See cross-section A-A)

Stations 34+10 to 35+10 - 100 feet of concrete floodwall. Because the wall needs to extend to 2 feet below the bottom of the channel to reduce the threat of undermining from erosion, the wall would need to be 14.5 feet high, with about 2.5 feet of that extending above existing ground.
(See cross-section C-C)

Stations 35+10 to 36+40 - 130 feet of new levee construction. The average height is 2.5 feet high.
(See cross-sections A-A)

6th Street to 7th Street - (Stations 36+40 to 42+40)

This section includes 600 feet of new levee constructed by the Bureau of Reclamation. At each end the new levee does not meet the NFIP freeboard criterion. In between these two sections is a subsection of 300 feet where no further work is needed. For the two end sections, the work would consist of placing suitable fill material on top of the new levee at the same side slope, compacting it properly, and then protecting it with rip-rap of 36 inches in depth.

Stations 36+40 to 39+00 - Raise 260 feet of Bureau of Reclamation levee an average of 1.25 feet (See cross-section D-D).

Stations 39+00 to 42+00 - No further work needed.

Stations 42+00 to 42+40 - Raise 40 feet of Bureau of Reclamation levee an average of 0.5 foot (See cross-section D-D).

7th Street to 9th Street - (Stations 42+40 to 48+40)

This section lies between the two new sections of levee just completed by the Bureau of Reclamation. There is an old levee section which is in a bad state of repair. It is also too low to provide adequate freeboard for a 100-year flood. The work would consist of removal of the old levee to prepare the section for the new levee and the subsequent construction of 600 feet of new levee at an average height of 2.5 feet (See cross-section B-B).

9th Street to 10th Street - (Station 48+40 to 52+85)

This is the second section of levee just completed by the Bureau of Reclamation upstream of the 4th Street Bridge. The entire section, 445 feet, needs to be raised an average of 0.75 foot (See cross-section D-D).

10th Street to Southwest Corner Town Park - (Stations 53+95 to 66+00)

This portion consists of two sections. Both involve the construction of new levee. The first subsection would include removal of the existing inadequate levee, while the second subsection would require much less site preparation since there is no existing levee.

(Stations 52+85 to 61+00) - 815 feet of old levee removal, followed by construction of new levee at an average height of 4 feet (See cross-section B-B).

(Stations 61+00 to 66+00) - 500 feet of new levee at an average height of 5 feet (See cross-section A-A).

Town Park to Upstream Limits of Study Reach - Stations 66+00 to 82+40)

Beginning at Station 66+00, two alternative levee alignments exist. Alternative A would turn north to Highway 145 immediately, while Alternative B would continue for an additional 1/4 mile along the riverbank before turning north. Each would involve construction of new levee. An important difference to note at the beginning is that Alternative A would not protect the Dolores Water Treatment Facility, while Alternative B would.

Alternative A

This alternative consists of two sections. At the point along the south side of Highway 145 where natural ground is already two feet above the 100-year flood elevation the project would end.

(Stations 66+00 to 68+00) - 200 feet of new levee at an average height of 5.5 feet. The levee would be perpendicular to the Dolores River, connecting the long section downstream along the river to the short section upstream adjacent to Highway 145 (See cross-section A-A).

(Stations 68+00 to 71+00) - 300 feet of "soft berming." This section would cross the north edge of the town park. To raise the high ground an average of 1.5 foot, the park would be recontoured with a berm that was consistent with the use of the site for recreational purposes. At the east end natural ground is already 2 feet above the 100-year flood elevation, so the recontouring would be tapered to tie into that natural ground (See cross-section A-A).

Alternative B

This alternative includes the reconstruction of the existing levee system which is severely eroded at a number of locations. The levee along the north riverbank would be continued east to the southeast corner of the Dolores Water Treatment Facility; thence, it would turn 90° to the north to tie into the south edge of Highway 145. A levee description is as follows:

(Stations 66+00 to 78+40) - 1240 feet of existing levee will have to be reconstructed. The height will average from 10.5 feet along the town park; 4 feet adjacent to the new water treatment plant; and 8 feet along the water treatment ponds (See cross section B-B).

(Stations 78+40 to 82+40) - 400 feet of new levee at an average height of 6 feet. This levee section lies between the water treatment facility and the mobile home park to its east, running north from the riverbank to Highway 145 (See cross-section A-A).

4.2. Description of Left (South) Bank Levee

On the south side of the Dolores River upstream of the 4th Street bridge is an area 1000 feet long where floodwaters would leave the channel and inundate a number of properties. Two structural alternatives were considered for this area. One alternative is the construction of 1000 feet of new levee with three feet of freeboard, and the other is to build a levee to the

100-year elevation with no freeboard, to minimize changes to existing driveways and landscaping and to reduce costs.

Alternative A

Construct a new levee to meet federal criteria with the westerly 300 feet having an average height of 9 feet and the easterly 700 feet having an average height of 4 feet (See cross-section A-A).

Alternative B

Minimal raising of existing driveway and connecting it to high ground. The existing driveway, even though it is reasonably far from the river, would serve minimally as a levee. 500 feet of new levee connecting the driveway to high ground will be constructed. The levee system will provide 100-year protection; however, it will not be in compliance with federal levee criteria. The purchase of flood insurance for structures will remain a federal requirment. (See cross-section A-A.)

4.3. Project Costs

The costs of the primary alternatives (those for the north side of the river) were estimated. In addition, the cost of each of the two alternatives for the south side of the river was estimated. Further discussion of the feasibility of a structural project and other options for south side is provided in Section 5, Recommendations.

Costs for the various alternatives were developed by using unit costs as listed in Table 2. Fill and clay materials and riprap are assumed to be available in the Dolores area. The unit costs were based on the experience of the U.S. Army Corps of Engineers throughout Colorado and on the recent experience of the U.S. Bureau of Reclamation

in Dolores. All of this experience reflects federal wage rates and construction costs (Davis-Bacon provisions).

TABLE 2

Dolores River at Dolores

Summary of Unit Construction Costs

Item	Units	Unit Costs
Levee Excavation	C.Y.	$ 2.00
Levee Embankment	C.Y.	5.00
Riprap (stone)	C.Y.	40.00
Concrete (in place	C.Y.	250.00
Construction Contingencies	Percent	20%
Engineering and Administration Fee	Percent	12%

Right-of-way costs were not considered in this cost estimate. It was assumed that the town of Dolores would acquire construction, access, and use easements from property owners along the levee alignments in exchange for benefits to them from the project.

Project costs are listed in Table 3 (North side) and Table 4 (South side). They are broken down by sections and subsections and by the various construction functions for each portion. The various sections and subsections are shown on Plates 5a and 5b. The beginning and ending stations for each portion are given in Tables 3 and 4 to further clarify their location.

TABLE 3

ESTIMATED COSTS - RIGHT (NORTH) BANK OF DOLORES RIVER FLOOD CONTROL PROJECT

	Stations	Functions	Length	Quantity	Unit Cost	Total Cost	Cumulative Cost
Section 1 - 4th Street to 6th Street							
Subsection A	28+80 - 34+10	Site Preparation	530 Ft.	———	———	$ 4,000	———
		Embankment	530 Ft.	1835 C.Y.	$ 5/C.Y.	9,175	———
		Riprap	530 Ft.	1205 C.Y.	40/C.Y.	48,200	$60,375
Subsection B	34+10 - 35+10	Excavation	100 Ft.	150 C.Y.	2/C.Y.	300	
		Concrete	100 Ft.	55 C.Y.	250/C.Y.	13,750	
		Regrading	100 Ft.	150 C.Y.	2/C.Y.	300	
							$74,725
Subsection C	35+10 - 36+40	Embankment	130 Ft.	205 C.Y.	5/C.Y.	1,025	
		Riprap	130 Ft.	295 C.Y.	40/C.Y.	11,800	
							$86,550
Section 2 - 6th Street to 7th Street							
Subsection A	36+40 - 39+00	Raise Levee	260 Ft.	150 C.Y.	5/C.Y.	750	
		Riprap	260 Ft.	50 C.Y.	40/C.Y.	2,000	
							$89,300
Subsection B	39+00 - 42+00	———	300 Ft.	———	———	———	
							$89,300
Subsection C	42+00 - 42+40	Raise Levee	40 Ft.	10 C.Y.	5/C.Y.	50	
		Riprap	40 Ft.	3 C.Y.	40/C.Y.	120	
							$89,470
Section 3 - 7th Street to 9th Street							
	42+40 - 48+40	Site Preparation	600 Ft.	———	———	3,000	
		Embankment	600 Ft.	945 C.Y.	5/C.Y.	4,725	
		Riprap	600 Ft.	1020 C.Y.	40/C.Y.	40,800	
							$137,995
Section 4 - 9th Street to 10th Street							
	48+40 - 52+85	Raise Levee	445 Ft.	170 C.Y.	5/C.Y.	850	
		Riprap	445 Ft.	55 C.Y.	40/C.Y.	2200	
							$140,245
Section 5 - 10th Street to S.W. Corner Town Park							
Subsection A	52+85 - 61+00	Site Preparation	815 Ft.	450/C.Y.	2/C.Y.	900	
		Embankment	815 Ft.	2415/C.Y.	5/C.Y.	12,075	
		Riprap	815 Ft.	1790/C.Y.	40/C.Y.	71,600	
							$224,820
Subsection B	61+00 - 66+00	Site Preparation	500 Ft.	110 C.Y.	2/C.Y.	220	
		Embankment	500 Ft.	2040 C.Y.	5 C.Y.	10,200	
		Riprap	500 Ft.	1135 C.Y.	40 C.Y.	45,400	
							$280,640
						Sub-total	$280,640

TABLE 3 (cont.)

Section 6 - Town Park to Upstream Study Limits

	Alternative A						
Subsection A	66+00 - 68+00	Site Preparation	200 Ft.	———	———	1,000	
		Embankment	200 Ft.	940 C.Y.	5/C.Y.	4,700	
		Riprap	200 Ft.	455 C.Y.	40/C.Y.	18,200	
							$ 23,900
Subsection B	68+00 - 71+00	Soft Berm	300 Ft.	2670 C.Y.	5/C.Y.	13,350	$ 13,350
						Sub-total	$ 37,250
	Alternative B						
Subsection A	66+00 - 72+00	Site Preparation	600 Ft.	———	———	10,000	
		Embankment	600 Ft.	7700 C.Y.	5/C.Y.	38,500	
		Riprap	600 Ft.	1365 C.Y.	40/C.Y.	54,600	
							$103,100
Subsection B	72+00 - 74+00	Embankment	200 Ft.	595 C.Y.	5/C.Y.	2,975	
		Riprap	200 Ft.	455 C.Y.	40/C.Y.	18,200	
							$ 21,175
Subsection C	74+00 - 78+40	Embankment	440 Ft.	3650 C.Y.	5/C.Y.	18,200	
		Riprap	440 Ft.	1000 C.Y.	40/C.Y.	40,000	
							$ 58,200
Subsection D	78+40 - 82+40	Embankment	400 Ft.	2135 C.Y.	5/C.Y.	10,675	
		Riprap	100 Ft.	125 C.Y.	40/C.Y.	5,000	
							$ 15,675
						Sub-total	$196,150

SUMMARY TABLE
RIGHT (NORTH) BANK OF DOLORES RIVER FLOOD CONTROL PROJECT

Items	Cost	20% Contingency	12% Engr. & Admin.	Total	
4th Street to S.W. Corner Town Park	$280,640	$56,130	$33,680	$370,450	
Town Park to Upstream Study Limits					
Alternative A	37,250	7,450	3,730	48,430	
Alternative B	196,150	39,630	19,920	257,600	
Total Project Cost W/Alternative A					$418,880
Total Project Cost W/Alternative B					$628,050

TABLE 4

ESTIMATED PROJECT COSTS - LEFT (SOUTH) BANK OF DOLORES RIVER FLOOD CONTROL PROJECT

	Stations	Functions	Length	Quantity	Unit Cost	Total Cost
			ALTERNATIVE A			
Section 8						
	Alternative A					
Subsection A	32+00 - 39+00	Embankment	700 Ft.	3000 C.Y.	$ 5/C.Y.	$15,000
		Riprap	700 Ft.	1590 C.Y.	40/C.Y.	63,600
Subsection B	39+00 - 42+00	Embankment	300 Ft.	2075 C.Y.	5/C.Y.	$10,380
		Riprap	300 Ft.	680 C.Y.	40/C.Y.	27,200
						Sub-total
	Alternative B					
Subsection A	37+00 - 40+00	Embankment	300 Ft.	160 C.Y.	5/C.Y.	800
		Riprap	300 Ft.	540 C.Y.	40/C.Y.	21,600
Subsection B	40+00 - 42+00	Embankment	200 Ft.	135 C.Y.	5/C.Y.	675
		Riprap	200 Ft.	360 C.Y.	40/C.Y.	14,400
						Sub-total

SUMMARY TABLE
LEFT (SOUTH) BANK OF DOLORES RIVER FLOOD CONTROL PROJECT

Items	Cost	20% Contingency	12% Engr. & Admin.	Total
Alternative A	$116,180	$13,240	$11,620	$141,040
Alternative B	$ 37,480	$ 7,500	$ 3,850	$ 48,830

4.4 Project Benefits

At present the vast majority of the town of Dolores lies within the 100-year floodplain of the Dolores River. At the east end of Dolores, near the high school, water would break over Highway 145 and enter the town. Between that breakout point and the 4th Street Bridge there are two additional breakout points for floodwaters. The result is that much of the town would experience flooding from 0 to 2 feet deep, while some of the town would experience flooding more than 2 feet deep.

Plate 3 showed the likely percent damage to a structure versus the depth of flooding. As can be seen from the table, damages in Dolores would range from 0% of the value of a structure (and its contents) to about 50%. Most structures would experience damage on the order of 20% to 30% during a 100-year flood.

A detailed benefit-cost analysis is beyond the scope of this report. An effort was made, however, to prepare very general values to determine whether the planning of a flood control project was worth pursuing. The estimation of average annual flood damages under present conditions was described in Section 2.4 of this report. If one accepts that a project designed to the 100-year level (with freeboard) will allow small residual damages for floods greater than a 100-year flood, one can proceed. These residual damages can be subtracted from the total average annual damages to estimate annual benefits attributable to the project.

The next step was to calculate annual costs. Average annual costs assume a 50-year project life, an 8 1/2% annual interest rate (per the U.S. Army Corps of Engineers), and the costs listed in Tables 3 and 4. Based on all of these estimates, it appears that average annual benefits for the north side of the river are over 2 times average annual costs. These general calculations clearly indicate that a flood control project in Dolores is worth pursuing.

With regard to the south side, average annual damages would be quite small. The average annual cost of even Alternative B, which is a bare minimum project, is significantly greater than the estimated annual benefits.

As far as the two alternatives for the project on the north side of the river are concerned, both protect essentially the same area. As a result, most of the benefits attributable to either alternative are identical. It would be, in that light, wisest to find the less expensive way to achieve the same benefits. That would be Alternative A. There is, however, one extremely important difference between the two alternatives. Alternative B would protect the Dolores Water Treatment Facility, while Alternative A would not.

5. Recommendations

Based on the findings of the reconnaissance investigation, it is recommended that the Town of Dolores pursue construction of a levee project to keep flood water from a 100-year flood event from entering the town. It is recommended that in the absence of such a flood control project town officials and residents familiarize themselves with floodproofing options for protecting individual buildings. It is also recommended that town officials and residents familiarize themselves with individual flood insurance needs and with the costs of such insurance.

Details regarding the recommended levee alternative are given below. Information regarding funding of such a project is provided. Then more details on pursuing options in floodproofing and flood insurance are given.

5.1 Recommended Levee Alternative

It is recommended that the town of Dolores pursue funding for the construction of Levee Alternative B for the north side of the Dolores River. This alternative would cost more than Alternative A, but it would provide protection for the Water Treatment Facility. Given the experience of several Colorado communities that have lost

vital parts of their water supply systems, Dolores should make every attempt to preclude that possibility.

The recommended alternative would include levee protection along the Dolores River's north bank from Station 28+80 (Fourth Street Bridge) to Station 78+40 (Southeast corner of Water Treatment Facility fence). Then 400 feet of levee running north from the riverbank to Station 82+40 at Highway 145 would complete the project. The total length of levee would be about 1 mile.

It is recommended that no levee be constructed by the town on the south side of the river. Such a project would not be cost effective. Instead individual action, either flood insurance, or landscaping to provide a berm, or both, by the property owners is recommended.

The estimated north side project cost would be about $480,000. The result of the project, if implemented as recommended, would be the protection of approximately 175 buildings in and around the town of Dolores and the protection of the Dolores Water Treatment Facility. The project would take advantage of the work done by the Bureau of Reclamation for the McPhee Reservoir project, and it would tie in to that work.

5.2. Implementation of the Levee Project

Given the estimated cost of $480,000, the Town of Dolores will need to try to combine local resources with state, and possibly federal resources. The town would face major economic disruptions in the event of a 50-year or 100-year flood. In addition, there would be a potential for major utility damages, particularly to the water supply system. For those reasons it seems the town should pursue funding opportunities with the State Impact Assistance Program and the State Community Development Block Grant Program (CDBG). No funding opportunities are available through the Colorado Health Department or the U.S. Environmental Protection Agency for flood protection of

water supply systems. There are flood control funding opportunities through the U.S. Army Corps of Engineers.

In addition to these funding sources the town should consider a local match. Such a match could include in-kind-services, acquisition of right-of-way, agreement to maintain the constructed project, and funds for construction.

5.3. Other Floodplain Management Recommendations

Two additional areas of floodplain management should be pursued by the Town of Dolores. These are floodproofing and flood insurance. The recommendations in this section have chiefly to do with education and increasing awareness.

The town should make available for review a copy of the Colorado Floodproofing Manual. With the manual, to be on display at the municipal building or the library, should be a large map showing the 100-year floodplain. This map would allow owners and/or occupants of individual buildings to determine whether their building would be affected by flooding or not. They could then pursue floodproofing options as appropriate, depending on the likelihood of completion of a structural project to reduce or eliminate flooding in the town. The town should also consider annual mailings to those persons, to let them know that their buildings are in the 100-year floodplain and are in need of some kind of flood protection.

Given that about 5% of the strucutures in the Dolores floodplain carry NFIP flood insurance, it appears that more information about the availability of flood insurance should be disseminated. As with knowledge of floodproofing, the means of dissemination could be maps and brochures at public buildings and annual mailings to affected residents and property owners. The Colorado Water Conservation Board has helped several local governments to develop brochures to send to residents of floodplain areas. Suitable maps are easily available or can be produced in a short time. If local insurance agents and/or lenders in southwestern

Colorado are not knowledgeable about the NFIP, one or more training sessions in that part of the state can be arranged. As a matter of preliminary information, Table 5 shows NFIP insurance rates for existing buildings in the 100-year floodplain. Rates are shown for communities in the Emergency Phase of the NFIP (like Dolores is at present) and for communities in the Regular Phase of the NFIP (like Dolores will be at some time in the next few years).

gl

TABLE 5

NATIONAL FLOOD INSURANCE PROGRAM

Some Examples of Insurance Rates for Existing Structures*

Rates per year per $100 coverage

EMERGENCY PHASE	Structure	Contents
(1) Residential	$0.45	$0.55
(2) All others (including hotels and motels)	.55	1.10

REGULAR PHASE** - Zones A, AO, AH, D; A1-A30

	1st $35,000	Addt'l Coverage	1st $35,000	Addt'l Coverage
(1) Single Family Residential No Basement	$0.45	$0.17	$0.55	$0.28
Finished and Unfinished Basement	0.50	0.35	0.55	0.55
Mobile Home	0.45	0.17	0.55	0.38
(2) All other residential (including hotels and motels)	0.45	0.33	***	***
No Basement	0.50	0.40	0.55	0.55
(3) Non-Residential W/Basement	0.60	0.40	1.10	0.95
No Basement	0.55	0.30	1.10	0.25
Mobile Home	0.55	0.30	1.10	0.25

*As of 1/8/86

**For the Emergency Phase Only "First Layer coverage "(up to $35,000 is available; For the Regular Phase "Second Layer Coverage" (up to an additional $150,000) is also available

***Rated on a case-by-case basis.

GLOSSARY

This glossary defines those terms frequently encountered in floodplain management.

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

- **Channel** - The bed of a stream or river.

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

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

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

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

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

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

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

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

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

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

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

- **Hydrologic Analysis** - The study of determining flood waters for a specific watershed.

- **Left or Right Bank** - The bank on the left or right side of a river or stream, looking downstream.

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

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

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

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

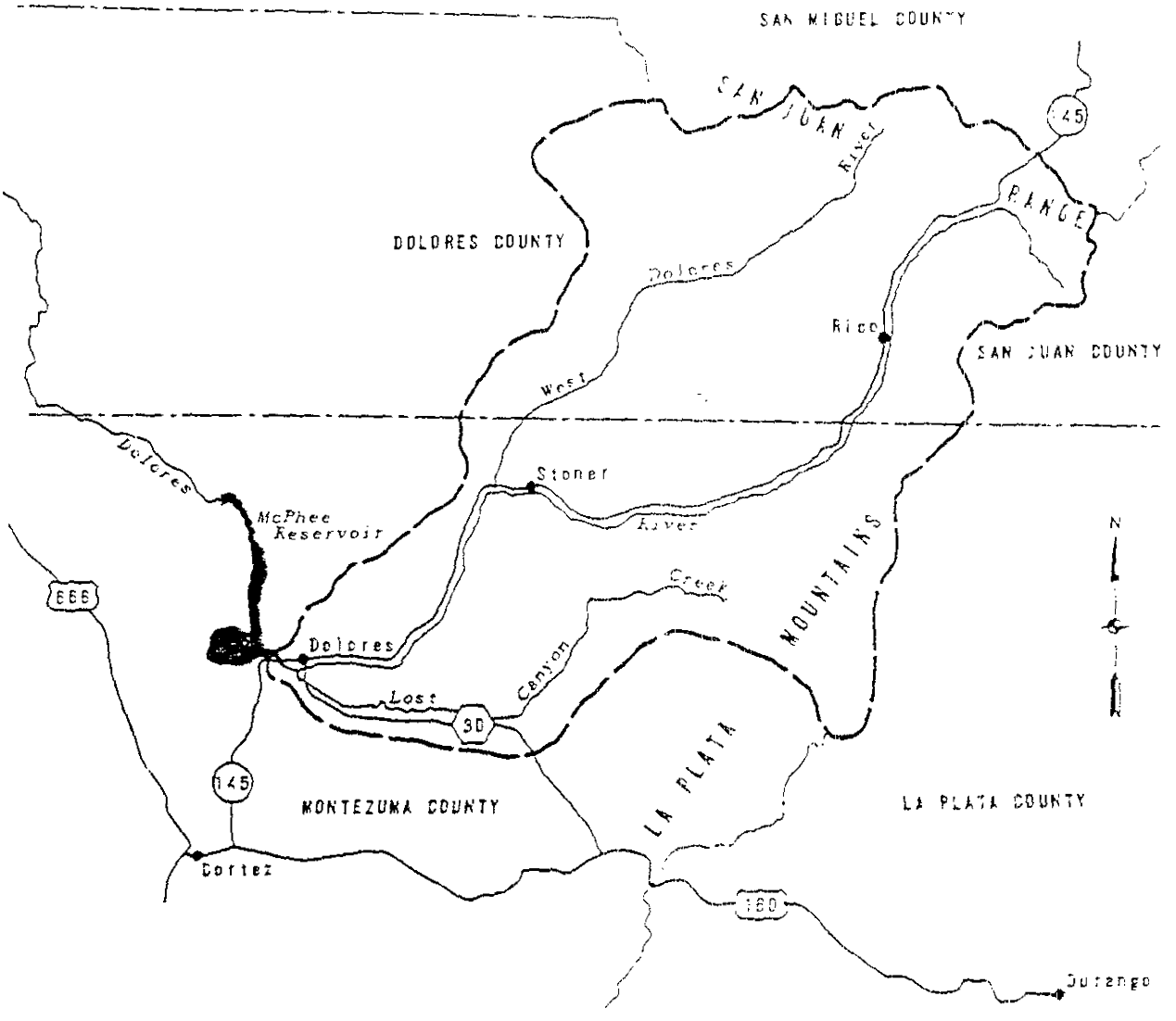
- **Seepage** - The act or process of water passing through small openings or pores.

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

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

- **Water Surface Profile** - (This term is synomymous with Flood Profile) - a graph showing the relationship of the water surface level of a flood event to location along a stream or river.

- **100-year Flood** - A flood having a one percent chance of occurring or being exceeded in any given year. It is reasonably expected to occur once in 100-years, but it may hit two or three times within a 100-year period.



Dolores River
Dolores, Colorado
FLOOD MITIGATION PLAN
LOCATION MAP
by
COLORADO WATER
CONSERVATION BOARD
January 1986

PLATE 1

TABLE 3

ESTIMATED COSTS - RIGHT (NORTH) BANK OF DOLORES RIVER FLOOD CONTROL PROJECT

	Stations	Functions	Length	Quantity	Unit Cost	Total Cost	Cumulative Cost
Section 1 - 4th Street to 6th Street							
Subsection A	28+80 - 34+10	Site Preparation	530 Ft.	------	-----	$ 4,000	---------
		Embankment	530 Ft.	1835 C.Y.	$ 5/C.Y.	9,175	---------
		Riprap	530 Ft.	1205 C.Y.	40/C.Y.	48,200	$60,375
Subsection B	34+10 - 35+10	Excavation	100 Ft.	150 C.Y.	2/C.Y.	300	
		Concrete	100 Ft.	55 C.Y.	250/C.Y.	13,750	
		Regrading	100 Ft.	150 C.Y.	2/C.Y.	300	
							$74,725
Subsection C	35+10 - 36+40	Embankment	130 Ft.	205 C.Y.	5/C.Y.	1,025	
		Riprap	130 Ft.	295 C.Y.	40/C.Y.	11,800	
							$86,550
Section 2 - 6th Street to 7th Street							
Subsection A	36+40 - 39+00	Raise Levee	260 Ft.	150 C.Y.	5/C.Y.	750	
		Riprap	260 Ft.	50 C.Y.	40/C.Y.	2,000	
							$89,300
Subsection B	39+00 - 42+00	-----	300 Ft.	------	-------	------	
							$89,300
Subsection C	42+00 - 42+40	Raise Levee	40 Ft.	10 C.Y.	5/C.Y.	50	
		Riprap	40 Ft.	3 C.Y.	40/C.Y.	120	
							$89,470
Section 3 - 7th Street to 9th Street							
	42+40 - 48+40	Site Preparation	600 Ft.	-------	------	3,000	
		Embankment	600 Ft.	945 C.Y.	5/C.Y.	4,725	
		Riprap	600 Ft.	1020 C.Y.	40/C.Y.	40,800	
							$137,195
Section 4 - 9th Street to 10th Street							
	48+40 - 52+85	Raise Levee	445 Ft.	170 C.Y.	5/C.Y.	850	
		Riprap	445 Ft.	55 C.Y.	40/C.Y.	2200	
							$140,245
Section 5 - 10th Street to S.W. Corner Town Park							
Subsection A	52+85 - 61+00	Site Preparation	815 Ft.	450/C.Y.	2/C.Y.	900	
		Embankment	815 Ft.	2415/C.Y.	5/C.Y.	12,075	
		Riprap	815 Ft.	1790/C.Y.	40/C.Y.	71,600	
							$224,820
Subsection B	61+00 - 66+00	Site Preparation	500 Ft.	110 C.Y.	2/C.Y.	220	
		Embankment	500 Ft.	2040 C.Y.	5/C.Y.	10,200	
		Riprap	500 Ft.	1135 C.Y.	40/C.Y.	45,400	
							$280,640
						Sub-total	$280,640

TABLE 3 (cont.)

Section 6 - Town Park to Upstream Study Limits

	Alternative A						
Subsection A	66+00 - 68+00	Site Preparation	200 Ft.	-----	-----	1,000	
		Embankment	200 Ft.	940 C.Y.	5/C.Y.	4,700	
		Riprap	200 Ft.	455 C.Y.	40/C.Y.	18,200	
							$ 23,900
Subsection B	68+00 - 71+00	Soft Berm	300 Ft.	2670 C.Y.	5/C.Y.	13,350	$ 13,350
						Sub-total	$ 37,250
	Alternative B						
Subsection A	66+00 - 72+00	Site Preparation	600 Ft.	-------	------	10,000	
		Embankment	600 Ft.	7700 C.Y	5/C.Y.	38,500	
		Riprap	600 Ft.	1365 C.Y.	40/C.Y.	54,600	
							$103,100
Subsection B	72+00 - 74+00	Embankment	200 Ft.	595 C.Y.	5/C.Y.	2,975	
		Riprap	200 Ft.	455 C.Y.	40/C.Y.	18,200	
							$ 21,175
Subsection C	74+00 - 78+40	Embankment	440 Ft.	3650 C.Y.	5/C.Y.	18,200	
		Riprap	440 Ft.	1000 C.Y.	40/C.Y.	40,000	
							$ 58,200
Subsection D	78+40 - 82+40	Embankment	400 Ft.	2135 C.Y.	5/C.Y.	10,675	
		Riprap	100 Ft.	125 C.Y.	40/C.Y.	5,000	
							$ 15,675
						Sub-total	$198,150

SUMMARY TABLE

RIGHT (NORTH) BANK OF DOLORES RIVER FLOOD CONTROL PROJECT

Items	Cost	20% Contingency	12% Engr. & Admin.	Total	
...h Street to S.W. Corner Town Park	$280,640	$56,130	$33,680	$370,450	
...wn Park to Upstream Study Limits					
Alternative A	37,250	7,450	3,730	48,430	
Alternative B	198,150	39,630	19,820	257,600	
Total Project Cost W/Alternative A					$418,880
Total Project Cost W/Alternative B					$628,050

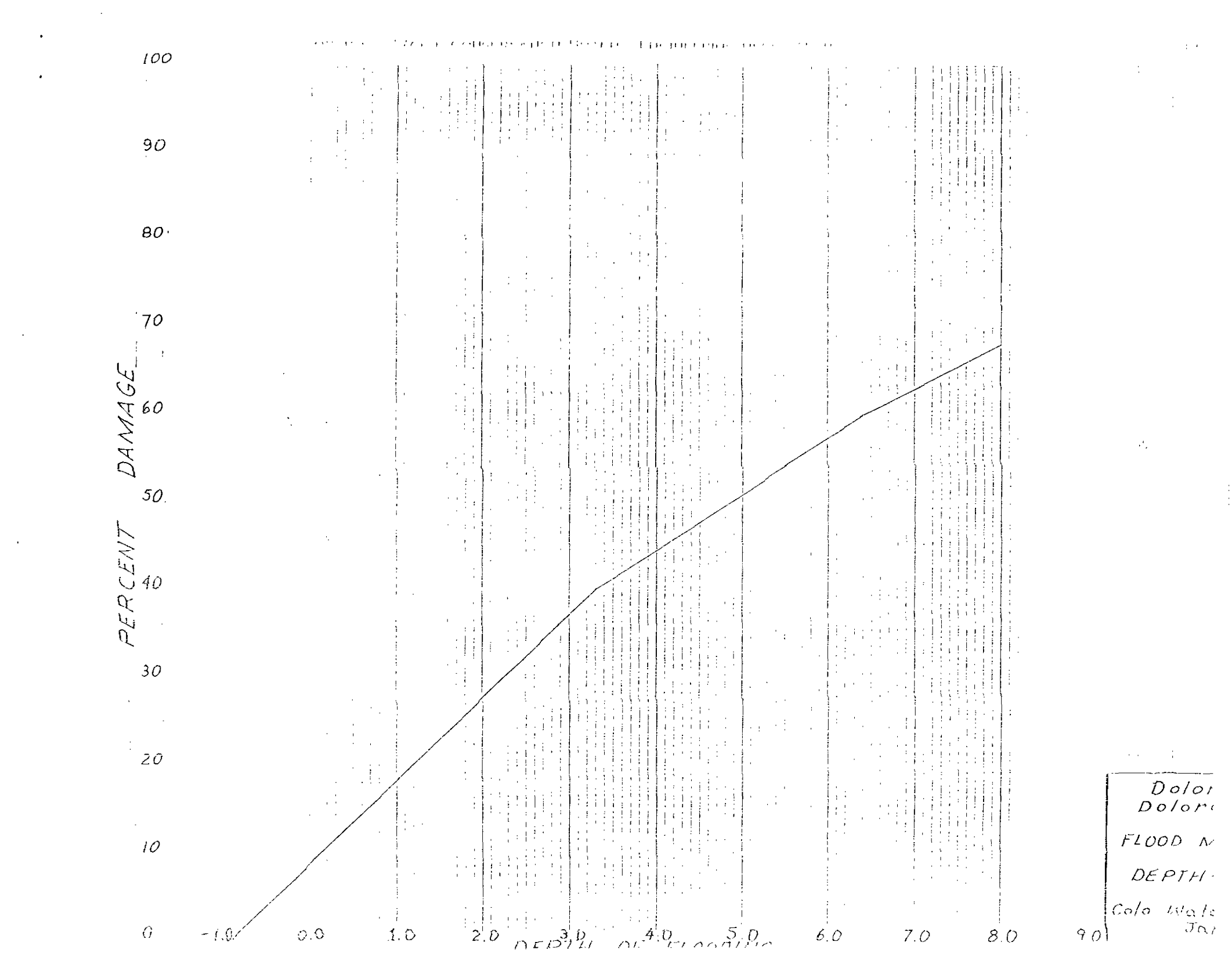
TABLE 4

ESTIMATED PROJECT COSTS - LEFT (SOUTH) BANK OF DOLORES RIVER FLOOD CONTROL PROJECT

	Stations	Functions	Length	Quantity	Unit Cost	Total Cost	Cumulative Cost
			ALTERNATIVE A				
Section 8							
	Alternative A						
Subsection A	32+00 - 39+00	Embankment	700 Ft.	3000 C.Y.	$ 5/C.Y.	$15,000	
		Riprap	700 Ft.	1590 C.Y.	40/C.Y.	63,600	
							$78,600
Subsection B	39+00 - 42+00	Embankment	300 Ft.	2075 C.Y.	5/C.Y.	$10,380	
		Riprap	300 Ft.	680 C.Y.	40/C.Y.	27,200	
							$37,580
						Sub-total	$116,180
	Alternative B						
Subsection A	37+00 - 40+00	Embankment	300 Ft.	160 C.Y.	5/C.Y.	800	
		Riprap	300 Ft.	540 C.Y.	40/C/.Y.	21,600	
							$ 22,400
Subsection B	40+00 - 42+00	Embankment	200 Ft.	135 C.Y.	5/C.Y.	675	
		Riprap	200 Ft.	360 C.Y.	40/C.Y.	14,400	
							$ 15,075
						Sub-total	$ 37,475

SUMMARY TABLE
LEFT (SOUTH) BANK OF DOLORES RIVER FLOOD CONTROL PROJECT

Items	Cost	20% Contingency	12% Engr. & Admin.	Total
Alternative A	$116,180	$13,240	$11,620	$141,040
Alternative B	$ 37,480	$ 7,500	$ 3,850	$ 48,830


PERCENT DAMAGE
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80
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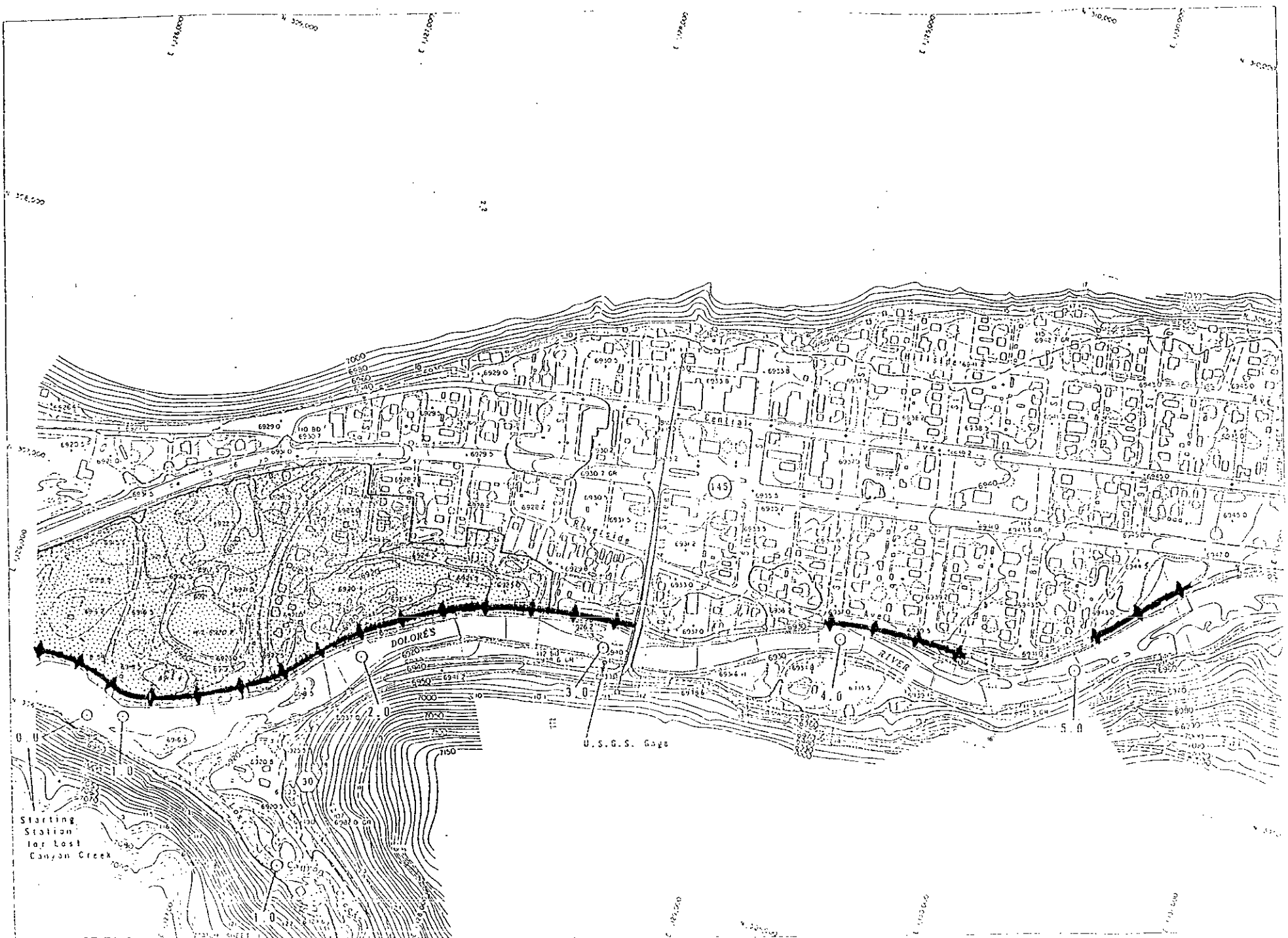
DOLORES
RIVER
Central
Ave.
Riverside
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U.S.G.S. Gage
Starting Station for Lost Canyon Creek
Canyon

PLATE

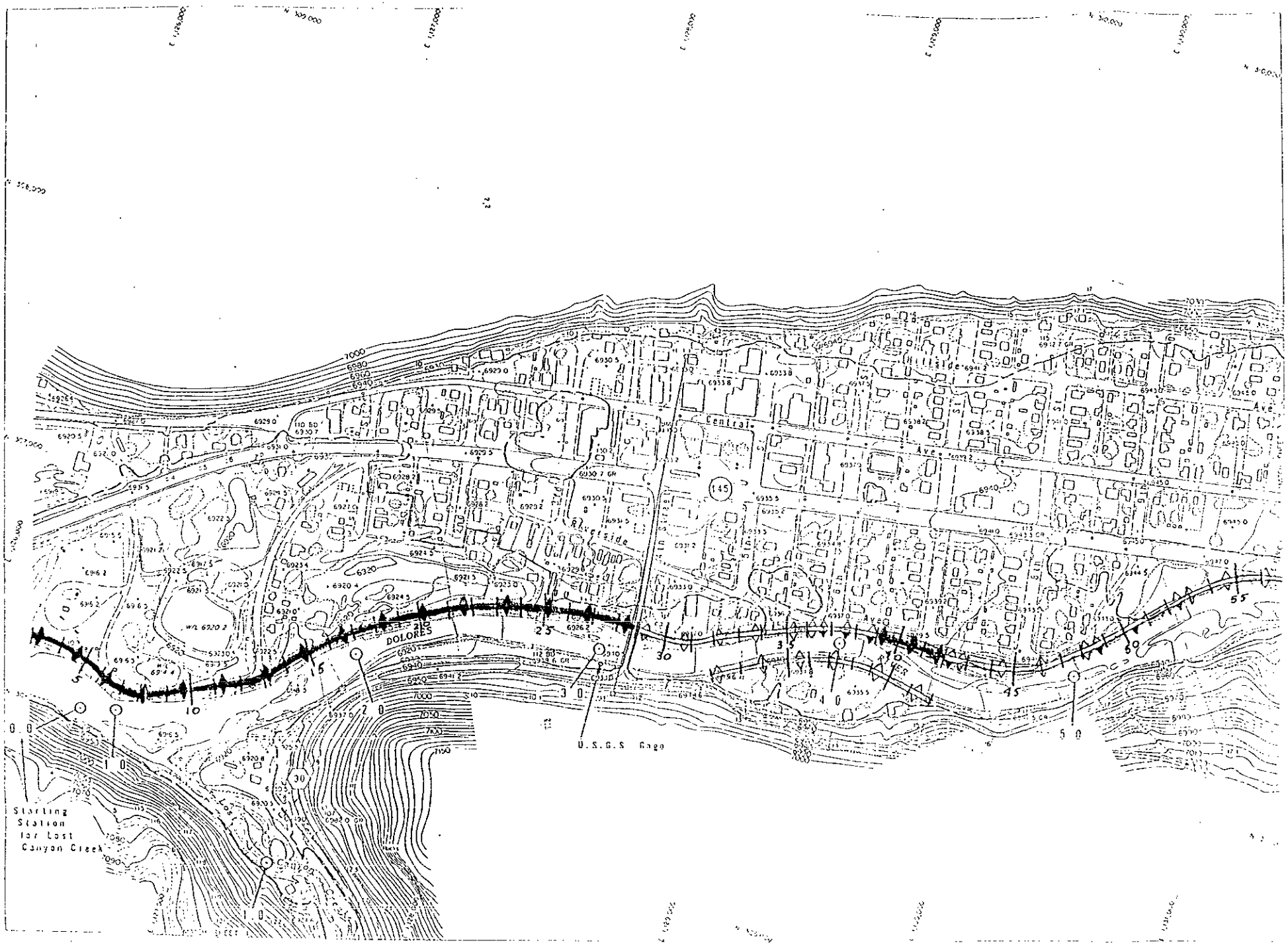
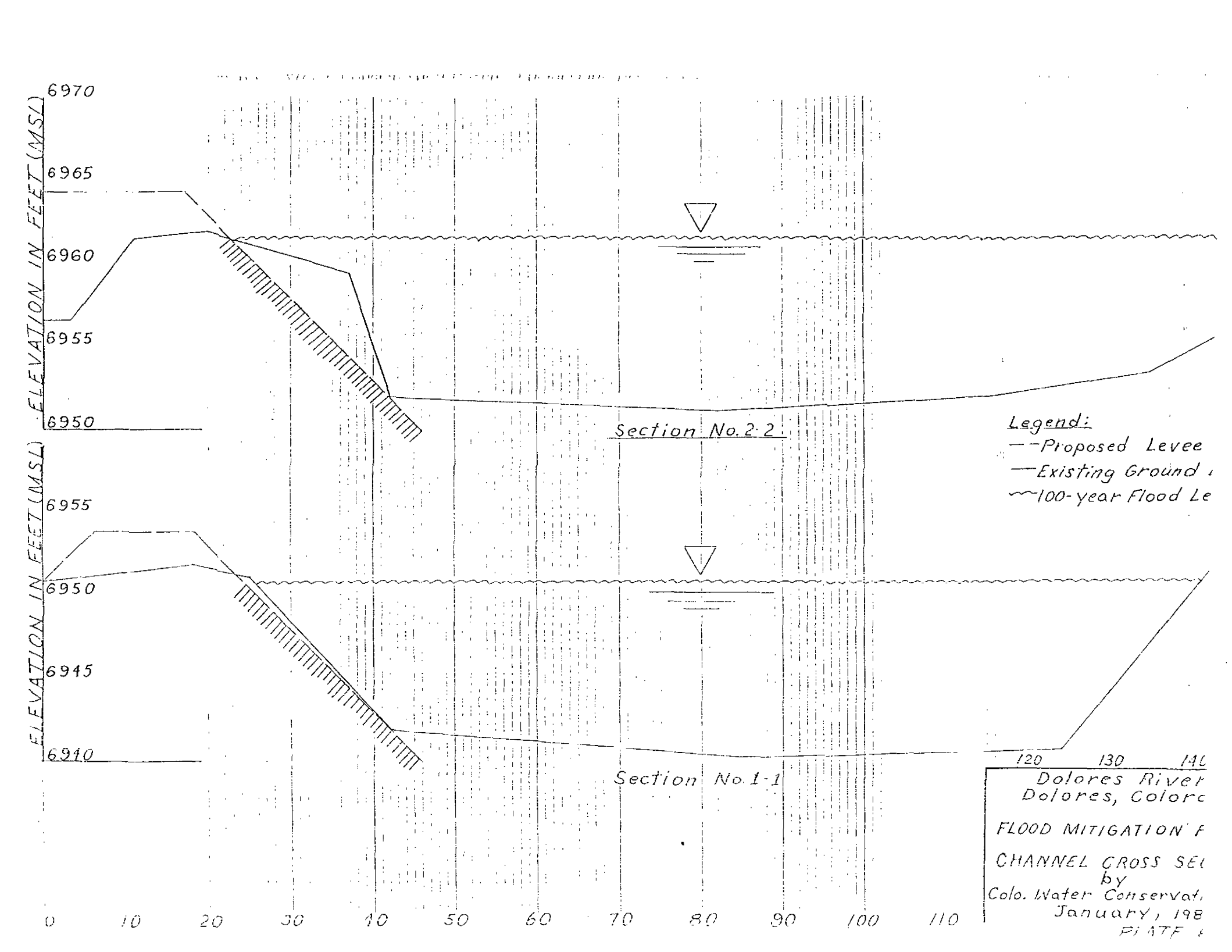

Starting Station for Lost Canyon Creek
DOLORES
U.S.G.S Gage
Central Ave

PLATE 5A


DOLORES
RIVER
MARSH STREET
Baseball Field
Football Field
Cemetery
60
65
75
80
9.0
10.0

PLATE 5B


6970
6965
6960
6955
6950
ELEVATION IN FEET (MSL)
Section No. 2-2
6955
6950
6945
6940
ELEVATION IN FEET (MSL)
Section No. 1-1
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40
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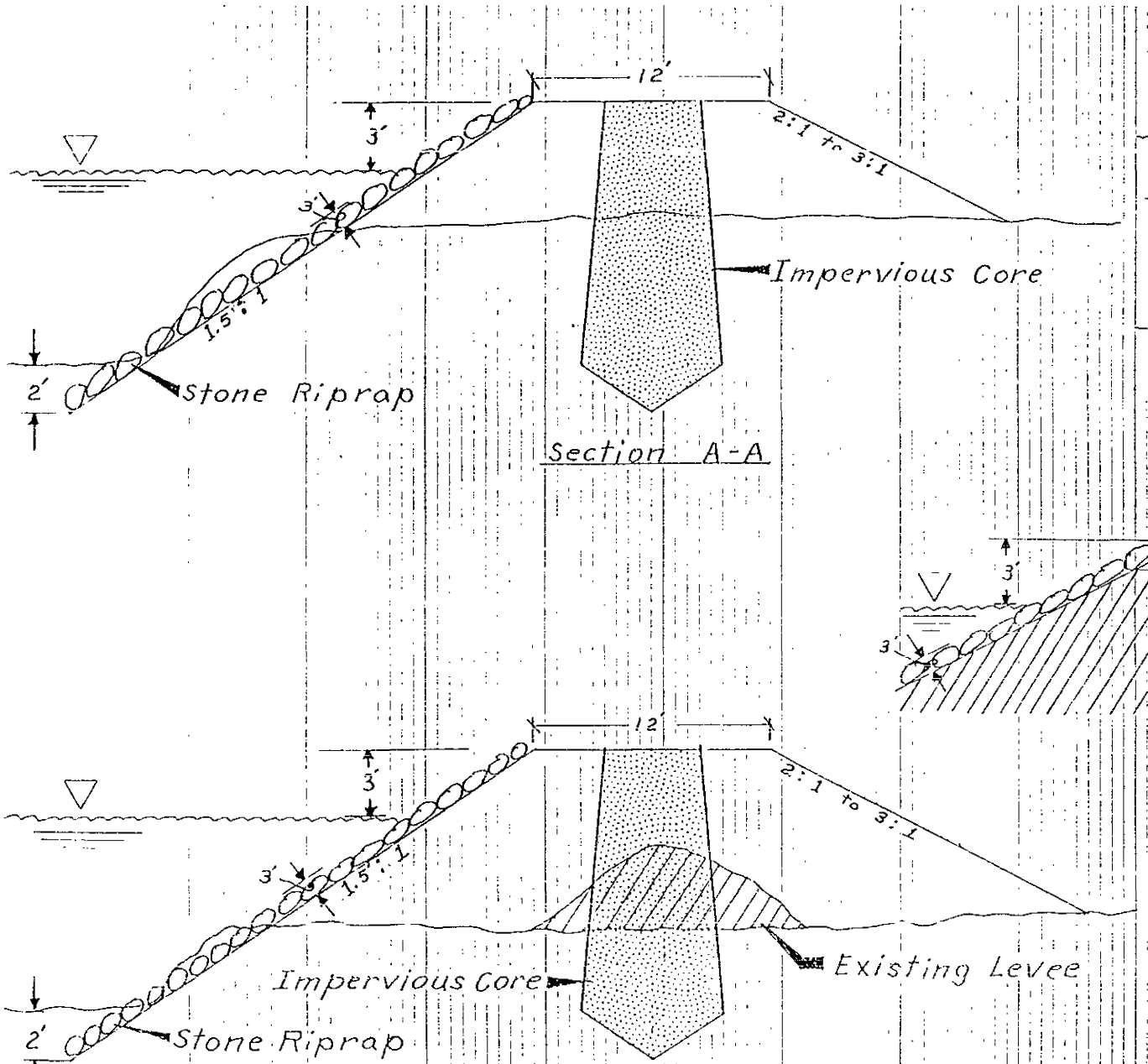
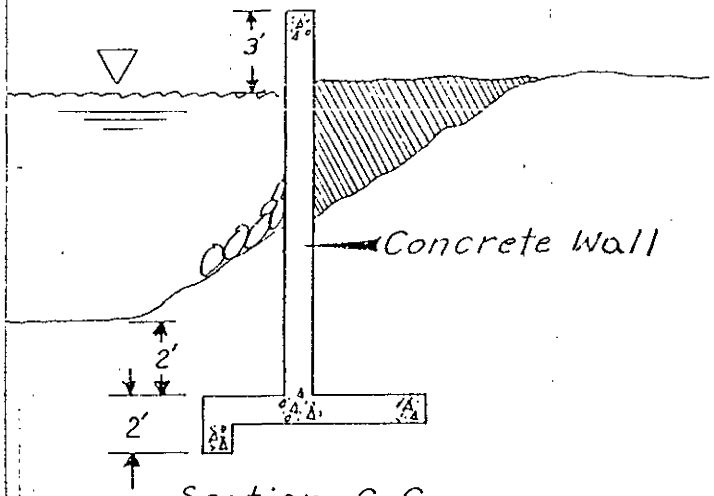
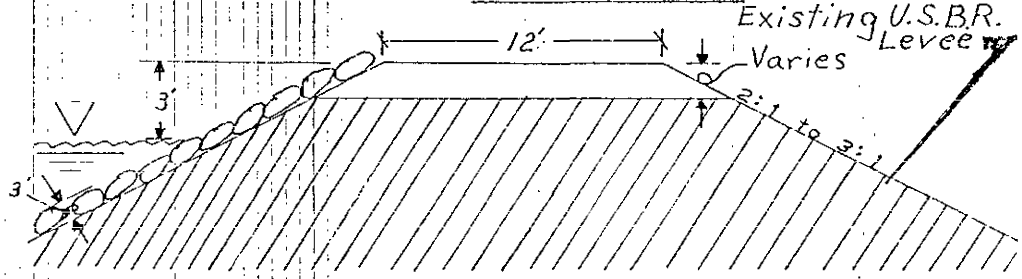
60
70
80
90
100
110
120
130
Legend:
--Proposed Levee
—Existing Ground
~100-year Flood Le
Dolores River
Dolores, Colorc
FLOOD MITIGATION F
CHANNEL CROSS SE
by
Colo. Water Conservat
January, 198



Section A-A



Section C-C



Section D-D

Section B-B

Dolores River
Dolores, Colorado

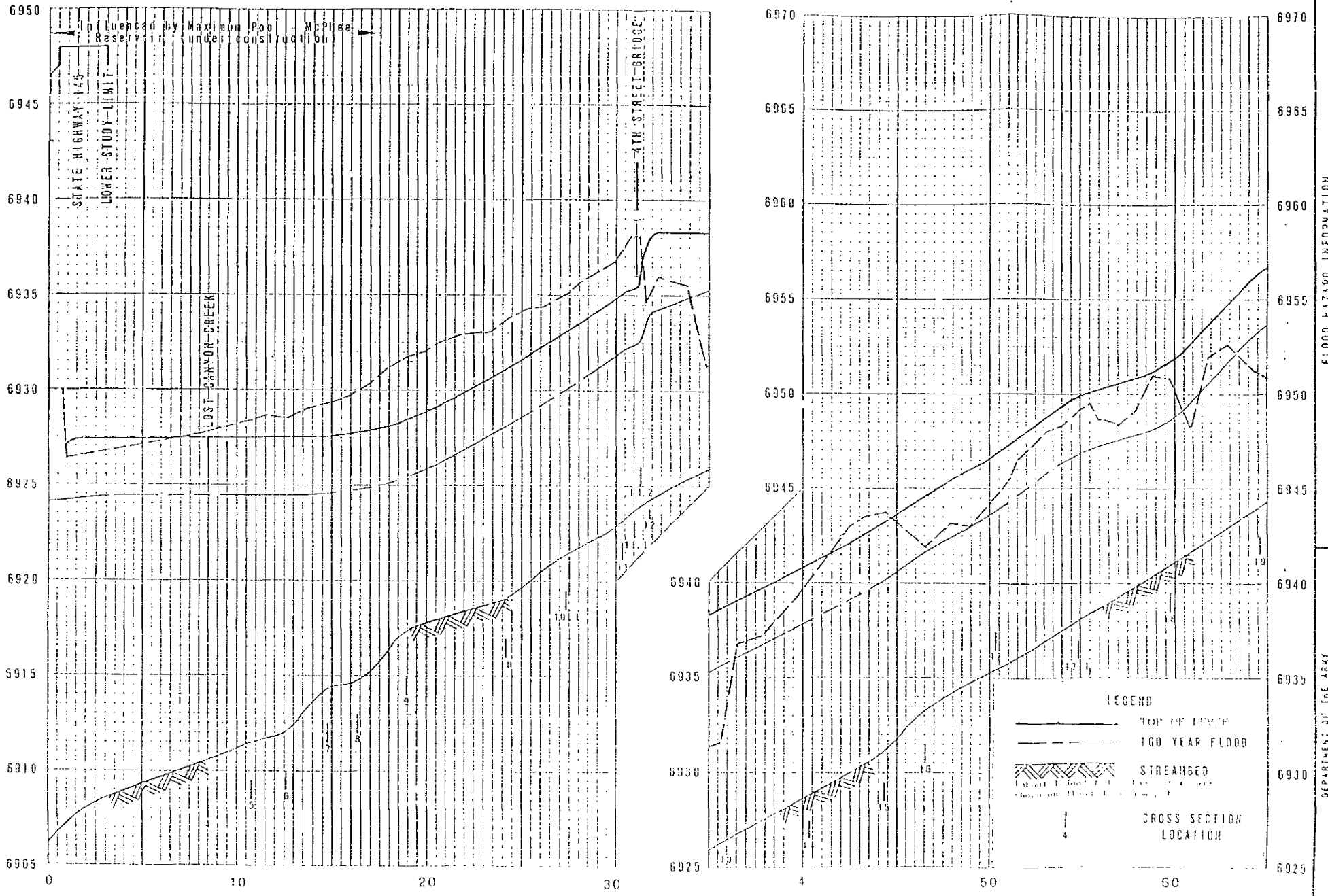
FLOOD MITIGATION PLAN

TYPICAL CROSS SECTIONS

by

Colo. Water Conservation Bd.

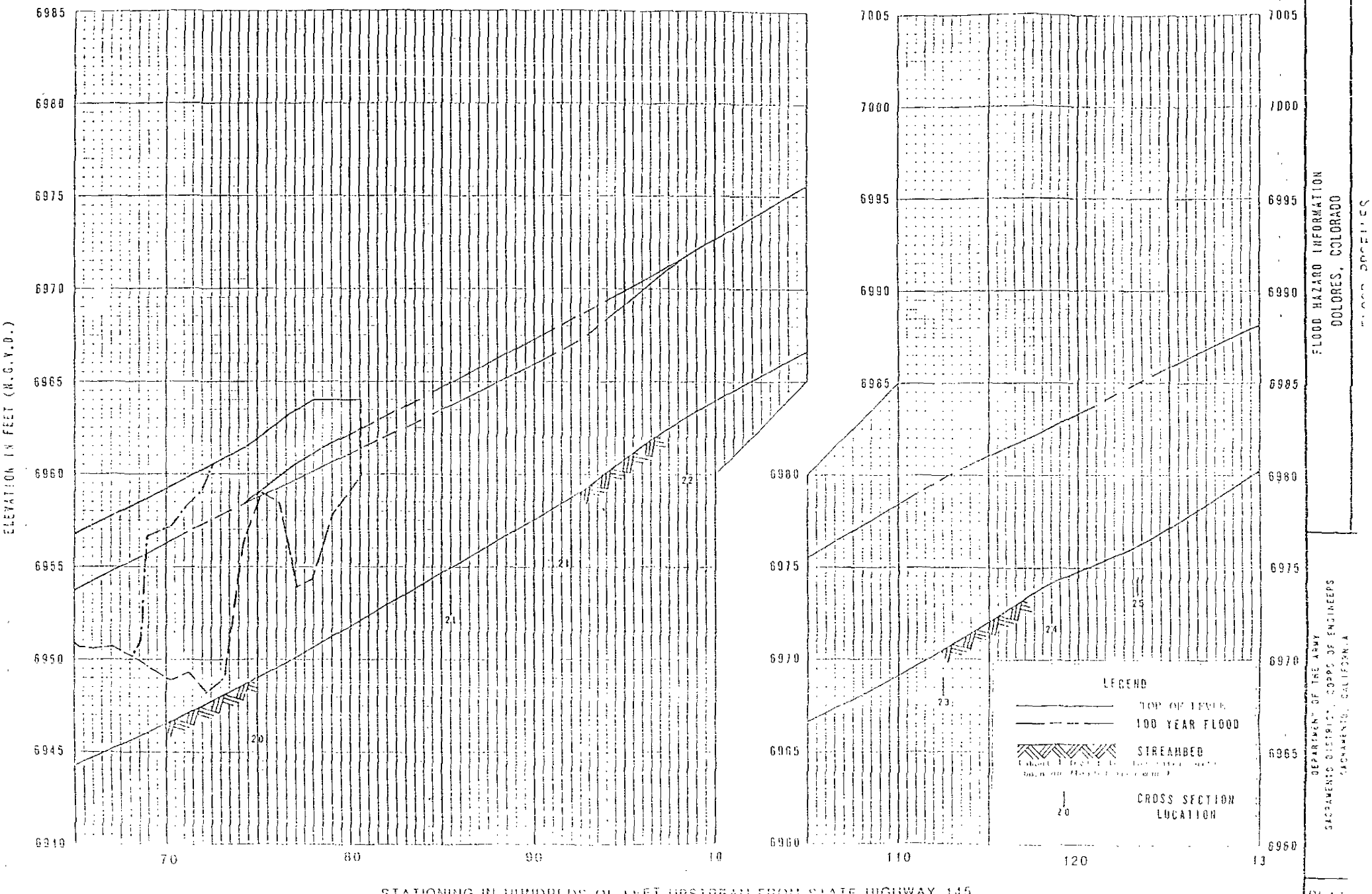
January, 1986



FLOOD HAZARD INFORMATION
DOLORES, COLORADO

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT CORPS OF ENGINEERS
SACRAMENTO CALIFORNIA

PLATE


ELEVATION IN FEET (N.G.V.D.)
6985
6980
6975
6970
6965
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6955
6950
6945
6940
7005
7000
6995
6990
6985
6980
6975
6970
6965
6960
70
80
90
10
110
120
13
20
21
22
23
24
25
LEGEND
TOP OF LEVEE
100 YEAR FLOOD
STREAMBED
CROSS SECTION LOCATION
STATIONING IN HUNDREDS OF FEET UPSTREAM FROM STATE HIGHWAY 145
FLOOD HAZARD INFORMATION
DOLORES, COLORADO
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
PLAT