A STUDY OF FLOOD PROBLEMS AND FLOOD PLAIN REGULATION IOWA RIVER AND LOCAL TRIBUTARIES AT IOWA CITY, IOWA

FLOOD PLAIN REGULATION STUDY NO. FR-1

Prepared by the
IOWA NATURAL RESOURCES COUNCIL
STATE HOUSE
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STATE OF IOWA

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TABLE OF CONTENTS

CHAPTER		PAGE
I	Introduction	1
II	Basin Characteristics and Coralville Reservoir Features	4
III	The Flood Potential of the Iowa River at Iowa City	7
IV	Selection and Discussion of Flooding Along the Iowa River	17
V	Flooding along Tributary Streams Within Urban Areas	22
VI	Regulation of Flood Plain Development	29
VII	Summary and Conclusions	32
	Selected Bibliography	.35

APPENDIX

A	Flood Profiles	
B	Flood Plain Regulation Maps	

TABLES

TABLE		PAGE
I	Primary Features, Coralville Flood Control Reservoir	5
II	Average Annual Benefits, Coralville Flood Control Reservoir	8
III	Reservoir Operation Plan 7	9
IV	Computed Effect of Reservoir Operations for Floods of Record	11
V	Average Recurrence Intervals, in Years, and Probable Peak Discharges, in cfs, on the North Branch, South Branch and Main Ralston Creek at Mouth	25

CHAPTER I

INTRODUCTION

The City of Iowa City and nearby valley areas have been subjected to several major floods by the Iowa River over the years. Damaging floods have occurred almost yearly, especially in agricultural areas. A reservoir for flood control was authorized by Congress as early as 1928 as part of a plan to develop a system of reservoirs on tributary basins of the Mississippi River. In 1958, the Coralville Flood Control Reservoir was completed and placed in operation by the Rock Island District, Corps of Engineers, U. S. Army. The Coralville Reservoir dam is located about nine miles upstream from the City of Iowa City.

There has been considerable local interest during the past two years in developing certain existing flood plain land which formerly was inundated too frequently to be considered for urban uses. However, it should be emphasized that the Coralville Reservoir will not eliminate all flooding in Iowa City, although it will provide a high degree of flood protection. For instance, many marginal flood plain lands will be flooded by normal releases from the Coralville Reservoir. This was confirmed by releases during the spring floods of April 1959 and April 1960. The City of Iowa City is in the process of developing a comprehensive city plan and the City Council has expressed a desire to incorporate flood plain zoning. The city requested the Iowa Natural Resources Council to study the flood problems and outline flooding limits.

AUTHORITY

This report has been prepared under the general authority contained in Chapter 455A, Code of Iowa 1958. This act directs the Iowa Natural Resources Council to make a comprehensive study and investigation of all pertinent conditions of the areas in the state affected by floods; to determine the best method and manner of establishing flood control; to adopt and establish a comprehensive plan for all areas of the state subject to floods; and to determine the best and most practical method and manner of establishing and constructing the necessary flood control works.

SCOPE

It is the purpose of this study to analyze the flood problems which exist in Iowa City, Iowa, and the effect of reservoir regulation on future floods which can be expected; to outline the flooding limits of the Iowa River at Iowa City; and to recommend certain actions regarding flood plain zoning which the city may desire to consider in meeting the problems created by floods on the Iowa River.

However, this study actually encompasses the reach of the Iowa River which extends from a point near the south corporate limits of Iowa City (Mile 72.7) upstream to the Coralville Reservoir dam (Mile 83.3). Information contained herein could be utilized by other local governmental units concerned with flood plain regulation in this reach. In addition, consideration is given to flood problems along several tributaries which flow into the Iowa River in this reach.

The office of the District Engineer, Rock Island District, Corps of Engineers, U. S. Army, cooperated throughout the course of the investigation, and furnished much technical data on the Iowa River and regulation aspects of the Coralville Flood Control Reservoir.

PRIOR REPORTS

The Iowa Natural Resources Council, in 1955, published Bulletin No. 3, "An Inventory of Water Resources and Water Problems, Iowa-Cedar River Basin, Iowa." This Bulletin summarized water control problems in the basin and made broad recommendations regarding problems of basic data collection, water use, and water control.

Several reports to Congress were prepared by the Rock Island District, Corps of Engineers, U. S. Army, during the investigations for flood control reservoirs on the Iowa River.

The definite project report and the preliminary regulation manual for Coralville Reservoir contain much pertinent data on flood problems in the Iowa City area.

An additional report entitled, "Report on Flooding From Ralston Creek," dated January 1952, was made available by the Engineers Club of Iowa City. Prepared by a committee of the Club, the report contains a considerable amount of information concerning flood problems on this tributary which flows through certain urban areas.

CHAPTER II

BASIN CHARACTERISTICS AND CORALVILLE RESERVOIR FEATURES

The Iowa River Basin has a long, narrow shape which is characteristic of other stream basins in eastern Iowa. The basin has a maximum width of about 40 miles and an average width of about 20 miles. The drainage area of the Iowa River at the Coralville Reservoir dam is 3,115 square miles and at the stream gaging station in Iowa City, 3,271 square miles.[1] Approximately 156 square miles of tributary drainage is contained in the intervening reach between the dam and Iowa City.

Most of the basin is naturally well drained. However, the upper one-third of the basin lies in the most recent glaciated areas of the Late Wisconsin drift, where the drainage pattern is imperfectly developed and drainage projects with artificial channels supplement the natural drainage. In the Late Wisconsin drift area, runoff is relatively slow and serious ponding may occur after period of heavy rainfall. The remaining portion of the basin above the Coralville Reservoir is covered with relatively thick mantles of loess which were deposited on large areas of the older glacial drift. Runoff from this more mature topography is relatively rapid.

Because the Coralville Reservoir controls almost all of the drainage area above Iowa City, the features of the reservoir, dam, and appurtenant works need to be mentioned. The area of the reservoir when filled to the spillway crest elevation of 712.0 is 24,800 acres. The total capacity at spillway crest is 492,000 acre-feet, equivalent to 2.96 inches of runoff over the basin above the dam. Other pertinent data is contained in Table I.

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[1] Iowa Highway Research Board Bulletin No. 7, "Drainage Areas of Iowa Streams."

TABLE I.

PRIMARY FEATURES
CORALVILLE FLOOD CONTROL RESERVOIR

Reservoir

Capacity (total)	492,000 acre-feet
Capacity (flood control)	475,000 acre-feet
Length (river miles)	41.5
Length (reservoir miles)	30.3
Area (at spillway crest elevation)	24,800 acres
Area (within taking line)	34,700 acres
Drainage Area (Corps of Engineers)	3,084 sq. mi.
Drainage Area (U.S.G.S. Revision)	3,115 sq. mi.
Capacity in runoff (flood control)	2.86 inches

Conservation Pool:

	Mid July to Mid Feb.	Mid Feb. to Mid July
Capacity	50,800 acre-feet	17,000 acre-feet
Elevation (initial)	680.0 msl.	670.0 msl.
Area (initial)	4,900 acres	1,820 acres
Length (river miles)	----------	17.4

Dam and Appurtenances:

Earth Embankment	
Elevation of crest	743.0 msl.
Volume of fill (approx.)	1,000,000 cu. yds.
Width of crest	22 feet
Length of crest (approx.)	1,400 feet
Height above riverbed (approx.)	100 feet
Outlet works	
Length of intake and control sections	60 feet
Length of upper transition section	75 feet
Length of circular conduit	250 feet
Diameter of circular conduit	23 feet
Length of lower transition section	25 feet

(Table I. continued)

Discharge structure	
Length of chute	110.33 feet
Length of stilling basin	70 feet
Width of stilling basin at end sill	75.35 feet
Elevation of invert, approach end	646.0 msl.
Number of control gates	3
Size of control gates	10 x 20 feet
Discharge capacity, pool at spillway crest	19,100 cfs
Spillway	
Elevation	712.0 msl.
Length of weir	500 feet
Length of pavement below weir	600 feet
Design discharge	244,000 cfs

CHAPTER III.

THE FLOOD POTENTIAL OF THE IOWA RIVER AT IOWA CITY

The flood potential which existed on the Iowa River at Iowa City prior to completion of Coralville Flood Control Reservoir will be modified considerably by reservoir operation, primarily because 95 per cent of the drainage area at Iowa City is controlled by the reservoir. The magnitude and frequency of flood flows which can be expected in the reach from the dam site to Iowa City will depend primarily on controlled releases from the reservoir, although uncontrolled flows from the 156 square miles of intervening area must also be considered.

RESERVOIR OPERATION PLAN

Seven plans of operation have been studied by the Corps of Engineers. The various alternatives were studied to determine a method of operation which would maximize the flood control benefits on reaches downstream from the reservoir.

The first six plans were studied prior to 1951. Plan 7, (Table III), was studied during additional cost studies subsequent to 1951, and although normal regulation was identical to that proposed in Plan 6, operation during major floods were modified to avoid exceeding elevation 712.0 (M.S.L.) in the reservoir. Plan 7 was selected for the following reasons. First, reservoir operation must consider benefits on both the Mississippi River and the Iowa River. Approximately 90 per cent of the average annual benefits for flood control are obtained from the reduction of stages on the Mississippi River, as indicated on Table II. Although information in Table II was based upon Plan 6, substantially the same benefits would result under operation with Plan 7.

In addition, cost studies made by the Corps of Engineers in 1951 revealed that it was not economically feasible to raise remedial works and relocations sufficiently high to permit the normal use of surcharge storage above the spillway crest as was

proposed in Plan 6. This use would have been advantageous because a five-foot surcharge would add over 25 per cent to the volume of flood control storage which is available up to the spillway crest; the uncontrolled spillway discharge at this surcharge level would be approximately 16,000 cubic feet per second (cfs) which would be lower than 20,000 cfs it is possible to release through the outlet works.

Because surcharge storage, which is the volume of storage above the spillway crest, cannot be utilized in normal reservoir operations, the controlled outflow will be regulated up to 20,000 cfs to limit, insofar as possible, reservoir flood stages to the spillway crest level at elevation 712.0.

The general plan of operation under Plan 7 is outlined in Table III.

TABLE II

AVERAGE ANNUAL BENEFITS

CORALVILLE FLOOD CONTROL RESERVOIR
BASED ON OPERATION PLAN 6

Flood Control	
Iowa River	$ 135,825
Mississippi River	$1,168,977
Sub Total	$1,304,802
Other Benefits	
Fish and Wildlife	$ 33,700
Net Income from leased land	$ 50,000
TOTAL----------	$1,388,502

TABLE III.

RESERVOIR OPERATION PLAN 7

FLOOD CONTROL OPERATION

1. Regulate release rates between 1,000 cfs. and 8,500 cfs. to reduce, insofar as possible:

   a. Maximum flow at Iowa City to 8,500 cfs.
   b. Maximum flow below the mouth of English River to 13,500 cfs. during the three-day period of maximum stage on the Lone Tree gage.
   c. Maximum flow below the mouth of Cedar River to 30,000 cfs. during the three-day period of maximum stage on the Wapello gage.
   d. Mississippi River flood crest during the several days of crest flow in those flood events which exceed stage 17.5 feet on the Muscatine, Iowa, gage.

2. During the non-growing season (16 Oct. - 30 Apr.) release rates will be regulated between 1,000 cfs. and 10,000 cfs. to reduce insofar as possible, the flows under 1a, 1b, and 1c, to 10,000 cfs., 15,000 cfs, and 35,000 cfs. respectively.

3. When predictions indicate that operation in accordance with 1 and 2 above, will result in a water surface elevation at the dam higher than elevation 712.0 feet, such operation will close and thereafter natural flood crests will be modified as much as possible without exceeding elevation 712.0 feet.

CONSERVATION OPERATION

1. Between 1 January and 31 December, at such times when natural flow is less than 150 cfs. in the Iowa River at Iowa City, releases from storage will be made to maintain a minimum of 150 cfs. In addition, between mid-July and mid-February, the conservation pool elevation will be carried from elevation 670 to elevation 680.

EFFECT OF PROPOSED PLAN OF OPERATION ON THE FLOOD POTENTIAL

Because of the limited capacity of the reservoir, it is not possible to control the higher floods of record to non-damaging stages on the Iowa River below the reservoir. Studies were made in 1950 of flow conditions in various reaches of the Iowa River below Iowa City to determine allowable releases. Urban flood damages become significant in the Iowa City reach as discharges exceed 10,000 cfs. During the growing season, discharges in rural areas in and adjacent to Iowa City cannot exceed 8,500 cfs without inundating marginal agricultural lands. During the non-growing season, flows up to 10,000 cfs could be permitted with only nominal damages.

The flow figures selected for Plans 6 and 7 would result in nominal damages in the respective reaches. With the increased release rates, greater storage capacity is reserved for operating the reservoir during flood periods on the Upper Mississippi River. In addition, the Corps has planned an extensive program for studying future rainfall-runoff amounts and flood flows to assist in developing any necessary improvements to the operational plan.

Reservoir operation, when applied to recorded flood events, would have reduced the floods of record considerably. The magnitude of the reduction is listed in Table IV.

However, a careful examination of Table IV confirms that the reservoir does not have sufficient capacity to control the higher floods of record to non-damaging stages on the Iowa River below the reservoir. In addition, the maximum flood of record, in 1851, was twice the discharge of the 1947 flood. Insufficient data of the rates and volume of runoff prevented its being used by the Corps of Engineers in the study.

However, the Corps of Engineers, to study the maximum capabilities of the reservoir, synthetically derived storms and runoff data which could be theoretically routed through the reservoir. This is achieved by the use of the "standard project flood" as defined, by the Corps of Engineers. The standard

TABLE IV.

COMPUTED EFFECT OF RESERVOIR OPERATIONS FOR FLOODS OF RECORD

IOWA RIVER AT IOWA CITY

Plan 7

DATE OF FLOOD	RECORDED PEAK DISCHARGE cfs	PEAK DISCHARGE AS REGULATED BY RESERVOIR cfs
April 1960[1]	31,000[2]	10,800[1]
April 1959[1]	15,400[2]	9,380[1]
April 1951	15,000	8,500
June 1947	33,800	12,000
May 1944	31,100	8,500
June 1918	36,200[3]	8,500
July 1881	51,000[4]	Not estimated[5]
June 1851	70,000[4]	Not estimated[5]

1. Actual regulation during reservoir operation
2. Flow measured at Marengo, Iowa, above reservoir
3. Revised upward to 42,500 cfs by U.S. Geological Survey
4. Estimated by U. S. Geological Survey
5. Insufficient data available to route through reservoir

project flood is one which can reasonably be expected to occur and would be exceeded only on rare occasions. It might, therefore, constitute a standard for the design of protective works when considering only the flood potentialities of the river basin involved.

Various maximum storms experienced in the region are transposed to the river basin involved and the flood flows which would result from such storms are estimated. Thus, storms which actually have occurred are normally used in determining the magnitude of the standard project flood. The storms and resulting floods which would occur from the probable maximum precipitation would be of much greater magnitude than this.

The standard project flood was synthesized during studies for the Coralville Reservoir. A check of the resulting flood hydrographs indicates the following:

Peak Inflow into Coralville Reservoir	83,000 cfs
Peak Outflow, Initial regulation method	30,000 cfs
Subsequent regulation method	20,000 cfs
Runoff in inches, approximately	6.3 in.
1851 Flood as comparison (est. USGS)	70,000 cfs
1947 Flood as comparison	33,800 cfs

This indicates that the peak outflow from Coralville Reservoir produced by a flood of the magnitude of the standard project flood would result in a discharge of at least 20,000 cfs. The variation in outflow noted between the initial and subsequent regulation methods (30,000 cfs to 20,000 cfs) is in operation method. By releasing high rates of flow, up to 20,000 cfs, early during the storm, additional storage is available during later periods.

FLOOD POTENTIAL OF THE INTERVENING DRAINAGE AREA

Additional consideration must be given to the uncontrolled tributary drainage areas between Coralville Reservoir and Iowa City. Flood flows originating in these areas, in addition to

flooding of their own valleys, may also cause flooding along the Iowa River. Drainage areas listed in Bulletin No. 7, Iowa Highway Research Board, are:

Iowa River at Iowa City gage	3271 sq. miles
Iowa River at Coralville Reservoir dam	3115 sq. miles
Intervening Uncontrolled Area	156 sq. miles

Principal tributaries in the uncontrolled area are:

Rapid Creek	33.0 square miles
Muddy Creek	9.91 square miles
Clear Creek	105 square miles

All three tributaries flow into the Iowa River in the reach above the corporate limits. Being smaller tributaries, flash flooding is of the most concern. Because flood flows from Rapid Creek and Muddy Creek discharge into the much larger Iowa River valley some distance upstream from Iowa City, some attenuation of the probable flood peaks would occur as any flash flood moved downstream. On the other hand, Clear Creek, the largest tributary, discharges into the Iowa River immediately upstream from Iowa City. For this reason, its flood potential was studied first.

A review of published flood data on many Iowa rivers indicates that the maximum flood peaks fall into some sort of a general pattern, especially when peak flood flows, in terms of cubic feet per second, are plotted versus the drainage area in square miles. A general envelope curve usually encompasses most of the recorded data, although rare floods have exceeded this. The following estimates of flood flows from a drainage area of 100 to 105 square miles results from a study of the existing flood data.

ESTIMATED FLOOD BASED UPON:	CFS
1947 envelope curve of Iowa floods	22,000
General envelope curve of Iowa floods at present time	26,000 - 28,000
Maximum recorded at several times in Iowa for 100 square miles drainage area, approximately	50,000

A study was next made of the flood potential of Clear Creek utilizing synthetic storm and hydrograph techniques. The following results were obtained from this study of peak discharges from Clear Creek:

SYNTHESIZED FLOOD PEAK BASED UPON:	CFS
(a) 50-year rainfall frequency	6,000 - 7,000
(b) Transposed Nishnabotna River storm of 1958 using experienced infiltration amounts	22,000 - 26,000
(c) Standard Project Type of Storm	20,000 - 25,000
(d) Reasonable estimates if probable maximum precipitation would occur	above 40,000

The combined flood potential of all tributaries in the intervening drainage area is more difficult to analyze. However, a major flood-producing storm could cover the entire intervening drainage area which includes the three principal tributaries listed before. To conclude the study, the Rock Island District, Corps of Engineers, U. S. Army, agreed to evaluate the standard project flood for the intervening area. The analysis resulted in a peak flood flow of approximately 40,000 cfs at Iowa City, including 1,000 cfs reservoir outflow.

If the previous estimate of 20,000 to 25,000 cfs flow for Clear Creek is increased on a proportionate area basis from 105

to 156 square miles, a maximum flow estimate of 37,000 cfs would result. There appears to be good agreement on the flood potential of this intervening drainage area. Thus, the probability of rare floods on the intervening drainage area still poses a problem to Iowa City and suburban areas located along the Iowa River and the tributaries.

FREQUENCY ANALYSIS

The Corps of Engineers' discharge-frequency curves for the Iowa River at Iowa City indicate the effect of reservoir operation on the expected frequency of floods. A flow of 10,000 cfs has an annual frequency, modified by reservoir operation, of about once in four years. A flow of 12,000 cfs has a modified frequency of about once in 50 years. The estimated 100-year frequency discharge is modified from 49,000 cfs to about 17,000 cfs. Thus, there remains a one per cent chance in any one year of receiving a flood flow equal to or greater than 17,000 cfs.

The estimated maximum controlled release from the reservoir of approximately 20,000 cfs is just above the one per cent chance occurrence of 17,000 cfs and probably would be in the range of one-half to one per cent chance of annual occurrence.

SUMMARY

Regulated releases from Coralville Reservoir can reasonably be expected to give flood discharges up to 20,000 cfs during major floods on the Iowa River. In addition, the flood potential of the intervening drainage area may produce peak floods at Iowa City varying in magnitude from 25,000 to 40,000 cfs. Because close regulation can be maintained of the reservoir, it is very improbable that such peaks will ever coincide. If a storm occurs over the intervening drainage area, in all probability the reservoir will not be full and releases will be cut to the minimum of 1,000 cfs. Floods which would result from the probable maximum precipitation would exceed these estimated flood flows, but have little significance in problems of project efficiency or regulation.

Therefore, the flood potential in the reach of the Iowa River under study can be summarized as follows:

For the reach between the Coralville Flood Control Reservoir and the confluence of Clear Creek and the Iowa River, the maximum regulated release of approximately 20,000 cfs (with a nominal flow added for the two principal tributaries, Rapid and Muddy Creeks) would be the flood which has a reasonable potential of occurring. This release is greater than an estimated flood flow of the standard project flood magnitude of approximately 12,000 to 15,000 cfs which could occur from this local area alone.

Below the confluence of Clear Creek and Iowa River and on through the city, there is a flood potential of standard project flood magnitude of approximately 40,000 cfs. This magnitude of flood potential must be recognized and consistently pointed out, because the construction of certain essential municipal facilities may need to be located safe from the threat of such rare floods. However, practical limitations must be considered in the normal regulation of both the development and use of flood plain lands. A flood flow of 25,000 cfs which provides for some tributary inflow at times when releases are at 20,000 cfs, has a reasonable potential of occurring. In addition, there is a reasonable potential of a 25,000 cfs flood flow from the intervening drainage area alone.

Therefore, for the reach being considered, it is recommended that development and use of land that would be inundated by a flood flow of 25,000 cfs in the Iowa River be regulated and controlled by appropriate flood plain regulations, to effectively minimize future flood damages.

CHAPTER IV.

SELECTION AND DISCUSSION OF FLOODING LIMITS ALONG THE IOWA RIVER

In the previous chapter, the variation in magnitude of floods which either have occurred or which have a potential of occurring were discussed. Of equal and more practical importance is the area inundated by such floods, the flood stages or water surface elevations for each flood flow, and the changes in flood stages which either have occurred or may occur in the future as flood plain lands are more intensively developed.

THE FLOOD PLAIN BOUNDARY

The definition of "flood plain" normally accepted is "the area adjoining the river or stream which has been or may be hereafter covered by flood water." The flood plain, as defined, can be determined and designated if data on floods of record are available and if sufficient hydraulic and hydrology data are available to synthesize the probable flood potential of the river. For instance, at Iowa City the maximum floods on the Iowa River in recorded history are the June 1851 and July 1881 floods, for which a few flood marks are still known to exist. Areas inundated by major floods in 1918 and 1947 undoubtedly were covered to a greater depth in 1851 despite the gradually increasing flood stages resulting from continued encroachment of the flood plain with fills, levees, dams, bridges, and other obstructions. Certainly all floods of record assist in the establishment of the flood plain boundary. Because the flood potential of standard project magnitude which exists at Iowa City, following the construction of Coralville Reservoir, is considerably lower in magnitude than the 1851 flood flow (40,000 cfs vs. 70,000 cfs) the latter flood flow serves as the basic criteria for the practical establishment of the flood plain boundary. However, the flood stages of each flood of record and the estimated stages for floods which have a reasonable potential of occurring all need to be compared and evaluated in determining flooded areas and designating the flood plain boundary.

Designation of the flood plain boundary is extremely useful and valuable in flood plain regulation. It clearly indicates to the public that the land within the flood plain has been flooded or is subject to flooding, and that any construction or other activity thereon should be initiated with full cognizance of flooding possibilities and consequences.

The flood plain boundary in the reach under study is shown on the maps contained in Appendix B. Determination of this boundary is based upon information obtained from the Corps of Engineers, Rock Island District, the U. S. Geological Survey district office, Iowa City, and other local information reports, of which the most important are listed in the bibliography. Certain peak flood marks are indicated on the flood profiles contained in Appendix A.

OTHER FLOODING LIMITS

It appears impractical at the present to regulate all flood plain lands because the construction and operation of Coralville Reservoir has reduced considerably the flood potential of the Iowa River. Of more importance is the area which would be inundated by floods which have a more reasonable probability of occurrence. In the previous chapter, it was concluded that floods which reasonably could be expected to occur along the main channel of the Iowa River would approach 25,000 cfs in magnitude although there is a potential for 40,000 cfs. The 25,000 cfs flow figure was recommended as a reasonable and practical limit in regulation of flood plain development in the reach under study.

Because future flood plain development may occur in areas which remain subject to inundation, the effect of removing such areas by filling, etc., also must be considered. During major floods, nature normally provides the entire flood plain for a floodway, i.e., that area of the flood plain which is reasonably required to carry and discharge the flood water or flood flow. Flood plain fills, bridge constrictions, dams, etc. may alter the existing conveyance characteristics and result in unreasonable or damaging increases in stage or water surface

elevations, or in velocity of flow. In addition to the physical conveyance or flow of water, valley storage is also a function of flood water discharge which cannot be overlooked. To flow at high stages, a flood must fill the valley to an appreciable degree. Often this results in a beneficial reduction in the peak magnitude of the flood flow, in terms of rate of flow, as a flood moves downstream although the total volume of flood water is unchanged. However, the storage available in Coralville Reservoir minimizes the need for valley storage and less area of the flood plain may be needed for conveyance if unreasonable or damaging increases in stage are avoided.

The Corps of Engineers previously has collected flood profile and elevation data and established profiles for various discharges which were based on flood plain conditions existing at the time of construction of the reservoir. A study was made herein to determine the effect on stages if the flood flows were restricted to various widths within the existing flood plain. The existing channel and overbank areas were used in estimating stages because it was considered that in the future there would be little, if any, interest in improving the channel to increase its ability to convey flood flows.

Water surface profiles were computed for discharges of 10,000, 20,000, 25,000, and 30,000 cfs for the following channel and overbank conditions:

1. Existing flood plain areas.
2. Main channel area only.
3. Main channel area and nearest low overbank areas adjoining the main channel.

The combination of the many bridges, the University levee system, flood plain fill operations at various locations, and the University Dam at Burlington Street has constricted the Iowa River in the reach between the Park Road bridge and Benton Street. The present improved channel appears to be adequate in conjunction with reservoir operation, to convey flood flows which reasonably can be expected to occur in the future. However, further encroachment in this area should not be permitted. Because the

existing channel is all that can be physically and economically obtained, flood profiles for existing and future conditions are identical. Fortunately, all bridges in the reach under study are considered to be adequate for the flood flows which reasonably can be expected.

This constricted reach described above affects flood flows to the extent that, for a particular flood flow, the water surface elevations at or above Park Road bridge are established at a relatively high elevation. For this reason, above this constricted reach the overbank areas which lie between the Park Road bridge and the low head power dam at Coralville are somewhat inefficient in conveying flood flows. This is indicated by the flood profiles in this reach. Above the low head dam at Coralville, Iowa, natural river valley conditions prevail and certain overbank areas are needed if water surface elevations are to be kept within reasonable limits under the existing stage of development.

The flood profiles are presented in Appendix A for each of the above conditions and discharges. Elevations are based upon mean sea level, 1929 adjustment.

A map of Iowa City and a map of the reach between Coralville Reservoir dam and Iowa City are included in Appendix B outlining the flood plain boundary and two additional flooding limits based upon a discharge of 25,000 cfs. The innermost flooding limits, entitled "encroachment limits," were determined under the third condition outlined above and represent the maximum limit to which landside flood plain fills and other obstructions, structures, etc. should be permitted to encroach. Only open type uses should be permitted in the area entitled District "A", within these encroachment limits, to assure that adequate area is available for conveyance of flood flows under future conditions of flood plain development.

The elevations and step limits shown on the map are based upon the flow of 25,000 cfs confined to the area within District "A", and represent the estimated water surface elevations under

this condition. The second flooding limits shown, entitled "inundation limits at water surface elevation shown," indicates the extent of flooding at the water surface elevation shown. In other words, if the area within District "B", the area between the encroachment limit and adjacent inundation limit, was filled to or above the indicated elevation, it would not be flooded or inundated by any discharge up to 25,000 cfs. Moreover, filling the area within the "B" District would not cause stages to be increased above the indicated elevations. Areas outside the inundation limits are, by definition, those areas which are above the indicated elevation, and which would not be flooded or inundated by flood flows up to 25,000 cfs.

Elevations are based upon mean sea level, 1929 adjustment. The elevations and inundation limits have been determined as accurately as possible consistent with available data. The actual position on the ground of the flooded areas will vary little from those shown on the map, and to determine the limits with a higher degree of accuracy is not warranted until subdivision or development surveys are submitted to the city.

It is estimated that for the reach downstream from the confluence of Clear Creek and the Iowa River, water surface elevations for a flow of 40,000 cfs would be approximately three to four feet above the indicated water surface elevations for 25,000 cfs.

CHAPTER V.

FLOODING ALONG TRIBUTARY STREAMS WITHIN URBAN AREAS

Numerous small tributaries to the Iowa River are located entirely within or flow through some portions of the city. All of these tributaries can cause flash flooding. Past encroachments upon the flood plain of these streams has resulted in additional flood problems. The tributaries of most concern, of course, are Clear Creek and Ralston Creek. The flood potential of Clear Creek has already been reported. Ralston Creek originates east and northeast of the city. The north branch has a drainage area of about 3.1 square miles at the stream gage location at Rochester Avenue. The confluence of the north and south branches is just downstream from this point and the creek flows on through residential and industrial areas. The drainage areas above the confluence of the north and south branches are 3.3 and 4.1 square miles respectively. The drainage area is 8.75 square miles at its confluence with the Iowa River near the sewage treatment plant. Approximately one-fifth of the drainage area is in urban areas and four-fifths in the rural agricultural area.

Other, much smaller, tributaries are actually short, steep ravines leading from the high bluffs directly to the Iowa River. In recent years, such areas have often been a challenge for residential builders who desired a unique building site.

Flood problems along these tributaries shcuild not be ignored, for they present a total damage potential which could easily exceed that of the Iowa River itself. However, construction of bridges and other encroachments which have existed for many years, make it exceedingly tedious and time-consuming to evaluate conveyance requirements.

In addition, economic feasibility should determine, normally, the level of protection and the frequency-of-flood-occurrence in minimizing flood damages. However, the danger to human life

and other intangibles are difficult if not impossible to evaluate in monetary terms under flash flood conditions. It appears that a one per cent chance of annual flood occurrence, or 100-year average frequency, should be the minimum to be considered in determining conveyance requirements and water surface elevations.

RALSTON CREEK FLOOD REPORT

A rather comprehensive report on flooding from Ralston Creek was prepared in January 1952, by the Engineers' Club of Iowa City. The committee which prepared the report made a study of the condition of the watershed and the channels within the city limits. Although special emphasis was placed on the south branch, much residential construction which occurred subsequently on the north branch could now cause additional concern.

However, the report of 1952 was divided into two parts, as quoted from the letter of transmittal:

> "(1) a general discussion of the problem, including the probability of flood damage, the determination of remedial measures, methods of financing such measures; and what should be done in the immediate future; and
>
> (2) a technical report, including the physiography of the watershed, hydrologic data, flood-producing storms, flood frequencies, flood damage, and detailed recommendations for improvements."

The report indicates that flood damage may occur to low-lying properties adjacent to Ralston Creek from floods which will occur on an average of once in every five years. Severe floods of greater magnitude would intensify local damages. A "catastrophic" flood (similar to a "standard project flood") would possibly destroy many low-lying properties, cause loss of life, and result in much damage to streets and bridges and could affect the city as a whole. As the report states, no such flood has occurred on Ralston Creek in its history, but some have occurred near Iowa City in recent years.

The existing flood damage situation is discussed in the 1952 report and is extracted below.

> "Flood damage in the Ralston Creek watershed practically all happens in Iowa City, and the greater proportion is concentrated along the South Branch. Comparatively little damage has so far occurred along the North Branch or along the main stream. The main stream was widened, deepened, straightened and lined some years ago, and while there is much yet to be done, including corrective measures at bridges and repair and cleaning of the lining, little flood damage has resulted along this stretch in recent years. The only area on the North Branch where flood damage occurs is in the vicinity of the abandoned railroad crossing near Porter Avenue.
>
> An indicated above, the flood damage along the South Branch comes in large measure from overflow into the old flood plain along Rundell Street, from about Sheridan to Muscatine Avenues. Above that point, some overflow also occurs and several houses which are on the flood plain get wet whenever the creek is carrying a flood of any magnitude.
>
> Considerable damage has been caused during floods by sanitary sewers backing up into the basements of homes. These sewers do not carry storm water intentionally, but infiltration, leakage around manholes, and water from flooded basements, all contribute to the sewers, which are apparently inadequate to carry it without going under considerable pressure, with the result that backups occur."

Floods have occurred on both branches of sufficient magnitude to cause flood damage by inundation of low-lying properties, and backup in sanitary and storm sewers. Major floods occurred in 1942, 1950, and 1956. The 1952 report indicates that for the July 1950 storm with rainfall of approximately 3.3 inches, peak

flood flows were estimated as follows:

North Branch at Rochester Avenue	1,510 cfs
South Branch at College Avenue	775 cfs
Main Stream at Gilbert Street	1,920 cfs

A more severe flood occurred in July 1956. The average rainfall over the north branch watershed for the entire storm was about three inches and the peak flood flow at Rochester Avenue was 1,690 cfs. Local newspapers gave substantial coverage to flood damage and bridge constriction problems.

Flood frequency data included in the 1952 report is listed in Table V.

TABLE V.

Average recurrence intervals, in years, and probable peak discharges, in cubic feet per second, on the North Branch, South Branch, and main Ralston Creek at mouth.

AVERAGE RECURRENCE INTERVAL	PROBABLE PEAK DISCHARGES, CFS		
	N. BRANCH (3.0 sq.mi.)	S. BRANCH (4.1 sq mi.)	MAIN STREAM (at mouth) (8 sq. mi.)
2	440	525	900
5	810	1,010	1,610
10	1,080	1,350	2,080
20	1,370	1,720	2,640
30	1,550	1,900	2,920
50	1,770	2,200	3,320

*At USGS gage.

It can be concluded that north branch has experienced a flood of about the 50-year frequency. In all probability, the main stream has not experienced a flood of this magnitude. It is certain that a catastrophic or rare flood has not been experienced.

The 1952 report contained the following conclusions and recommendations:

I. The damages caused by flooding can be materially reduced, possibly eliminated. The method of accomplishment and, in particular, its cost, can be determined only by a careful study by a competent consulting engineer. It is recommended that the city initiate this study without delay. The committee has not considered the possibilities of diverting any part of the flow around the city or upstream storage.

II. In the interval prior to completion of the above study, the present flood dangers can be materially lessened through certain remedial measures, which might become a part of the comprehensive plan. These have been set forth in the foregoing discussion and consist principally of channel improvements and the removal of constrictions.

III. Any future building developments along the flood plain of the stream system will be subject to the same dangers from flooding as present developments and should be discouraged, if possible. Consideration by the city of advising any person who in the future requests permission to build along the creek, within what appears to be the flood plain, of the ever-present hazards of flooding should be given.

IV. The sanitary sewer systems within the watersheds of the North and South Branches are subject to serious overloading through entry of storm waters. The entire system should be critically examined and rebuilt where necessary, to eliminate storm waters and improve flow capacity.

V. A storm-sewer system to alleviate local flooding within the watershed is indicated, particularly in the Rundell Addition. Plans for this should be made before the center of Rundell Street is paved.

VI. Serious consideration should be given to the use of presently undeveloped areas within the flood plains of the North and South Branches as parkways for landscape planting and beautification.

VII. The design of future stream crossings, such as the one contemplated on Parsons Street over the North Branch, should be based on available hydrologic data. The bridge should in no way obstruct the channel.

Little, if any, action has been taken to date in regard to these recommendations. The recommendations are still pertinent and should be followed so that the problem of flooding along Ralston Creek can be alleviated. It is noted that recommendations III and VI pertain to flood plain regulation.

CLEAR CREEK:

Because urban development along Clear Creek is becoming more intensified, flood problems should be mentioned.

Almost the entire watershed of Clear Creek is in the rural agricultural area. The only urban development which is affected lies between the C. R. I. & P. Railroad bridge and the mouth of the creek. This low area is a part of the flood plain of both Clear Creek and the Iowa River, and continued filling of the area for urban development has progressed to a point where only a relatively narrow channel remains for the conveyance of flood flows. Flood damages during major floods could become severe and an improved channel may become a necessity to adequately convey a flood flow of the frequency of either a one or two per cent chance

of annual occurrence. At the stream gaging station upstream from the Town of Coralville, the maximum recorded flood flow is about 3,160 cfs in 1960, which is less than the estimated flood of a two per cent chance of annual occurrence (once in 50 years as an average.)

Regulation of flood plain development and improvement of the channel is needed in this area along with regulation of areas upstream from the railroad bridge to control future development.

SUMMARY

Because of lack of sufficient data, it is recommended that in these tributary streams, the encroachment and inundation limits be synonymous and should encompass all areas which have been inundated by the floods of record. This approach would limit future development to open type uses. Existing structures within the encroachment limits presumably would become non-conforming uses. Although the floods of record on Clear Creek and Ralston Creek have been less than an estimated one per cent chance occurrence, they are believed to have been of sufficient magnitude to determine these flooding limits. Exceptions may be evident, however, depending on the hazards involved. Studies should be continued to determine the additional flood potential of these tributaries and to determine if flood protection works or other remedial measures could be economically justified, or if some adjustment in structures or occupancy should be proposed.

CHAPTER VI.

REGULATION OF FLOOD PLAIN DEVELOPMENT

Both state and local government agencies in Iowa have responsibilities and regulatory powers for controlling and regulating developments in or on the flood plains. The Iowa Natural Resources Council administers Iowa Code Chapter 455A regulating flood control works and construction in or on the floodway. Municipal and county governments have statutory authority for adopting zoning ordinances.

LEGAL ASPECTS

Zoning is a legal tool used to control and direct the use and development of land for the purpose of promoting the health, safety, morals, or general welfare of the community. The power to zone rests initially in the state under its police powers and may be delegated to its political subdivisions by the state constitution or by legislative enactment. Where, as in Iowa, the zoning power is granted to cities and towns by statute (Chapter 414, Iowa Code 1958) the municipality has only such power in zoning matters as is expressly granted by the statute or is necessarily implied for the purpose of carrying out the power granted. Generally, municipalities may not regulate in those area where the state has undertaken regulation under the police power.

Flood plain zoning is a means of regulation of land which is subject to flooding by placing it in a separate district with appropriate restrictive use provisions so that flood damage can be minimized.

Inasmuch as statutes such as Chapter 414 of the Iowa Code contain no specific reference to floods, flood plains, or floodways, some authorities have declared that flood plain zoning is, at best, of questionable legality. Better authority representing the current trend of legal opinion in these matters holds that flood plain zoning is designed to accomplish a purpose which is

properly a subject of the zoning power and merely involves inclusion of a flood plain district as part of the comprehensive zoning plan. In some states, flood plain districts have been established under the authority of a statute similar to Chapter 414 of the Iowa Code and in at least one state, the enabling statute has been amended to specifically provide for flood plain regulation.

Under present statutes, therefore, cities and towns in Iowa very probably have the power to regulate the use of flood plain lands within the borders of such city or town. Cooperation in the determination of flooding limits, and enactment of a municipal zoning ordinance establishing flood plain districts and providing for regulation thereof would provide effective control over the use of all flood plain lands within the municipal limits of the city.

FLOOD PLAIN ZONING TECHNIQUES

The Planning and Zoning Commission of Iowa City has recently developed a comprehensive plan to guide the growth and development of the city. It is their basic responsibility to determine and designate which areas of the city are most suitable for various urban uses, such as residential, commercial, industrial, recreational, etc. Flood plain zoning is recommended to assure: (1) that sufficient area is provided for conveyance of future flood flows, and (2) that development of the flood plain for designated uses proceeds in an orderly manner. Flood plain zoning, therefore, does not necessarily prohibit development, but instead regulates the development so that, for instance, the public will not subsequently be forced to expend exorbitant funds to remedy a flood problem.

Flood plain zoning could be established in the following manner. First, the area within the encroachment limits, labeled District "A", would be placed in a flood plain district in which only open types of uses would be permitted since the area must be kept free to convey and discharge the flood flows. All other areas in District "B", the area between the encroachment limit

CHAPTER VII.

SUMMARY AND CONCLUSIONS

The study confirms that flood problems still exist along the Iowa River and its tributaries at Iowa City. Although the operation of the Coralville Flood Control Reservoir will provide a high degree of flood protection to the urban areas located on the Iowa River flood plain, the potential for serious flooding is still present.

The flood problems can be summarized as follows:

(1) Controlled release from Coralville Reservoir may reasonably be expected to reach a discharge of 20,000 cubic feet per second during regulation of major floods originating in the basin above the reservoir. Consideration must be given to additional flood flows occurring at the same time from the 156 square miles of intervening drainage area between the reservoir and Iowa City.

(2) The flood potential of this intervening drainage area of 156 square miles has been evaluated. A reasonable potential for flood flows of approximately 25,000 cubic feet per second has been established. A flood potential of standard project magnitude of 40,000 cfs on the Iowa River below the confluence with Clear Creek is indicated.

(3) Flood problems exist along the tributary streams, and in urban areas the problems are becoming more serious. The major tributary streams above Iowa City are Rapid, Muddy, and Clear Creek, and within the city the major tributary is Ralston Creek. Other short tributaries and ravines often pose flash flood problems.

Flood plain regulation is recommended to minimize future flood damages. These damages could easily become excessive if existing undeveloped flood plain areas are permitted to develop into urban uses in a haphazard and uncontrolled manner. A flood

and the adjacent inundation limit, would be placed in a second flood plain district which would be superimposed over the basic zoning districts designated by the Planning and Zoning Commission. Also, building and subdivision regulations would provide that, within District "B":

(1) No streets, alleys, thoroughfares, etc. shall hereafter be constructed at an elevation lower than the elevation indicated for the flood plain districts shown on the zoning map.

(2) No first floor, nor basement floor, of any house, building, structure, etc. shall be constructed at an elevation lower than an elevation of one foot above the elevation indicated for the flood plain districts shown on the zoning map.

Additional subdivision regulations may be desirable to assure proper grading, etc. to meet the above mentioned regulations. Open type uses and access roads to such uses could be permitted at a lower elevation.

Because long periods of bankfull flows will result from operation of Coralville Reservoir, and releases up to 10,000 cfs may frequently occur, saturation of low flood plain areas and other ground-water problems may be expected to increase, and may prohibit the development of some urban uses.

A second alternative would be the creation of additional flood plain districts for particular uses which would eliminate the superposition technique. However, the first technique is recommended.

flow of 25,000 cubic feet per second, and its associated flood profile, is recommended as the basis for flood plain regulation on the Iowa River.

The flood plain boundary has been outlined upon suitable maps, and flooding limits have been determined along the Iowa River for the 25,000 cfs flood flow. An innermost encroachment limit is established to assure that sufficient flood plain area is provided for future conveyance of flood flows up to 25,000 cfs. Areas situated between the encroachment limits and the inundation limits are in a second flood plain area or district and, unless filled to the indicated elevation or stage of the 25,000 cfs flood flow, would be inundated by that flood flow.

Zoning of these flood plain areas through establishment of two flood plain districts with appropriate use and building restrictions is recommended. Only open types of land use can be permitted in the "A" District within the encroachment limits since its ability to convey and discharge flood flows must not be impaired. In the "B" District, the area between the encroachment limit and the adjacent inundation limit, regulations should provide that (1) No streets, alleys, or thoroughfares, etc. shall hereafter be constructed at an elevation lower than the elevation indicated for the flood plain districts shown on the zoning map, and (2) No first floor, nor basement floor, or any house, building, structure, etc. shall be constructed at an elevation lower than an elevation of one foot above the elevation indicated for the flood plain districts shown on the zoning map. Additional regulations should permit open type uses and access roads to such uses. Such regulations would assure that certain flood plain areas could be developed in an orderly manner for the most advantageous use as outlined in the comprehensive city plan and permitted by the zoning ordinance.

In view of the apparent intent of the Iowa City Planning and Zoning Commission to recommend adoption of an entirely new zoning ordinance, no specific recommendations can be made as to the language to be employed in the sections relating to flood plain zoning. However, examples of such sections incorporated

in existing zoning ordinances are included in the references listed in the selected bibliography. In addition, the staff of the Iowa Natural Resources Council is prepared, upon request, to assist the City of Iowa City and its representatives in the preparation of sections relating to flood plain zoning.

Studies should be continued to evaluate the flood potential, flood problems, and flooding limits on all tributaries within urban areas. Previous reports, on Ralston Creek in particular, are available and should be utilized. Flood plain regulation and zoning should be incorporated in these tributary areas, as well as the planning and construction of any necessary remedial flood protection works and/or adjustments in structures or occupancy to complete the program to minimize flood damages in Iowa City.

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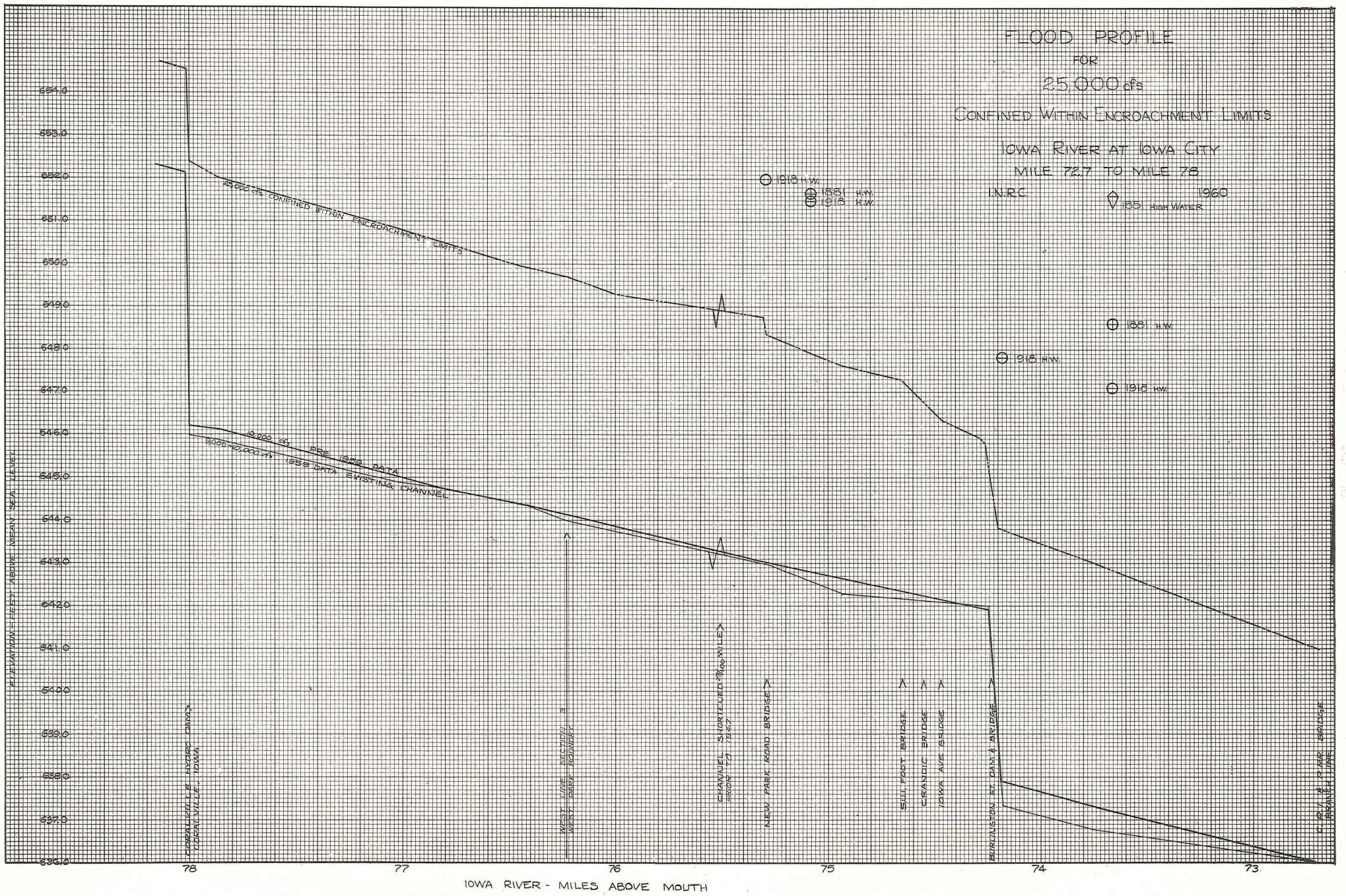
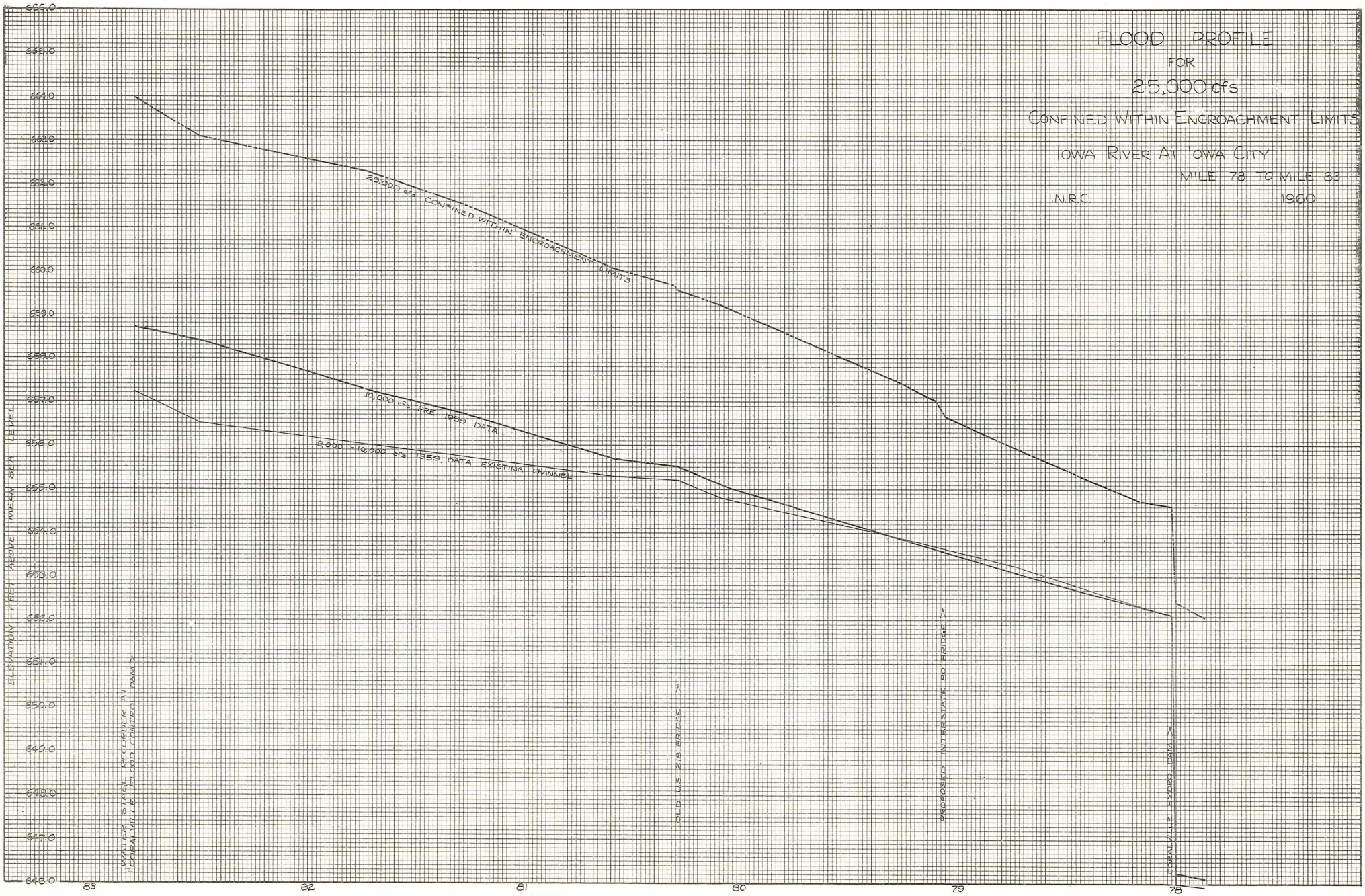
APPENDIX A

FLOOD PROFILES

Sheet No. 1	Flood Profile for 25,000 cfs Confined Within Encroachment Limits. C.R.I. & P.R.R. (Branch Line, Mile 72.7) to Coralville Low-Head Hydro-Dam (Mile 78.0)
Sheet No. 2	Flood Profile for 25,000 cfs Confined Within Encroachment Limits. Coralville Low-Head Hydro-Dam (Mile 78.0) to Coralville Flood Control Dam (Mile 83.3)
Sheet No. 3	Flood Profiles for Selected Discharges. C.R.I. & P.R.R. (Branch Line, Mile 72.7) to Coralville Low-Head Hydro-Dam (Mile 78.0)
Sheet No. 4	Flood Profiles for Selected Discharges. Coralville Low-Head Hydro-Dam (Mile 78.0) to Coralville Flood Control Dam (Mile 83.3).


FLOOD PROFILE
FOR
25,000 cfs
CONFINED WITHIN ENCROACHMENT LIMITS
IOWA RIVER AT IOWA CITY
MILE 72.7 TO MILE 78
I.N.R.C.
1960
1851 HIGH WATER
1918 H.W.
1881 H.W.
1918 H.W.
1881 H.W.
1918 H.W.
1918 H.W.
25,000 cfs CONFINED WITHIN ENCROACHMENT LIMITS
19,000 cfs PRE 1958 DATA
9000 to 10,000 cfs 1958 DATA EXISTING CHANNEL
ELEVATION = FEET ABOVE MEAN SEA LEVEL
654.0
653.0
652.0
651.0
650.0
649.0
648.0
647.0
646.0
645.0
644.0
643.0
642.0
641.0
640.0
639.0
638.0
637.0
636.0
78
77
76
75
74
73
IOWA RIVER - MILES ABOVE MOUTH
CORALVILLE HYDRO DAM
CORALVILLE IOWA
WEST LOOP SECTION
WEST DEPOT ROUNDKY
CHANNEL SHORTENED 3.9 MILES
NEW PARK ROAD BRIDGE
SUI FOOT BRIDGE
CRANDIC BRIDGE
IOWA AVE BRIDGE
BURLINGTON ST. DAM & BRIDGE
C.R.I. & P. R.R. BRIDGE
RIVERSIDE LINE


FLOOD PROFILE
FOR
25,000 cfs
CONFINED WITHIN ENCROACHMENT LIMITS
IOWA RIVER AT IOWA CITY
MILE 78 TO MILE 83
I.N.R.C. 1960
25,000 cfs - CONFINED WITHIN ENCROACHMENT LIMITS
10,000 cfs - PRE-1959 DATA
5,000 - 10,000 cfs - 1959 DATA - EXISTING CHANNEL
WATER STAGE RECORDER AT CORALVILLE RESERVOIR CONTROL DAM
OLD U.S. 218 BRIDGE
PROPOSED INTERSTATE 80 BRIDGE
CORALVILLE HYDRO DAM
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
665.0
664.0
663.0
662.0
661.0
660.0
659.0
658.0
657.0
656.0
655.0
654.0
653.0
652.0
651.0
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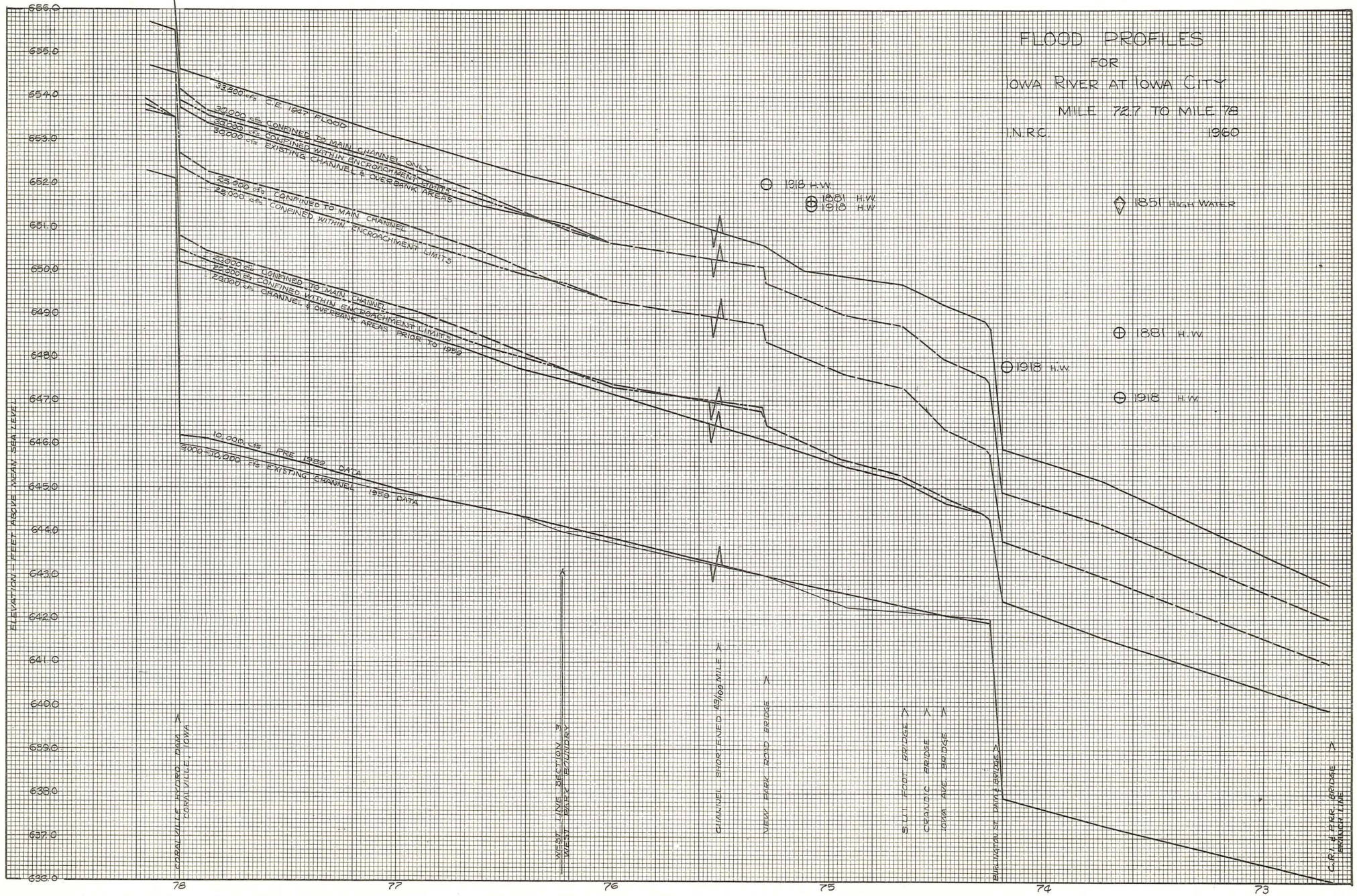
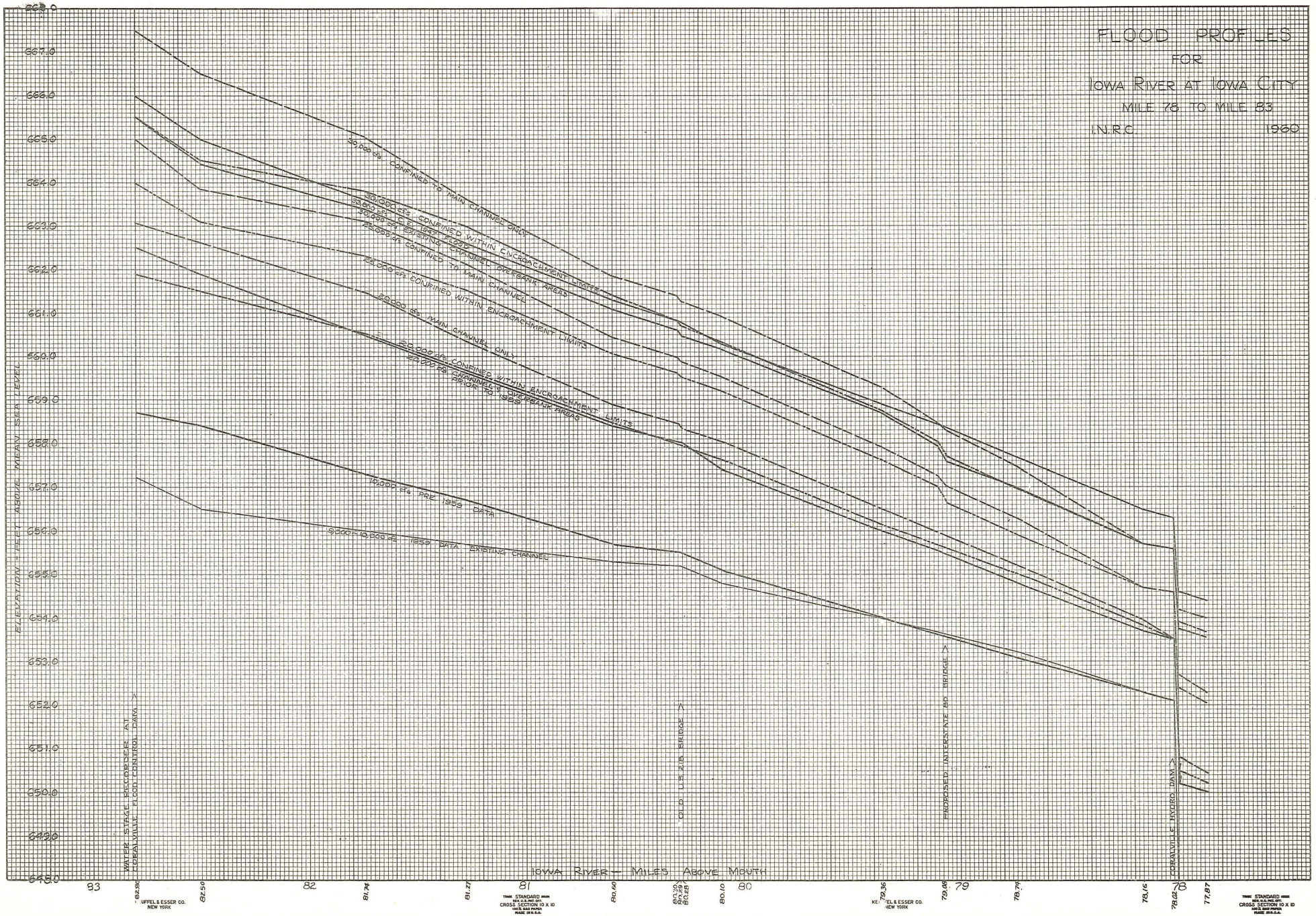
648.0
647.0
646.0
83
82
81
80
79
78
IOWA RIVER - MILES ABOVE MOUTH

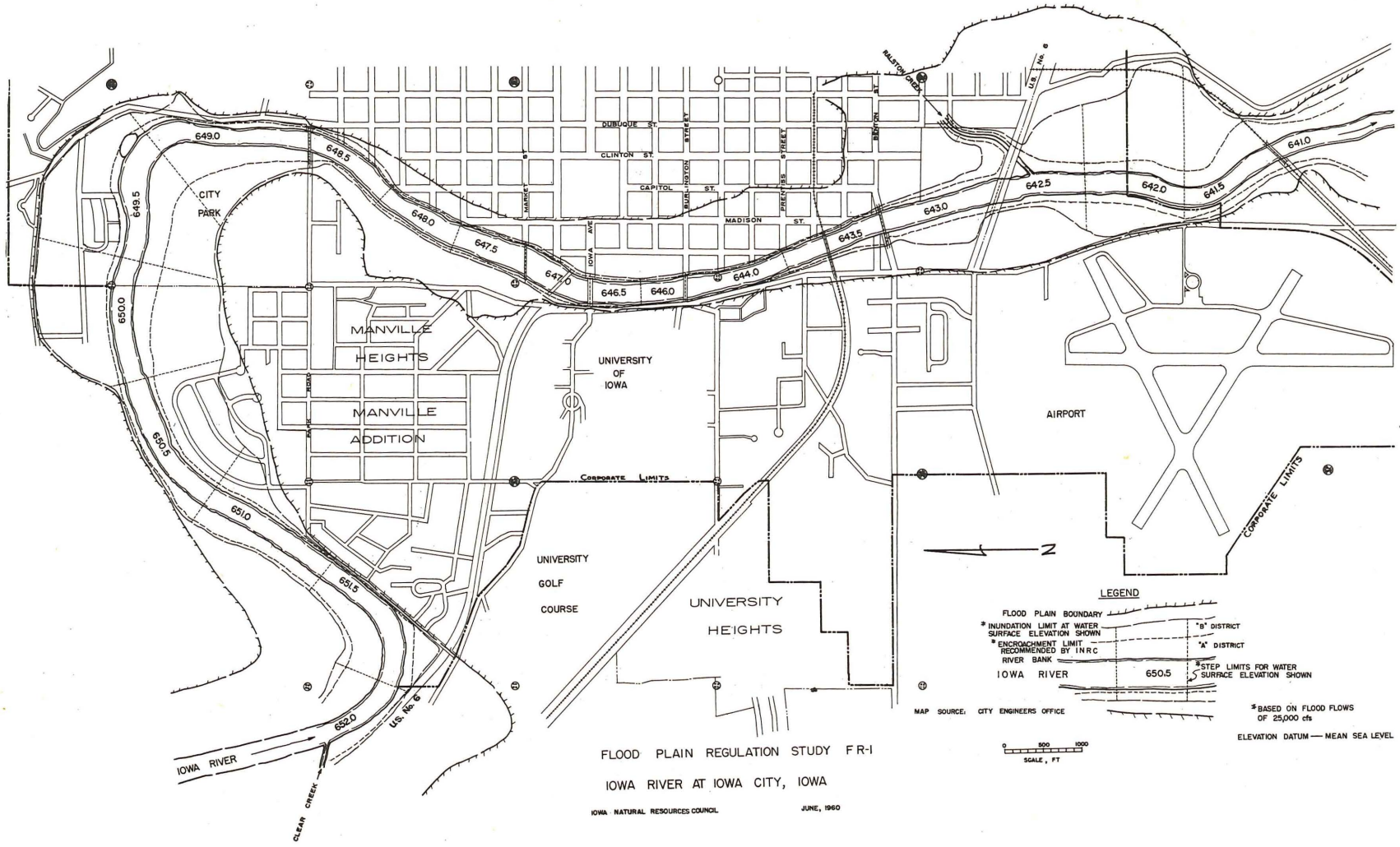

FLOOD PROFILES
FOR
IOWA RIVER AT IOWA CITY
MILE 72.7 TO MILE 78
I.N.R.C. 1960
35,300 cfs P.E. 1947 FLOOD
30,000 cfs CONFINED TO MAIN CHANNEL ONLY
30,000 cfs CONFINED WITHIN ENCROACHMENT LIMITS
30,000 cfs EXISTING CHANNEL & OVERBANK AREAS
25,900 cfs CONFINED TO MAIN CHANNEL
25,900 cfs CONFINED WITHIN ENCROACHMENT LIMITS
20,000 cfs CONFINED TO MAIN CHANNEL
20,000 cfs CONFINED WITHIN ENCROACHMENT LIMITS
20,000 cfs EXISTING CHANNEL & OVERBANK AREAS PRIOR TO 1959
10,000 cfs PRE 1959 DATA
9,000 - 10,000 cfs EXISTING CHANNEL 1959 DATA
1918 H.W.
1881 H.W.
1918 H.W.
1851 HIGH WATER
1881 H.W.
1918 H.W.
1918 H.W.
ELEVATION - FEET ABOVE MEAN SEA LEVEL
656.0
655.0
654.0
653.0
652.0
651.0
650.0
649.0
648.0
647.0
646.0
645.0
644.0
643.0
642.0
641.0
640.0
639.0
638.0
637.0
636.0
CORALVILLE HYDRO DAM
CORALVILLE, IOWA
WEST LINE SECTION 3
WEST BOUNDARY
CHANNEL SHORTENED 4370 FEET
VIEW PARK ROAD BRIDGE
S.U.I. FOOT BRIDGE
CRAWDC BRIDGE
IOWA AVE. BRIDGE
BURLINGTON ST. DAM & BRIDGE
C.R.I.&P.R.R. BRIDGE
BRANCH LINE
78
77
76
75
74
73
IOWA RIVER - MILES ABOVE MOUTH


FLOOD PROFILES
FOR
IOWA RIVER AT IOWA CITY
MILE 78 TO MILE 83
I.N.R.C. 1960
ELEVATION = FEET ABOVE MEAN SEA LEVEL
IOWA RIVER - MILES ABOVE MOUTH
50,000 cfs CONFINED TO MAIN CHANNEL ONLY
50,000 cfs CONFINED WITHIN ENCROACHMENT LIMITS
50,000 cfs CONFINED TO MAIN CHANNEL OVERBANK AREAS
50,000 cfs CONFINED TO MAIN CHANNEL
50,000 cfs CONFINED WITHIN ENCROACHMENT LIMITS
50,000 cfs MAIN CHANNEL ONLY
50,000 cfs CONFINED WITHIN ENCROACHMENT LIMITS
50,000 cfs CONFINED TO MAIN CHANNEL OVERBANK AREAS
50,000 cfs CONFINED TO MAIN CHANNEL
10,000 cfs FREE 1959 DATA
9,000 to 10,000 cfs 1959 DATA EXISTING CHANNEL
WATER STAGE RECORDER AT CORALVILLE FLOOD CONTROL DAM
U.S. 218 BRIDGE
PROPOSED INTERSTATE 80 BRIDGE
CORALVILLE RIVERS DAM
UFFEL & ESSER CO. NEW YORK
KEUFFEL & ESSER CO. NEW YORK
TRIANGLE STANDARD MADE IN U.S.A. NO. 077 CROSS SECTION 10 X 10 100% RAG PAPER MADE IN U.S.A.

APPENDIX B

FLOOD PLAIN REGULATION MAPS

Map No. 1	Iowa River at Iowa City, Iowa
Map No. 2	Iowa River from Coralville Flood Control Dam to Iowa City



MAP SOURCE: CITY ENGINEERS OFFICE

*BASED ON FLOOD FLOWS OF 25,000 cfs

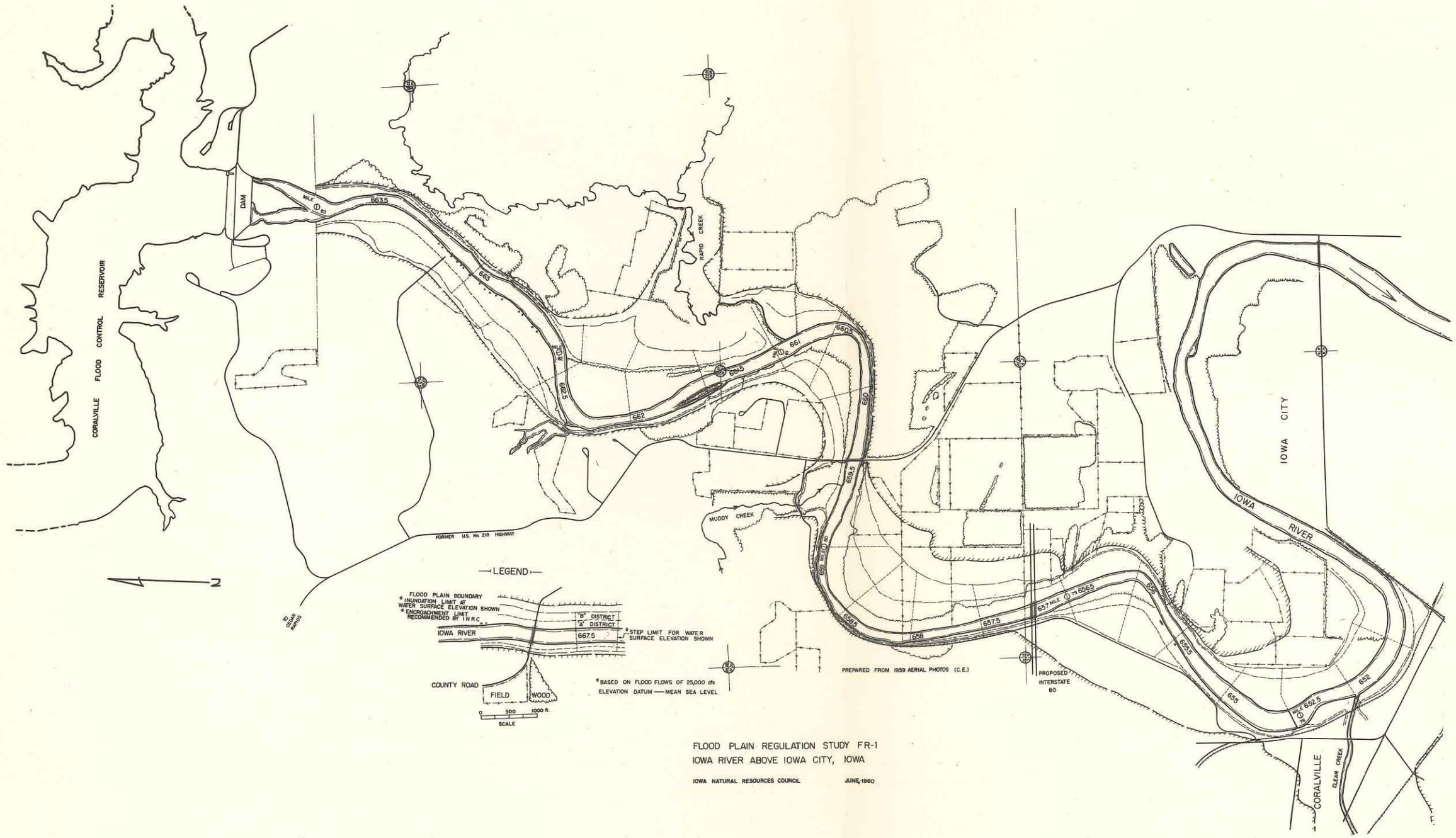
ELEVATION DATUM — MEAN SEA LEVEL

FLOOD PLAIN REGULATION STUDY F R-1

IOWA RIVER AT IOWA CITY, IOWA

IOWA NATURAL RESOURCES COUNCIL

JUNE, 1960



FLOOD PLAIN REGULATION STUDY FR-1

IOWA RIVER ABOVE IOWA CITY, IOWA

IOWA NATURAL RESOURCES COUNCIL JUNE, 1960