Feasibility Report

Utilization of I-280 Highway Embankment as an Impounding Structure to Provide a 95-acre Recreation Lake Development

****

Black Hawk Creek, Sections 25 and 36, T78N, R2E, Scott County, Iowa

Volume II. Hydrology and Hydraulic Studies

Lechner ENGINEERING CO.

AMES, IOWA

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Volume II. Hydrology and Hydraulic Studies

conducted for

Lechner Engineering Company
Ames, Iowa

by

Merwin D. Dougal, P.E.
Assistant Professor, Civil Engineering
Ames, Iowa
Water Resources Consultant

September, 1966

Ames, Iowa
September 15, 1966

Mr. Carl Lechner, P.E.
Lechner Engineering Company
Lechner Building
Ames, Iowa

Dear Mr. Lechner:

Volume II, Hydrology and Hydraulic Studies, for the Scott County I-280 feasibility report is submitted herewith. This report contains the detailed information concerning the proposed impoundments and related hydraulic structures from which additional planning and development may progress.

Many complexities arise in considering the utilization of the proposed I-280 highway embankment as an impounding structure. The additional impoundments proposed by your firm in the initial development plan are desirable, but add to the design complexities. Several local, state, and federal agencies are involved with the project either directly, indirectly, or in a regulatory capacity. These include the Iowa Highway Commission, Bureau of Public Roads, U.S. Department of Commerce, Scott County Conservation Board, Scott County Board of Supervisors, City of Davenport, State Conservation Commission, Natural Resources Council, Water Pollution Control Commission, and possibly others. The presence of a large urban area located downstream and in close proximity to the proposed impoundments, requires assignment of a high hazard risk in the consideration of overall concept and in design features. Urbanization of the design watershed is progressing rapidly, and requires analysis of future conditions.

For these several reasons, the hydrology and hydraulic studies were performed in detail. In this manner, the results are sufficiently final to give the affected agencies a maximum amount of information upon which to base their decisions.

I concur in your considered treatment of the area and find that the proposed development concept, consisting of a three-lake system, is technically feasible and provides an optimum plan for water associated recreation. It can be recommended for additional site planning and evaluation for overall costs of development.

Respectfully submitted,

Merwin D. Dougal

Merwin D. Dougal, P.E.
Water Resources Consultant

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I hereby certify that this report was prepared by me or under my personal supervision and that I am a duly Registered Professional Engineer under the laws of the State of Iowa.

Merwin D. Dougal

Reg. No. 3985

Merwin D. Dougal
September 15, 1966

Volume II. Hydrology and Hydraulic Studies

Synopsis

The proposed alignment for Interstate Highway No. 280 in Scott County, Iowa crosses the valley of Black Hawk Creek in an area of rolling topography. Hydrology and hydraulic studies have been conducted to determine the technical feasibility of modifying the proposed I-280 crossing of the valley to create a recreation lake development. The results of these studies show that the following conclusions and recommendations can be made:

1. Optimum development for recreation use under the proposed plan provides for a three-lake system containing a total of 95 acres of public water area. The main impoundment, designated as the I-280 Lake, has a water surface area of 57 acres at the design elevation of 695 feet, M.S.L. Two smaller impoundments are located upstream of the main impoundment, and at higher elevations. The first, designated as the Railroad Lake, has 29 acres of water surface area at an elevation of 705 feet, M.S.L., and the second, designated the Northeast Lake, has nine acres of water surface area at an elevation of 700 feet, M.S.L.

2. The watershed of Black Hawk Creek has a contributing area of 1,755 acres at the site of the main impoundment. Yield studies indicate that runoff from the design watershed will be sufficient to support the proposed recreational water areas, including a small existing private lake. Release facilities are recommended at the two smaller public impoundments to permit the I-280 Lake to be maintained at full lake level at all times, including severe droughts.

3. Control of land areas within the watershed is needed to prevent excess erosion and sediment production, limit flood runoff volumes, and retain the required land for public park use. A minimum acquisition of 500 acres of the more rolling topography around the proposed impoundments is recommended.

4. Desirable impoundment characteristics prevail in the Black Hawk Creek valley, and seepage around or through the proposed embankments should not pose any problem. Urbanization of the watershed in the future will require positive control measures to prevent water quality problems from arising.

5. Urban areas located on the flood plain downstream of the proposed impoundments have been at times subjected to flooding. The proposed impoundments create an additional hazard, because of height and volume of water stored. Spillway combinations are provided to accommodate the most severe floods which may occur. In addition, the proposed three-lake system achieves substantial reduction of peak discharges for the more frequent floods, through temporary storage of floodwaters.

It is concluded that the proposed development plan is technically sound and feasible. The findings in this report will substantiate the desirability of pursuing additional site planning, development, and cost evaluation to meet water recreational needs for the metropolitan area on the perimeter of the City of Davenport, Iowa.

Volume II. Hydrology and Hydraulic Studies

I. Introduction

1. Purpose.

The general purpose of these studies is to determine the suitability of the area for one or more impoundments, the capability of the watershed to support a recreational water surface area of the desired size, the flood potential of the watershed, and the hydraulic structures which will be required to convey flood discharges around or through the dams proposed in this recreational development.

The impounding reservoirs must be capable of storing sufficient volume and holding a fairly constant water level to yield the desired water surface area needed to enhance outdoor recreation and permit uninterrupted use for water-borne sports. The valley soils in each impoundment area must be sufficiently impervious to prevent undue seepage and loss of water through the foundation of any proposed dam. The watershed should be of a size to yield sufficient runoff in drought periods to prevent undue lowering of the water surface from evaporation and transpiration processes. The flood potential of the watershed needs to be estimated in relation to downstream flood plain developments, the hazard posed to those developments by construction of a dam and impoundment, and the possible loss of investment in the dam and appurtenant structures if rare, exceptionally severe floods do occur. Hydraulic structures must be designed to satisfy the assigned safety criteria, for the hazards involved. These problems will be studied in turn in this report

2. General Characteristics of the Watershed.

Black Hawk Creek is a small tributary of the Mississippi River, having a drainage area of 7.3 square miles at its mouth. The watershed of Black Hawk Creek begins almost due west of the City of Davenport, on relatively flat uplands above the bluffs of the Mississippi River. The creek flows eastward for more than four miles in a narrow, youthful valley with the hills becoming very steep in the lower reaches, then veers southward for a mile across the flood plain of the Mississippi River to its mouth. The total watershed is about two miles wide and five miles in length. Walnut Creek is a small tributary which drains the bluff area south of the major portion of the Black Hawk Creek watershed, and joins Black Hawk Creek on the Mississippi River flood plain. The area north and west of the watershed of Black Hawk Creek is in the Duck Creek watershed, and the bluff area to the south drains into several small tributaries flowing directly into the Mississippi River.

Topographically, the upland area at the divide of the watershed is relatively flat, becoming more rolling as the stream channel becomes well defined. In the downstream reaches, the topography is very hilly. Elevations, above mean sea level, range from 680 to 690 feet at the divide, about 665 feet on the flood plain at the proposed dam site (I-280), and 560 to 570 feet along the lower reach on the Mississippi River flood plain. The average valley slope is about 25 feet per mile, giving a comparatively steep slope which can rapidly concentrate and deliver flood flows down the valley.

The orientation of the watershed, the stream pattern, and the topographic characteristics tend to combine somewhat to create a serious flash flood hazard to downstream urban areas. The two principal tributaries at the upper end of the watershed form a circular drainage area which rapidly collects and delivers surface runoff to the main channel of the creek in the vicinity of the proposed I-280 route. The watershed narrows in the downstream direction, and additional small tributaries flow more steeply and directly from the high uplands to the stream channel. Once the stream reaches the bluff line, it turns at a sharp angle onto the wide Mississippi River flood plain, upon which a large urban area is located. The orientation of the stream, flowing eastward, coincides with the normal severe storm pattern experienced in Iowa and other midwestern regions, having an east-west orientation with an eastward movement. This tends to concentrate additionally the flood flows which may occur in the valley.

The general topographic and location features of the watershed are shown in Figure 1.

3. Soil and Cover Characteristics.

Two reports published by Iowa State University, and soil borings obtained during preliminary surveys for the proposed impoundment permit a thorough analysis to be made of soil and cover characteristics both in the watershed and in proposed impoundment areas. The most recent soil report is entitled "Principal Soils of Iowa", Special Report No. 42, Department of Agronomy, 1965. This report places the Black Hawk Creek watershed in the Tama-Muscatine soil association area, with the Downs soil association area located in some prairie-forest borders of the former. The Tama-Muscatine association consists of a loess-covered glacial till plain, and in Scott County the report categorizes the topography as consisting of broad, nearly level divides separated by shallow, narrow valleys. The wind-blown loess material is fairly thick, up to 200 inches in maximum depth.

Additional explanation of the Tama and Muscatine soils is as follows:

"Tama are well-drained soils which developed from moderately thick loess primarily under prairie vegetation. They occur on nearly level to gently sloping convex ridges and gently to moderately sloping side slopes. Slopes of 2 to 5 percent are most extensive but may range from 1 to 20 percent. The surface layer is very dark brown silty clay loam, 9 to 16 inches thick unless eroded. The moderately permeable subsoil is a dark brown silty clay loam, and the substratum is leached silt loam loess.

Muscatine soils are somewhat poorly drained and occur on nearly level slopes of 1 to 3 persent. Muscatine soils developed from moderately thick to thick loess under the influence of prairie vegetation. They have black silty clay loam surface layers 15 to 20 inches thick, moderately permeable gray and brown silty clay subsoils, and leached silt loam loess substrata."

The erosion hazard of the Tama silty clay loam is listed as slight to severe, depending upon slope, and for the Muscatine silty clay loam, slight erosion hazard. Permeability of each is listed as moderate.

Other soil association areas listed in the report and which occur in this area, especially along the Mississippi River bluffs, are the Fayette and Fayette-Dubuque-Stonyland soil association areas. In many of these areas, the loess blankets the limestone bedrock, although glacial till, shale or sandstone underlie the loess in certain locations. On the steeper slopes,

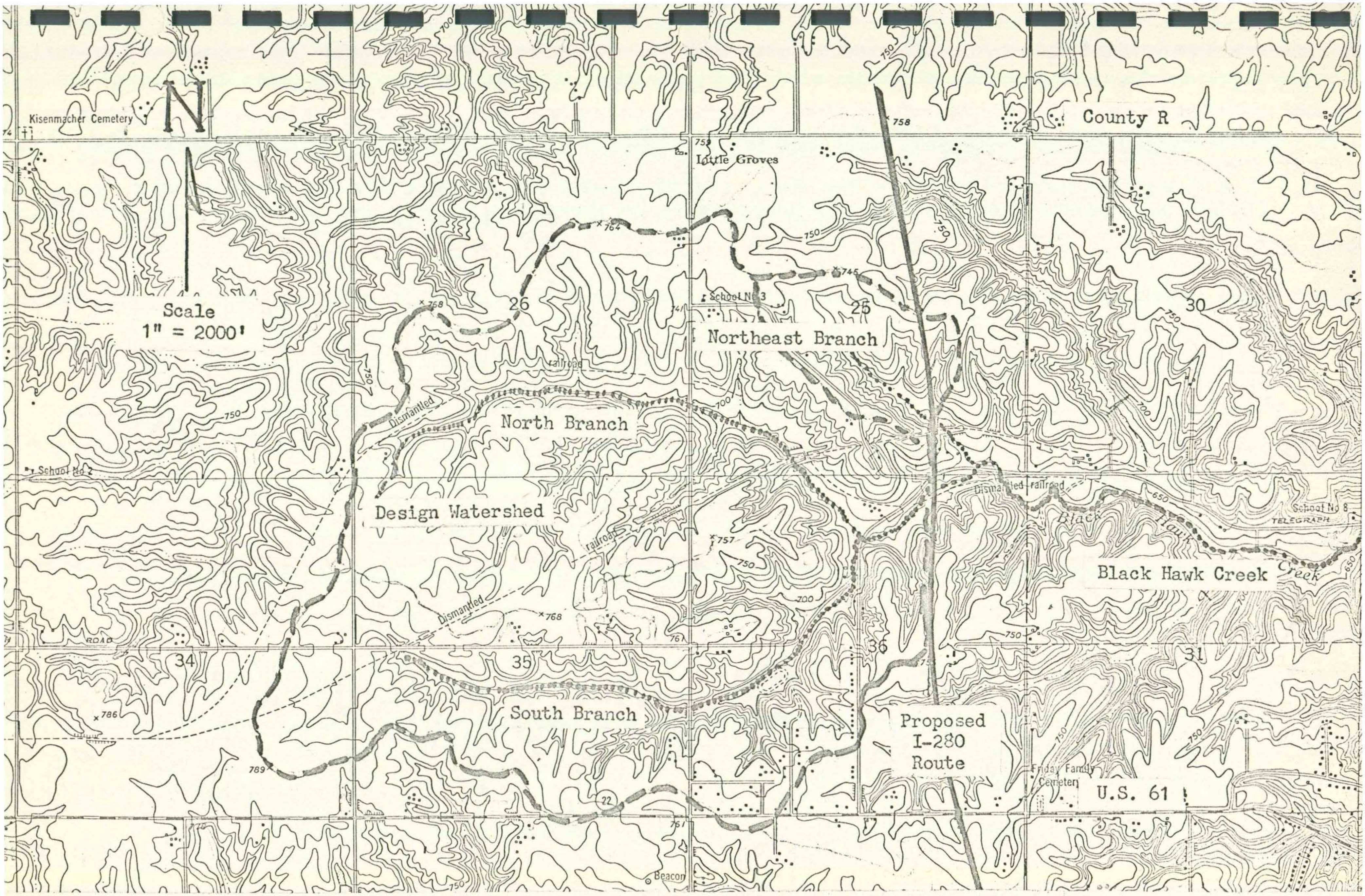


Figure 1. General Watershed Features

bedrock is frequently exposed.

The second soils report is the original "Soil Survey of Iowa, Scott County", Report No. 9, 1919. The soil map contained in this report shows the several soils predominating in the watershed. For the watershed upstream of the proposed I-280 route, Muscatine silt loam predominates, with Muscatine silt loam (rolling phase), Lindley silt loam and Clinton silt loam existing on the steeper side slopes. All of these are listed as loess soils, with the latter three being listed as having an erosion hazard. Bottomland areas are shown to be Wabash silt loam, colluvial phase, in this upper watershed area.

The soil borings which have been taken along the proposed I-280 route confirm the information contained in the soil reports. A brown silt, of loess origin, overlies brown or grey glacial till. Alluvium exists in the valleys, being either silts or sandy silts, with an occasional sand lens. The soil borings show that borrow areas are available which would yield both loess and glacial till materials with which impervious embankments can be constructed.

Field inspection of the watershed also confirms the information reviewed above. Road cuts, recent construction excavations, stream channel banks, etc. all show that a deep layer of loess or glacial till overlies the watershed, with no outcropping of bedrock in the watershed area above the proposed I-280 route.

Several significant conclusions can be drawn from this review of available information and field inspection. First, the proposed impoundment areas, being underlain with glacial till, will be impervious, and little or no seepage around the proposed dams will be expected. Seepage under the principal dam (I-280 embankment), through the pervious alluvium, can be controlled adequately by means of a core trench along the centerline of the proposed embankment, excavated through the alluvium to the impervious glacial till. Depths of 10 to 15 feet will be required, with compacted impervious clay being backfilled in the core trench. Seepage under the other proposed dams can be controlled in a similar manner. Second, adequate impervious materials are available in proposed borrow areas for constructing impervious embankments. Loess, excavated and recompacted, can be utilized in the proposed embankments of the several structures being proposed, and in conjunction with the glacial till and alluvial deposits it will permit adequate zoning of materials in the embankments. Potential foundation problems, in areas where compacted earth fill will rest upon loess, will have to be considered in detailed planning, and may require ponding during preconstruction periods to minimize settlement upon construction. The third conclusion concerns the erosion potential of the soils on the steeper valley slopes. If continued in agricultural row crop production, the sediment production could easily cause rapid siltation of the proposed impoundments. In addition, areas exposed during urbanization are frequently heavy sediment producers. To minimize the erosion and sediment problem, the steeper slopes adjacent to the proposed impoundments should be placed in grass cover and be incorporated into park lands so that positive control can be maintained. Additional terracing and waterway improvement may also be needed in some areas.

It is therefore concluded that the Black Hawk Creek watershed is a suitable area for an impoundment and that seepage problems are of little significance. A maximum amount of land should be placed in park use to control land use on the steeper slopes, and to minimize the sedimentation problem.

4. Urbanization and Hazard Classification.

Several urban developments exist in the Black Hawk Creek watershed, and fairly rapid expansion of suburban developments is occurring within the portion of the watershed located upstream of the proposed I-280 route. Telegraph Road traverses the flood plain of Black Hawk Creek throughout much of its length, from the bluff to the upper reaches of the watershed. Existing since early days, many suburban homes, acreages, and commercial enterprises have located along the road and on the flood plain. A large urban area of homes and some commercial developments exist on the flood plain between the bluff line and the Mississippi River. A principal area, the Garden Addition, has been subjected to floods from both Black Hawk Creek and the Mississippi River. Continued development of flood plain areas continues in the valley downstream of the proposed I-280 crossing on the creek. Of additional concern is the rapid pace of urbanization taking place within the design watershed upstream of the proposed I-280 route. Almost all of this development is occuring in the watershed of the south branch of the creek in this area. Enhanced by the existence of the paved highway, U.S. No. 61, subdividing and residential construction is rapidly converting agricultural land to urban use. Recognizing that any recreational development will enhance further the rate of urbanization, it can be concluded that portions of the design watershed which are not placed in park use will be urbanized completely in the future.

Research to date has indicated that the flood potential of a watershed is increased upon urbanization. Residents in downstream areas can expect that the volume of runoff from a given amount of rainfall will increase, the time of arrival will be hastened, and the peak flood discharges will be greater. Although precise changes are impossible to predict from the limited data available, reasonable estimates must be made in order that the effects of urbanization are included in the hydrologic design of any proposed impoundments.

The problem of urbanization requires that three items be considered in detailed studies:

1. The design watershed, except for portions reserved for park and recreational use, will be completely urbanized in the future.

2. The possibility of reducing peak flood discharges, by temporary storage of flood waters in any proposed impoundments, should be considered in the design.

3. An appreciable hazard is created by constructing a fairly large dam in a watershed upstream of a large urban area already noted for its flood problems. The size of the proposed embankment, of I-280, and the volume of water stored, will be sufficient to require that extreme flood events be safely discharged without causing overtopping and possible failure of

the dam. A high hazard classification is considered necessary in the proposed I-280 embankment as a dam, and for other major impounding structures located upstream of the I-280 route.

II. Characteristics of the Proposed Impoundments

5. Development of a Three-Lake System.

One objective of the combined studies for the proposed park development was to obtain the maximum amount of lake surface area which the watershed could support. The heavy use expected of the proposed park accompanied by the shortage of natural lakes and other water areas in the upland areas away from the Mississippi River dictated that this objective be given a high priority. In addition, the erosion and sediment potential of the watershed indicated that additional impoundments upstream of the proposed main lake would be needed for sediment storage if rapid sedimentation of the main lake was to be prevented. The design of the main impoundment also had to conform to the requirements of highway geometrics for the proposed I-280 route, including the location problems accentuated by the high-voltage power line crossing the valley in the same location. The existence of a small private impoundment on the south branch of the creek in the design watershed also had to be considered.

Several locations for additional impoundments were considered in a preliminary study of the watershed. Two locations which were studied are situated on the north branch of the creek, the first utilizing the location of the existing railroad embankment in the SW$\frac{1}{4}$ of Sec. 25-78-2E, and the second utilizing the county road grade along the west side of the same section. Additional impoundments in the south watershed did not appear to be warranted, in view of the existence of the private impoundment and general limitations of watershed yield to support additional water surface areas in that watershed.

A third additional impoundment was included in the proposed development by diverting a small watershed located northeast of the north branch of the design watershed. The proposed I-280 route crosses this watershed near its confluence with Black Hawk Creek, and only a narrow bluff separates the two watersheds at the proposed highway crossing. This bluff was designated as a borrow area for embankment materials. The proposed highway alignment and excavation plans made it possible to consider adding this small watershed to the design watershed. A separate impoundment would be created by the embankment of the proposed I-280 route, if appropriate hydraulic structures were provided to spill excess water into the main impoundment.

Initial studies were made for the three smaller impoundments as well as the main impoundment to determine water surface areas and storage volumes at various elevations. Topographic maps of the U.S. Geological Survey were used in these initial studies, and the data indicated that all three of the smaller impoundments would be desirable. However, large scale topographic maps which were made available subsequently through aerial photogrammetric methods yielded smaller areas and storage volumes for identical elevations. As a result the two smaller impoundments located on the north branch of the creek were combined into one impoundment at a slightly higher elevation. In all of the initial analysis, consideration of temporary flood storage requirements was balanced with desirable water surface areas for recreation and with the elevation limitations imposed by several road structures and the power line.

6. Characteristics of the Three Impoundments.

The proposed three-lake system as recommended for development is shown in Figure 2, and details of the subdivision of the watershed into three subwatersheds and of the characteristics of the three impoundments are included in Table 1. For the purpose of clarification in this report, the three impoundments are labeled as (1) the Northeast Lake, (2) the Railroad Lake, and (3) the Interstate I-280 Lake. The private lake has an estimated water surface area of 12 acres, at elevation 707.5 feet, M.S.L.

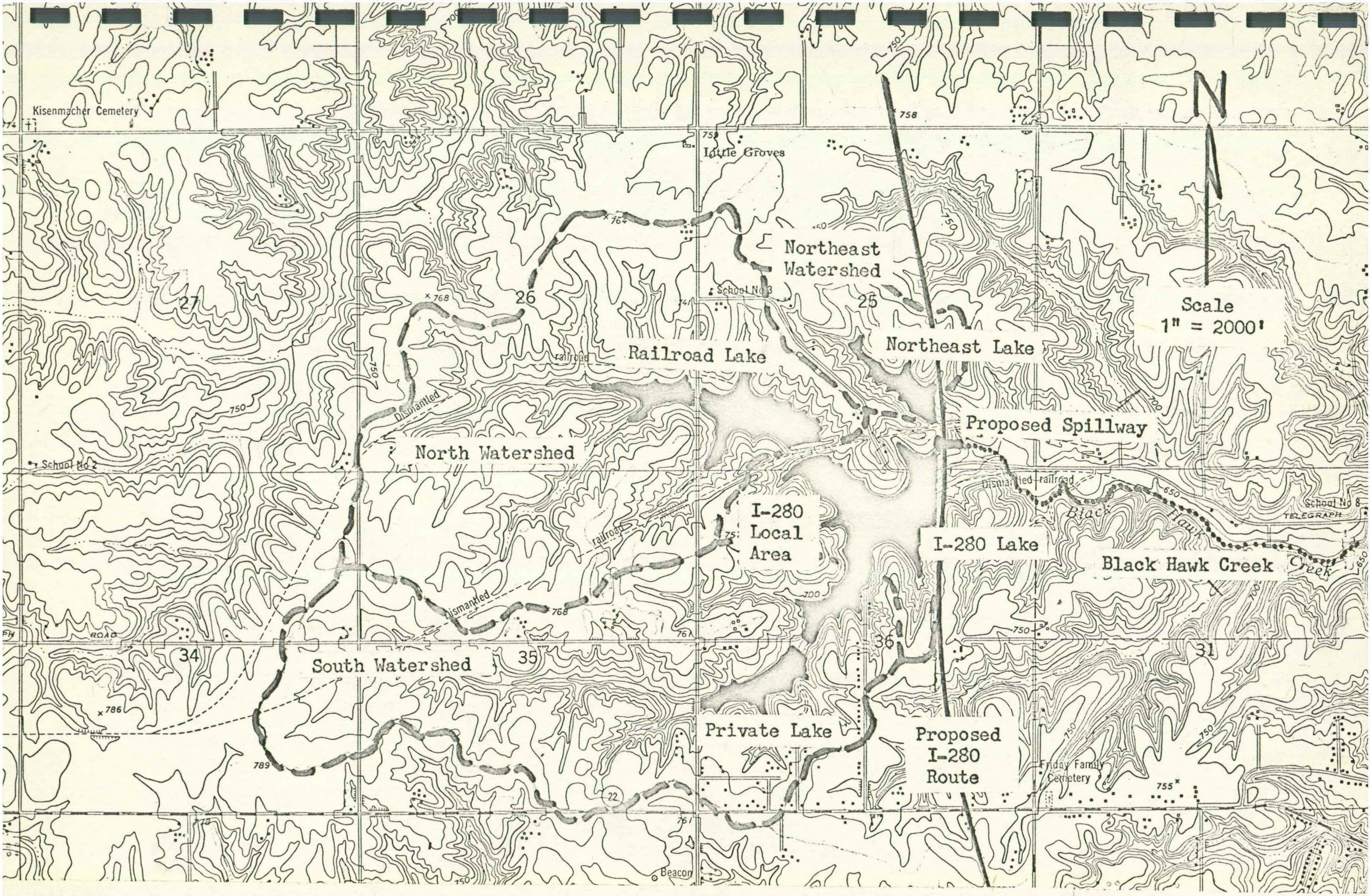


Figure 2. Sub-watersheds and Impoundment Locations

Table 1. Area and Volume Characteristics of the Three Proposed Impoundments.

Elevation, feet	Northeast Lake		Railroad Lake		I-280 Lake	
	Area, acres	Volume, ac-ft	Area, acres	Volume, ac-ft	Area, acres	Volume, ac-ft
665					0	0
670					2.4	6
675					10.0	37
680	0	0			18.2	108
685	1.6	4	0	0	32.1	234
690	3.5	17	2.0	5	44.1	424
695	6.1	41	9.1	33	56.6*	676*
700	9.0*	79*	17.8	100	66.9	985
705	12.2	132	29.2*	217*	79.1	1350
710	15.6	200	42.5	395	92.0	1775
715	19.5	290	57.0	645	105.	2270

* Area and volume at design water surface elevation for recreational purposes

The watershed areas and total water surface area, at design recreational pool elevations, for each proposed impoundment are as follows:

Lake	Watershed Area, acres	Elevation, feet	Water Surface Area, acres Public	Private	Total
Private	530	707.5		12	12
Northeast	125	700.0	9		9
Railroad	815	705.0	29		29
I-280	1755*	695.0	57	—	57
		Total	95	12	107

* Includes watershed areas of other three lakes and local area surround I-280 Lake.

With a total watershed area of 1,755 acres or 2.75 square miles, a ratio of watershed area to total lake area of 16.4 is obtained. As will be discussed additionally in a later section, this ratio is somewhat less than the 20 to 25 ratio normally desired. However, the design ratio of 16.4 provides considerably more temporary flood storage in comparison to watershed area, and in view of the urbanization of the watershed this is a desirable item. Hydraulic structure sizes are minimized also by keeping the ratio low. Release facilities are recommended at each of the two smaller public impoundments to provide additional water for the I-280 Lake during excessive drought periods when needed.

III. Hydrology

7. Climatology.

The climate of the Davenport area is similar to that of other midwestern areas located in the interior of the North American land mass. High pressure areas in the polar regions cause an outflow of cold dry air in the winter period. During the summer period, warm moist air flows into the area from tropical areas through low pressure predominance. This results in a marked seasonal contrast in both precipitation and temperature, and extremes in both are frequently experienced.

For the normal period 1931 - 1960, the mean annual temperature at Davenport is 51 degrees, but extremes of 110 degrees and minus 27 degrees have been experienced in this region of Iowa. The mean annual precipitation, for the normal period of 1931 - 1960, is 33.9 inches. About two-thirds of the annual precipitation occurs during the growing season, April 1 to September 30. During this period, the frequency and intensity of precipitation increases to a maximum in June, with precipitation occuring mainly in the form of thunderstorms. Winter snowfall averages 25 to 30 inches along the Mississippi River valley in this region.

8. Watershield Yield, Lake Evaporation, and Sedimentation.

The average annual runoff of water from the watershed constitutes the average yield of the watershed. Over a period of years, the average yield must be sufficient to maintain the desired recreational water surface elevation and area, yet satisfy the demands of evaporation from the lake surface, transpiration of aquatic vegetation around the perimeter and in shallow areas, and of the seepage which may occur through the dam. In addition, the variability of yield during drought periods, during which precipitation is infrequent and low in quantity and evapotranspiration processes are more severe, requires analysis to reflect the reduction of lake surface area and elevation which may be experienced.

The average annual runoff of gaged streams in this region of eastern Iowa varies from seven to eight inches, on the basin, as determined from records of the U.S. Geological Survey. This represents a little more than one-fifth of the mean annual precipitation, and is above the average of many central and western streams. For the total design watershed area of 1755 acres, the average annual runoff, in terms of volume, amount to 12,300 to 14,000 acre-inches, or 1020 to 1170 acre-feet. Expressed in terms of average rate of flow, in cubic feet per second, the watershed yields from 1.4 to 1.6 cfs. The upland nature of the design watershed within the total Black Hawk Creek watershed indicates that the ground water contribution to total flow may not be as substantial as would be expected in lower reaches, and as a result the lower values of yield are more applicable for this study.

Estimates of lake evaporation are obtained most readily from the bulletin, "Evaporation Maps of the United States", Technical Paper No. 37, Weather Bureau, U.S. Department of Commerce, 1959. This bulletin indicates that the average annual lake evaporation for the Davenport area is 34 inches, based upon a Class A pan evaporation of 45 inches and a pan-to-lake coefficient of 76 percent. The average May-October lake evaporation is estimated to be about 80 percent of the annual, or about 27 inches. The bulletin also provides some data from which estimates of lake evaporation during severe droughts might be made. These data indicate that as much as 45 inches of lake evaporation might be expected once every 50 years.

Seepage is not expected to be appreciable, in view of the soil and cover characteristics in the impoundment areas and the availability of impervious embankment materials. A nominal value of 5 percent of the average annual flow, or 0.07 cfs, is selected for comparative purposes in evaluating the capability of the watershed to maintain the proposed lake development.

Evapotranspiration requirements for vegetation growing around the perimeter of the lake must also be included. It is believed that this can be estimated simply and adequately by assigning an equivalent evaporation value to the area around the proposed impoundments which would include all land located within two feet or less in elevation to the design water surface elevation of each proposed impoundment. Field data indicate that maximum evapotranspiration of aquatic vegetation closely approximates the lake evaporation values.

Variations in runoff and precipitation which have been experienced in Iowa indicate that very low values occur during major droughts. Such gaged watersheds include Rapid Creek and Ralston Creek at Iowa City, in this general region. Annual runoff can reach a minimum of one-fourth to one-third inch on the basin, and annual precipitation values of 13 to 15 inches have been noted. Minimum two-year total runoff values of about 2.5 inches have been experienced, during severe drought periods.

These data can be used to evaluated the capability of the design watershed to sustain the proposed lake system. At the proposed design water elevations, the combined water surface area, public and private, is 107 acres. Including the perimeter area subjected to additional acquatic growth, the total surface area to be considered for evaporation analysis is about 120 acres. The remaining watershed area, 1635 acres, would contribute runoff to the proposed lake system, if it is realized that all precipitation falling upon the 120 acres contributes directly to replenishing the lakes.

Because the estimated average annual lake evaporation amount of 34 inches is almost exactly equal to the mean annual precipitation in the Davenport area, there is no problem of maintaining the proposed lake system if average precipitation is received. In addition, the annual runoff of seven inches on the basin is more than adequate to offset above normal evaporation losses, yielding about 11,500 acre-inches of runoff which would more than satisfy the seepage demand of 600 acre-inches and up to 10 to 12 inches of additional lake evaporation on the 120 acre area.

Critical drought conditions could result in a reduced annual precipitation value of 15 inches or less, accompanied by increased lake evaporation of as much as 45 inches, as mentioned. This results in an estimated deficiency of 30 inches in depth upon the proposed lake development, or 3600 acre-inches of volume for the 120 acre evapotranspiration area. The design annual seepage requirement of 600 acre-inches of volume, must also be added, to yield a total requirement of 4200 acre-inches. If the minimum yield of one-fourth inch of runoff occurs on the remaining 1635 acres, only 410 acre-inches of inflow will will occur. The net shortage of almost 3800 acre-inches would result in an overall lowering of the lake system of 3.5 feet. This severe condition, which considers minimum precipitation and runoff occuring the same year as maximum evaporation, would be an exceedingly rare event, perhaps having an average recurrence interval of 50 to 100 years or more. If it is next considered that the minimum two-year runoff would be about 2.5 inches on the basin, additional 2.25 inches of runoff the second year would make up the net shortage of the prior severest year, although some additional net evaporation loss might be experienced the second year in comparison to second year precipitation and lake evaporation. In any event, substantial recovery would be expected in the year following a severe drought year.

It can be concluded that minor monthly fluctuations may occur under normal circumstances, due to short-term monthly variations in hydrologic phenomena, but that the design watershed has the capability of maintaining the design lake development at satisfactory levels. Infrequent drought periods might cause a substantial reduction of the lake levels for a one-year period, but rapid recovery should ensue.

In order that the principal impoundment of the three lake system, the I-280 Lake, might be kept at the design elevation almost all of the time, it is proposed that release facilities be provided in the two upstream impoundments, the Railroad Lake and the Northeast Lake. Gate structures and conduits would be constructed to permit release of water to the downstream impoundment, I-280 Lake.

In this manner, over 200 acre-feet, or 2400 acre-inches, of volume is potentially available in the two smaller impoundments to release into the 57 acre I-280 Lake. This would permit the main impoundment to be fully maintained, even during a severe drought when a three foot deficit could otherwise be expected.

Sedimentation has been considered in view of the urbanization of the watershed. Under agricultural cropping conditions, up to two inches of sheet erosion and bank erosion equivalent might be expected from the design watershed, in a 50 to 100 year period. Raw areas exposed during urban construction can produce large amounts of sediment. However, upon completion of urban development, sediment production should be reduced to a rather small value. Paved areas and seeded lawns and yards provide a rather complete cover, and few exposed areas remain. The area which will remain in park use will be under grass cover, and with proper management little erosion will be expected.

It is impossible to predict accurately the rate at which the watershed will become urbanized. For design purposes, a value of one inch of sediment production from the design watershed has been adopted. This provides for a substantial contribution from agriculture lands during the period in which urbanization is completed, and for minor amounts following this period.

Sediment deposition in the proposed impoundments has been allocated in the following manner. Sediment produced from the watershed area upstream of the country road across the Railroad Lake, a 540 acre watershed, will be allocated to the portion of the Railroad Lake upstream of the county road embankment. Sediment produced from the 275 acres directly tributary to the lower portion of the Railroad Lake is allocated to the impoundment area between the county road and the proposed dam. Sediment produced in the south watershed above the private lake, 675 acres of area, is assumed to remain primarily in the backwater area above the county road and in the private impoundment.

Likewise, sediment produced in the watershed of the Northeast Lake, 125 acres, is presumed to settle in that impoundment. The remainder of the design watershed which is directly tributary to the main impoundment, I-280 Lake, amounting to 140 acres, would contribute one inch of sediment to the main impoundment. Although this assumes a trap efficiency of 100 percent in each reservoir, additional refinement is hardly believed to be justified.

In each impoundment, the sediment storage was allocated such that one-half was below the design elevation of the water surface, and one-half above this elevation, in the flood surcharge zone. Accordingly, water surface areas and storage volumes were reduced to reflect the deposition of sediment.

Inasmuch as the total volume of storage in the proposed three-lake system is equivelent to 972 acre-feet, or 6.6 inches on the basin, the one-inch sediment allocation does not severely deplete the available storage in the system. The relatively large amount of permanent storage, amounting to the average annual runoff, does indicate that one or more years may be required to fill the three impoundments upon completion of construction, unless an exceptionally high runoff year occurs immediately.

9. Selection of Design Rainfall Amounts.

The most serious floods which can be expected in this region in small watersheds normally occur as the result of thunderstorm activity in the summer. Snowmelt floods require some consideration, but seldom produce the volume or peak rates of runoff which maximum experienced storm conditions are capable of accumulating. Rainfall data, analyzed for intensity-duration-frequency relationships, can be obtained from several publications of the U. S. Weather Bureau. The most recent publication is Technical Paper No. 40, "Rainfall-Frequency Atlas of the United States", May, 1961, Weather Bureau, U. S. Department of Commerce. An earlier publication contained results obtained from data collected at the first-order station located at Davenport, and is entitled "Rainfall Intensity-Duration-Frequency Curves", Technical Paper No. 25. Intensities in terms of inches-per-hour were extracted from the curves and converted to accumulated volume by the Soil Conservation Service, U. S. Department of Agriculture. These latter data were used in this study, and for certain selected durations and frequencies are contained in Table 2.

The most severe thunderstorms which have occurred in Iowa and adjacent states often have produced rainfall amounts far exceeding those for even a 50 or 100-year average recurrence interval. As a result, hydrologic design cannot terminate at the levels for which reasonable frequencies can be assigned, but must consider more rare occurrences. The most severe storms which have occurred in Iowa have produced from 12 to 16 inches of rainfall in a short period of time, six to eight hours. Several of these storms have been recorded in Iowa in the past decade, although one of the first notable storms of this magnitude occurred in the Bonaparte-Stockport-Keosauqua area in 1905. For the purposes of analyzing the requirements imposed upon the proposed three-lake system if such a storm occurred, a value of 16 inches in 6 hours is adopted as the regional maximum experienced storm.

The high hazard risk assigned to the proposed development because of the urban area downstream requires that the probability of occurrence of storms greater than those experienced also be considered. For such conditions, the Weather Bureau has developed from meteorological studies the concept of probable maximum precipitation, the maximum amount which might reasonably be expected under exceptional conditions. A value of 25 inches in six hours duration is shown in the above-mentioned Technical Paper No. 40 for the Davenport area. These selected storm events with the indicated rainfall amounts were used in subsequent hydrologic studies to determine the overall flood potential of the watershed. Because the design watershed of 2.75 square miles in size is less than the ten square mile limit for areal rainfall reduction which is presently in use, the design amounts were not reduced for areal extent, but applied to the watershed as tabulated.

Table 2. Design Rainfall Amounts for Selected Durations and Frequencies.

Duration, hours	Rainfall, inches, for given frequency 25-yr	50-yr	100-yr
1	2.48	2.75	3.05
2	3.10	3.44	3.80
6	4.05	4.53	5.00
12	4.62	5.22	5.75
24	5.26	5.88	6.50
6	Regional maximum experienced, 16 inches		
6	Probable maximum precipitation, 25 inches		

10. Storm Rainfall-Runoff Relations.

Reasonable estimates must be made of initial losses and infiltration losses in evaluating the volume of surface runoff which might occur from a designated amount of rainfall. Standard estimating techniques developed by the Soil Conservation Service, U. S. Department of Agriculture, for small watersheds were used in computing the rainfall-runoff relations for design amounts of rainfall. These techniques have been adopted also by the Bureau of Reclamation, and published in "Design of Small Dams", Bureau of Reclamation, U. S. Department of Interior, 1960. These techniques use a soil-cover concept for estimating infiltration and other losses, and arriving at reasonable run-off amounts.

The amount of infiltration and other losses which will occur in a watershed depends upon the antecedent moisture conditions. Three antecedent moisture conditions are used in design practice: Condition I, "dry" antecedent conditions; Condition II, "normal" antecedent conditions; and Condition III, "wet", or "saturated" antecedent conditions as pertains to vegetative surface cover, soil surface conditions, and soil moisture. Rural watersheds which have been gaged and analyzed for rainfall and surface runoff relationships in Iowa have exhibited Condition I for most storms, approaching Condition II in a few instances. Condition III infers almost 100 percent runoff. Condition II was adopted for design purposes, reflecting more severe moisture conditions for the design storms, and the future urbanization of the design watershed.

Classification of the watershed area according to various vegetative-cover conditions and soil association areas enables a design rainfall-runoff relation to be developed. This classification permits a runoff curve number to be computed, from which the rainfall-runoff relationship is then derived. Urbanization of the design watershed was assumed to be completed, except for portions retained for park purposes. This gave two types of areas for the design watershed, an urban area and a park area.

Preliminary analysis and consideration of land acquisition indicated that the following portions of the watershed could reasonably be expected to remain in park use:

Area	Acreage, acres
1. NW¼, Section 36-78-2E	160
2. W½ of NE¼ Section 36-78-2E (to I-280 right-of-way)	80
3. SW¼ Section 25-78-2E	160
4. W½ of SE¼ Section 25-78-2E (to I-280 right-of-way)	80
5. Impoundment area upstream of county road, SE¼ Section 26-78-2E	20 (minimum)
Total land in park use	500 acres

In evaluating the park land for runoff potential, the probability of heavy use by the public was considered. Being close to a densely populated area, with future urbanization of the areas around the proposed park highly probable, all of the park area undoubtedly will be developed for some type of recreational activity. It is improbable that any so-called "wilderness" areas would remain. Runoff curve numbers in the range of 65 to 75 were considered to be appropriate for the park area, depending upon degree of use. In view of the heavy use estimated for the park, runoff curve number 75 was adopted for design purposes for the 500-acre park area.

The remainder of the watershed, 1255 acres, was placed in urban use for design purposes. Storm runoff curve numbers under these conditions were estimated to be in the range of 80 to 90. For urban design, in residential areas, from one-fourth to one-third of the surface area could be in paved surfaces, including streets, sidewalks, driveways, and roof areas. However, most roof drains frequently drain onto grassed lawns, and additional opportunity for infiltration occurs. The soils in the watershed are predominantly loess in origin, and infiltration in such soils is good to excellent. In view of these conditions, a value of 85 was selected as the runoff curve number for the urban area.

Runoff amounts, in terms of inches-on-the-basin, are tabulated in Table 3 for the design rainfall durations and frequencies. The time distribution of these runoff volumes are evaluated in flood hydrograph studies.

Table 3. Design Surface Runoff Amounts for Hydrology Studies.

Storm Duration, hours	Rainfall Frequency, years	Design Rainfall, inches	Surface Runoff Amounts, inches Park Area, Curve 75	Urban Area, Curve 85
6	25-yrs	4.05	1.70	2.50
	50-yrs	4.53	2.10	2.95
	100-yrs	5.00	2.45	3.40
	Regional Max. Exp.	16.0	12.7	14.0
	Probable Max. Precip.	25.	21.3	22.9
12	25-yrs	4.62	2.15	3.02
	50-yrs	5.22	2.63	3.60
	100-yrs	5.75	3.10	4.10
24	25-yrs	5.26	2.65	3.62
	50-yrs	5.88	3.20	4.20
	100-yrs	6.50	3.72	4.80

11. Development of Design Flood Hydrographs.

The time-distribution of flood surface-runoff volumes must be estimated in order that spillway requirements can be determined for safely discharging floodwaters through the proposed impoundments. In the absence of actual stream flow records for the design watershed, synthetic hydrographs of runoff were developed using watershed characteristics. Design techniques as published by the Bureau of Reclamation and the Soil Conservation Service were utilized.

Synthetic hydrograph development yields the time distribution of runoff, and primarily requires that the peak discharge, time-of-rise or concentration time, the total time of runoff, and the shape or time distribution be estimated. Composite hydrograph techniques of the Soil Conservation Service were used, and modified to extend the 6-hour storm period to a 24-hour storm period for the 50-yr and 100-yr floods, and further modified to reflect a more rapid time-of-rise to the peak discharge both for future urban conditions and for the more extreme flood events. Experience has indicated that floods such as the regional maximum experienced and the probable maximum flood would have a quicker time-of-rise to the peak discharge. Because of the small size of the watershed and the large volume of rainfall involved, six-hour amounts are considered sufficient, and 24-hour were not estimated for the two rare events. The relative greater amounts of temporary storage of smaller volumes of runoff experienced for the frequency-assigned floods, 50-yr and 100-yr events, is sufficiently great to require 24-hour duration analysis.

The proposed three-lake development required a rather detailed hydrologic study for flood study and analysis. Originally the entire design watershed was divided into five sub-watersheds for the five sub-impoundments and impoundments. These consisted of (1) the portion of the Railroad Lake upstream of the county road fed by the west part of the north watershed, (2) the remaining portion of Railroad Lake between the county road and the proposed dam at the railroad grade, including the intervening drainage area, (3) the Northeast Lake and its watershed, (4) the Private Lake and the south watershed contributing to it, and (5) the main impoundment, I-280 Lake, and the watershed area directly adjacent to it. Flood discharge from the watershed of each upstream impoundment will flow through that impoundment, and the attenuated outflow passes into the next impoundment downstream. Flood runoff from areas adjacent to each lake flow directly into it. All outflow eventually reaches the main impoundment, I-280 Lake, where it must be discharged to the valley downstream.

Preliminary study indicated that the private lake did not have the storage capacity to affect appreciably the flood discharges of the south watershed. The embankment is low, and no overflow spillway exists for the lake. As a result the flood hydrographs of the south watershed and those for the local watershed area of the I-280 Lake were combined in the development of flood hydrographs for final flood routings. This preliminary study also indicated, once the decision had been made to develop the Railroad Lake at Elevation 705 both upstream and downstream of the county road, that the existing culvert structure would have sufficient discharge capacity to enable the entire north watershed to be considered one unit for the Railroad Lake. As long as the road grade remains fairly low in elevation, little additional attenuation of the regional floods will occur, although the road grade undoubtedly will be overtopped.

Preliminary study of the rare flood events, the regional maximum experienced and the probable maximum flood, showed that backflow would occur into the Northeast Lake from I-280 Lake for these events. The rise of flood waters in the main impoundment, amounting to more than 10 feet, is much greater than the five foot differential in normal lake elevations. As a result, to simplify the hydrology for these two rare flood events, the flood hydrograph of the northeast watershed was combined with those of the south watershed and local area of I-280, and the storage capacity of the Northeast Lake above its normal lake level was added to the main impoundment storage capacity.

The design flood hydrographs for each of the five sub-impoundments are illustrated in Figure 3, for the probable maximum flood condition. The hydrographs are shown in their correct relative time location to represent inflow at the designated impoundment for a uniform storm over the watershed. Similar hydrographs were developed for the regional maximum experienced flood, and for the 50-yr and 100-yr estimated floods. Tabulation of flood hydrograph ordinates are presented in Tables 4 through 6 for review purposes. The surface runoff for the regional maximum experienced storm conditions is 60 percent of the runoff for the probable maximum precipitation; as the ordinates of the flood hydrographs are proportional to the runoff volumes, the values were not tabulated for the regional maximum experienced, as is indicated in Table 6.

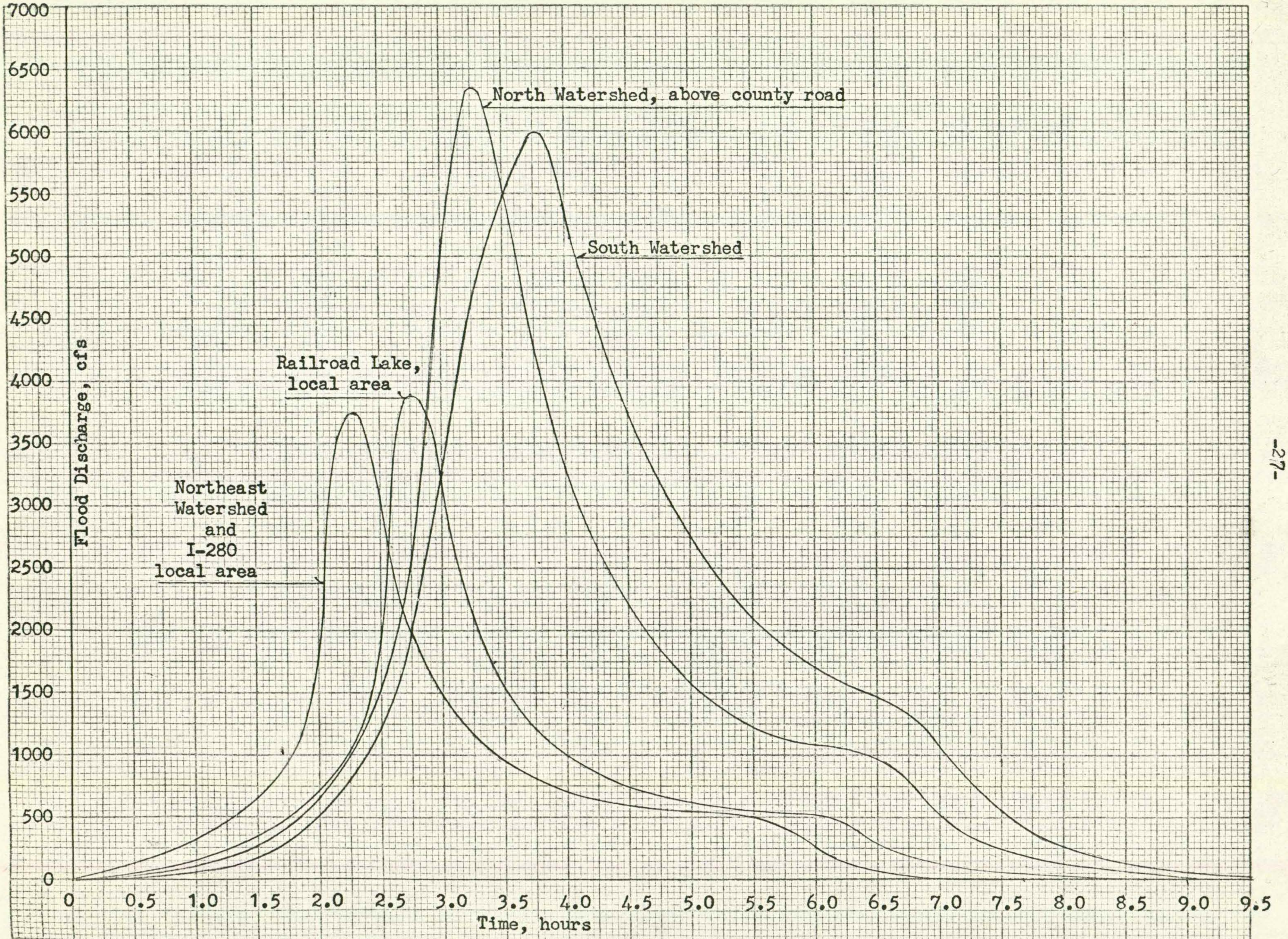


Figure 3. Typical Flood Hydrographs. for Probable Maximum Flood Conditions

Table 4. Flood Hydrographs for Estimated 50-year Frequency Floods.

Time, hours	Flood Discharge, cfs, for Indicated Watershed			
	Northeast Lake Watershed	I-280 Lake, Local Area	Railroad Lake Watershed	South Watershed
0	0	0	0	0
0.25	1	1	2	1
0.50	2	3	4	2
0.75	3	5	8	4
1.00	4	7	10	6
1.25	6	9	15	8
1.50	11	12	20	10
1.75	18	21	33	12
2.00	47	53	50	14
2.25	123	137	70	16
2.50	158	177	100	31
2.75	119	134	150	60
3.00	86	97	300	115
3.25	66	74	950	285
3.50	54	61	1105	480
3.75	47	53	970	675
4.00	42	46	820	745
4.25	37	41	765	710
4.50	34	38	540	660
4.75	31	35	450	580
5.00	29	33	370	490
5.25	27	30	330	420
5.50	25	28	290	370
5.75	24	27	265	330
6.00	22	25	245	300
6.25	21	23	225	270
6.50	20	22	210	245
6.75	18	21	200	223
7.00	17	19	190	205
7.25	16	18	180	190
7.50	15	17	170	176
7.75	15	17	163	163
8.00	14	16	155	152
8.25	14	16	148	143
8.50	14	15	140	134
8.75	14	15	135	126
9.0	14	14	130	120
9.5	13	14	118	109
10.0	13	13	112	100
10.5	13	13	106	92
11.0	12	12	100	87
11.5	12	12	94	83
12.0	11	11	82	80
24.0	0	0	0	0

Table 5. Flood Hydrographs for Estimated 100-year Frequency Floods.

Time, hours	Flood Discharge, cfs, for Indicated Watershed			
	Northeast Lake Watershed	I-280 Lake, Local Area	Railroad Lake Watershed	South Watershed
0	0	0	0	0
0.25	1	1	3	2
0.50	2	2	6	4
0.75	3	4	12	6
1.00	4	6	15	8
1.25	7	8	18	10
1.50	13	14	23	12
1.75	21	24	39	14
2.00	55	61	58	16
2.25	143	159	82	18
2.50	184	205	115	35
2.75	139	155	175	69
3.00	101	112	350	132
3.25	77	86	1110	326
3.50	63	70	1290	550
3.75	55	61	1130	773
4.00	48	53	960	803
4.25	43	47	890	813
4.50	40	44	630	756
4.75	36	41	530	664
5.00	34	38	430	561
5.25	31	35	380	481
5.50	29	32	340	424
5.75	27	31	312	378
6.00	26	29	285	344
6.25	24	27	265	309
6.50	23	25	245	280
6.75	21	24	232	255
7.00	20	22	220	234
7.25	19	21	210	218
7.50	18	20	200	202
7.75	18	19	190	187
8.00	17	18	180	174
8.25	17	17	170	164
8.50	17	17	160	154
8.75	16	16	154	144
9.0	16	16	148	137
9.5	15	15	138	125
10.0	15	15	131	115
10.5	14	14	124	105
11.0	14	14	117	100
11.5	13	13	110	95
12.0	13	13	95	92
15.0	10	10	48	68
24.0	0	0	0	0

Table 6. Flood Hydrograph Ordinates for Probable Maximum Flood Event.*

Time, hours	Flood Discharge, cfs, for Indicated Watershed			
	I-280 & NE Lake	Railroad Lake, Local Area	North Watershed, at co. rd.	South Watershed
0	0	0	0	0
0.25	15	3	2	2
0.50	110	7	4	5
0.75	200	40	10	10
1.00	300	100	50	20
1.25	450	220	150	70
1.50	650	320	260	150
1.75	950	460	440	290
2.00	1750	670	670	500
2.25	3750	960	1030	780
2.50	3250	1850	1500	1220
2.75	2050	3900	2500	2000
3.00	1500	3400	5000	3250
3.25	1150	2150	6400	4600
3.50	950	1550	5600	5500
3.75	820	1220	4300	6000
4.00	720	1000	3350	5400
4.25	650	850	2700	4500
4.50	600	740	2200	3750
4.75	570	660	1850	3200
5.00	550	610	1600	2760
5.25	530	580	1380	2400
5.50	500	550	1250	2130
5.75	420	540	1150	1910
6.00	270	520	1100	1730
6.25	100	440	1050	1590
6.50	50	300	980	1480
6.75	30	150	800	1320
7.00	20	80	550	1100
7.25	10	40	300	820
7.50	0	20	150	550
7.75		10	75	380
8.00		0	50	300
8.50			40	260
9.0			30	225
9.5			20	185
10.0			10	150
10.5			5	110
11.0			0	75
11.5				30
12.0				0

*Note: Flood hydrograph ordinates for regional maximum experienced flood are 60 percent of these values.

Peak discharge values are tabulated below, for the five sub-watersheds:

Flood Frequency	Northeast Lake	North Watershed above co. road	Railroad Lake Local Area	South Watershed	I-280 Local Area
50-yr	158	785	350	745	177
100-yr	184	900	405	860	205
Regional Maximum Experienced	1060	3840	2340	3600	1190
Probable Maximum Flood	1770	6400	3900	6000	1980
Watershed Area, acres	125	540	275	675	140

The peak discharge values appear to be reasonable, in comparison with data collected from gaged watersheds in this region. They also compare favorably with estimates derived from use of culvert discharge relationships developed by the Iowa Highway Commission, if land use factors are selected to represent urban conditions on the upper watershed areas, and permanent cover for the park areas. The value for the peak flood discharge estimated for the regional maximum experienced flood compares closely with similar estimates made by the Corps of Engineers, U. S. Army, in flood plain information studies for Duck Creek at Davenport. It was concluded that the design flood hydrographs were adequate and could be used in flood routing studies through the proposed impoundments to determine spillway capacities and reduction in the peak inflow discharges.

IV. Flood Routing Studies

12. Principles of Reservoir Flood Routing.

The primary purpose of developing flood hydrographs is to permit a thorough analysis to be made of spillway requirements. Temporary storage of a portion of the incoming floodwaters frequently reduces the required spillway capacity, in relation to the peak inflow. The most economical design can be obtained as various alternatives are studied.

Flood routings of the design flood hydrographs were made using a computer program developed at Iowa State University. This program utilizes the basic equation for flood routing in a reservoir, which is, for short increments of time:

$$\frac{I_1 + I_2}{2}(\Delta t) - \frac{O_1 + O_2}{2}(\Delta t) = S_2 - S_1 \qquad (1)$$

where

I_1 = Inflow at beginning of period, cfs

I_2 = Inflow at end of period, cfs

Δt = Time period, days

O_1 = Outflow at beginning of time period, cfs

O_2 = Outflow at end of time period, cfs

S_1 = Reservoir storage volume at beginning of period, cfs-days

S_2 = Reservoir storage volume at end of period, cfs-days

Since all quantities at the beginning of a time period are known, the equation is transformed:

$$I_1 + I_2 + \left(\frac{2S_1}{\Delta t} - O_1\right) = \frac{2S_2}{\Delta t} + O_2 \qquad (2)$$

With the assistance of the graphical relationship between Elev., Storage (S) and Outflow (O), Equation 2 can be solved for successive time periods. Additional explanation can be obtained in "Hydrology for Engineers", by Linsley, Kohler and Paulhus, McGraw Hill, 1958. This equation has been adopted for a computer program which is available through Iowa State University.

13. General Plan for Discharging Floods Through the Impoundments.

Several factors influence the depth and volume of surcharge storage which can be utilized in all three of the design lakes, surcharge which could be used to attenuate the inflowing peak discharge and decrease spillway sizes. The water surface area for recreational use was made as large as possible. As a result, land requirements for additional flood surcharge storage become substantial. This is especially true for the Railroad Lake. The high cost of increasing the elevation of the proposed I-280 embankment to serve as a dam, for both the Northeast Lake and I-280 Lake, places a limitation on the additional height which can be obtained to increase surcharge storage. The high-voltage electric transmission line imposes additional elevation control. It was determined that surcharge storage should be limited to a five-foot increase for floods up to the 100-yr event, and to approximately ten feet for the probable maximum flood. The regional maximum experienced flood was selected as the design flood for determining hydraulic characteristics of the required auxiliary spillway structures for the two smaller lakes, and for the spillway of the I-280 Lake. Also imposed was the general requirement that two to three feet of freeboard remain as the flood hydrographs for this flood were routed through the system. The probable maximum flood would be used to establish top-of-dam elevations.

The three-lake system was next reviewed, under hydraulic and topographic limitations, for possible types and locations of spillway structures. Both the Northeast Lake and the Railroad Lake discharge into the main impoundment, I-280 Lake. As the latter rises in elevation during flood periods, it could influence the discharge capacity of certain types of structures, such as drop-inlets and submerged conduits. To minimize this effect, principal spillway structures were selected that would maintain their full discharge capacity for all floods except the most rare events. Preliminary evaluation indicated that the optimum structure for the Northeast Lake would be a simple reinforced-concrete straight drop spillway structure. This simple vertical drop will maintain the Northeast Lake at Elevation 700, five feet above the I-280 Lake. The latter must rise at least five feet before any influence will be exerted on the flow from the Northeast Lake. Because some back-flow may occur between the two lakes during the rare flood events, the straight drop spillway with its open crest will permit backflow easily and rapidly. The straight drop spillway would be the principal spillway structure for the Northeast Lake, and designed to discharge all floods up to and including the 50-yr and 100 yr flood hydrographs. To discharge floods of more rare recurrence intervals, including the regional maximum experienced and the probable maximum, an auxiliary earth spillway with a heavy vegetative cover would be constructed between the two lakes. It would have a crest elevation above the discharge level of the 100-yr flood, as routed through the Northeast Lake. Both structures would be located in the borrow area to be excavated during enbankment construction and which is located in the ridge separating the two valleys.

The proposed dam for the Railroad Lake requires reconstruction and modification of the existing enbankment across the valley in this location. The ten-foot elevation difference between this lake and the main impoundment requires a hydraulic structure which can safely convey flood discharge from the upper lake to the lower, in a relatively short distance, The drop is too large, in view of the anticipated lake rises during floods, for a straight drop spillway. A culvert spillway was selected as a simple, yet economical and adequate principal spillway structure. As in the case of the Northeast Lake, this hydraulic structure would have sufficient capacity to discharge all floods up to and including the estimated 100-yr flood event. The topographic maps show that an auxiliary earth spillway could be provided at the right (west) abutment, in an area where the abandoned railroad grade passes from cut to fill. This area would be a borrow area for embankment materials, and the auxiliary spillway would be shaped upon completion of excavation. Its crest elevation would be five feet higher than the crest of the culvert spillway.

The highway geometrics of the proposed I-280 embankment across the Black Hawk Creek valley, in conjunction with the high hazard classification of the major impoundment, makes it necessary to discharge all floods in one principal spillway structure. In order that the estimated regional maximum experienced flood and the probable maximum floods do not exceed the allowable surcharge elevations, considerable spillway capacity is required. The type of structure which is most ideal is the concrete chute spillway, with an ogee crest to give maximum discharge at low elevations. This type of spillway can adequately convey the design flood discharges through the I-280 embankment. The total drop, from the crest elevation of 695, to stream elevation of about 663, is approximately 32 feet. This is sufficient to require a stilling basin at the outlet.

It is normal practice to construct important concrete spillway structures, such as the proposed I-280 spillway, on undistrubed foundations. The problems of settlement if constructed in the compacted embankment must be considered, since the foundation beneath the compacted embankment can settle as well as can the embankment itself. These problems can be avoided to a large degree if a location in one abutment can be obtained. Inspection of the topography and soil borings indicate that the proposed spillway structure can be placed on undisturbed material in the left (north) abutment of the dam. This is in the vicinity of a narrow ridge separating the Northeast Lake and I-280 Lake, approximately at Station 300+00 along the highway stationing. Inspection of the soil borings show that footings can be placed in the glacial clay which exists beneath the loess covering the slopes. A new outlet channel would be required to connect with the present channel near the most downstream county road bridge in the vicinity of the dam.

Approximate spillway discharge rating curves were developed for the proposed spillway structures at each dam, using a range of spillway crest lengths to obtain the minimum structure sizes under the imposed limitations. Design criteria published by the Bureau of Reclamation in "Design of Small Dams", 1960, were used to develop rating curves. Preliminary analysis of temporary surcharge storage and outflow capacity required to discharge the entire volume of inflow assisted in establishing the range of spillway crest lengths. The initial flood hydrograph routings gave results from which later computer studies were based after revised reservoir storage values were made available.

14. Results of the Flood Routing Studies.

Results of the flood routing studies using various spillway crest lengths at each proposed lake are contained in Table 7. This table shows the maximum reservoir elevation reached during the flood routing procedure for the indicated flood hydrograph. All routings were made from an initial elevation of one foot above crest elevation for the 50-year and 100-year flood hydrographs, and two feet for the regional maximum experienced and probable maximum flood hydrographs. This was done to reflect the chance opportunity of prior floods partially depleting the surcharge storage in each impoundment.

This is believed to be adequate and simpler than use of a longer period of storm rainfall conditions, such as a five or ten day rainfall period.

The preliminary results confirmed that minimum size structures had been obtained for the Northeast Lake and the Railroad Lake. Because the Northeast Lake is five feet higher in design water surface elevation than the I-280 Lake, there is less surcharge height available below the grade of I-280. This requires placing the auxiliary spillway no more than three feet higher than the principal spillway, and limiting the maximum reservoir elevation to about six feet above the design water surface. Based upon this analysis, a standard width of straight drop spillway of six feet was adopted to balance the fall to the lower lake and the required sidewall heights. The auxiliary spillway of 100-foot crest length at elevation 703 is adequate. This adopted combination of hydraulic structures for the Northeast Lake was selected for final flood routings for report presentation.

The preliminary routings indicated that the 10-foot spillway crest length was satisfactory for the proposed culvert spillway. In addition, the auxiliary spillway of 250-foot crest length was adequate for hydraulic performance upon vegetated earth spillways, with a hydraulic head of three feet for the regional maximum experienced flood, and with a maximum depth less than the desired ten feet of surcharge. For final flood routings a twin 5x5 culvert spillway with a flume outlet was selected as a principal spillway, giving a ten foot crest length, and the 250-foot auxiliary spillway at crest elevation of 710.

The initial flood routings for the I-280 Lake were made using the reservoir storage values obtained from the U.S.G.S. topographic map and one composite flood hydrograph for the entire watershed. This routing gave a maximum reservoir elevation for the probable maximum flood hydrograph of 706.2 for a spillway crest length of 50 feet. It appeared that this would be a satisfactory size, and exceeded the ten-foot limit by only one foot. Additional preliminary planning and estimates were made for these results. The results shown in Table 7 indicate that the reduced storage values obtained from the detailed aerial topographic maps had caused a significant change in water surface elevations. About a 1.5 foot increase resulted for the routings of the probable maximum flood hydrographs for each selected spillway crest length. Because the spillway crest length of 50 feet is itself a substantial length for this size of drainage area, it was retained for final routings although it requires establishing El. 707.7 as the top of the proposed I-280 embankment (minimum grade elevation of the finished paved surface). Additional cost studies can be made using the data contained in Table 7 if the absolute minimum cost of joint facilities, embankment versus spillway cost, is to be evaluated in detail. The final flood hydrograph routings for report presentation were made with the crest length of 50 feet.

The computer input and output for each routing are included in Appendix A. This printed information provides the storage values, discharge ratings, inflow hydrographs, and outflow hydrographs for each flood event, 50-yr, 100-yr, regional maximum experienced and probable maximum precipitation. An additional computer program enables machine plots of the inflow and outflow hydrographs to be obtained, and these are shown in Figures 4 through 15. Figures 4, 5, 6, and 7 are for the Northeast Lake routings, figures 8, 9, 10 and 11 are for the Railroad Lake routings, and figures 12, 13, 14 and 15 are for the I-280 Lake routings. The figures show clearly the degree of attenuation between peak inflow and outflow for the various flood events.

15. <u>Review of Reduction of Peak Flood Discharges.</u>

A secondary benefit of the proposed three-lake recreational system is the

Table 7. Reservoir Elevations for Selected Spillway Lengths.

	Lake	Spillway Type	Crest Length Feet	Crest Elevation Feet	Maximum Reservoir Elevation, feet 50-yr	100-yr	Regional Max.	Probable Max.
1.	Northeast	drop auxiliary	5 100	700 703	701.9	702.1	704.9	705.8
2.	Northeast	drop auxiliary	10 100	700 703	701.5	701.7	704.5	705.6
3.	Railroad	culvert auxiliary	10 250	705 710	709.5	710.0	713.1	714.7
4.	Railroad	culvert auxiliary	12 250	705 710	709.3	709.8	713.0	714.6
5.	I-280	ogee crest, chute spillway	40	695	697.6	697.9	704.6	708.9
6.	I-280	ogee crest, chute spillway	50	695	697.4	697.6	703.8	707.7
7.	I-280	ogee crest, chute spillway	60	695	697.2	697.4	703.2	706.8
8.	I-280	ogee crest, chute spillway	80	695	696.9	697.1	702.3	705.4

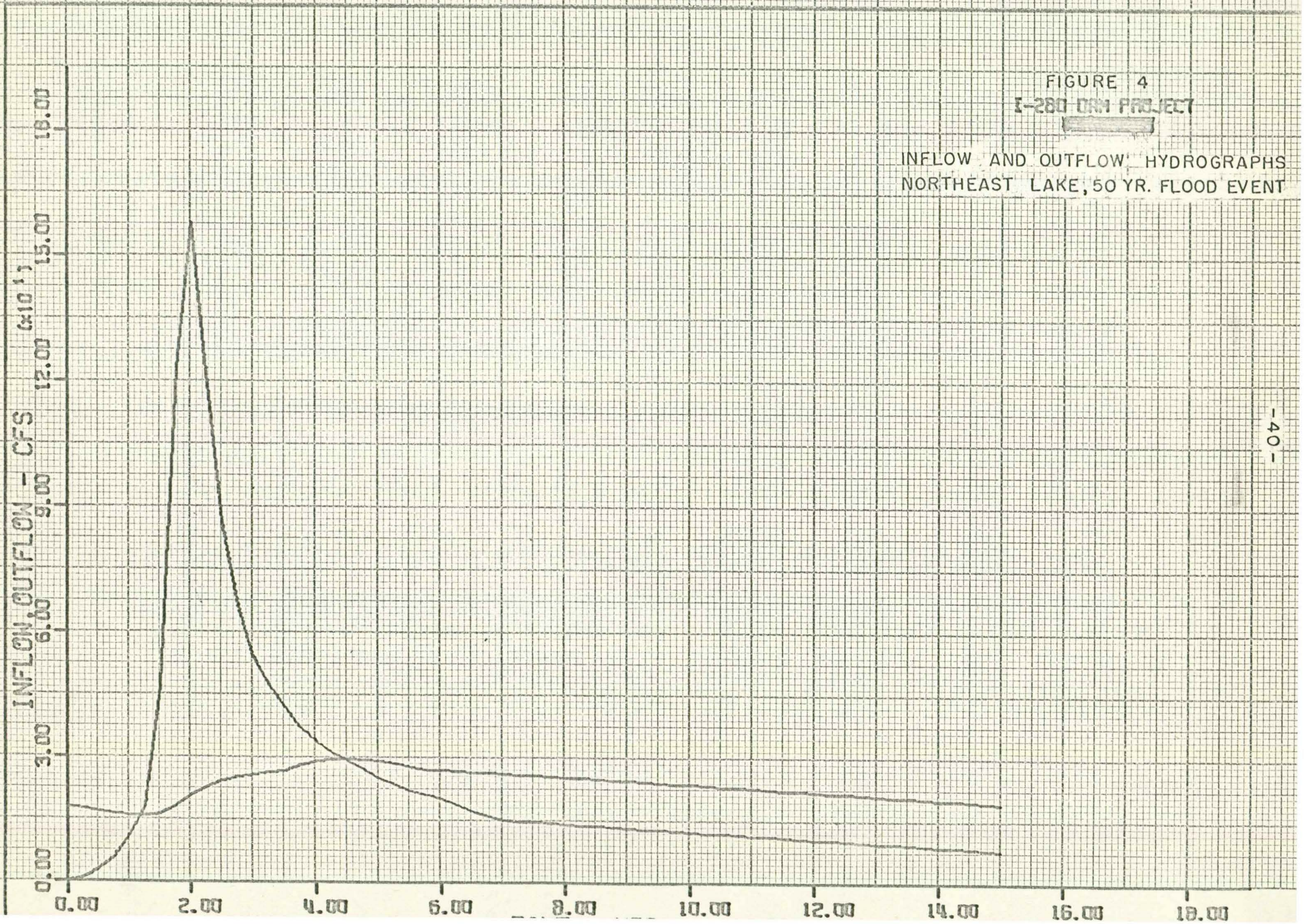
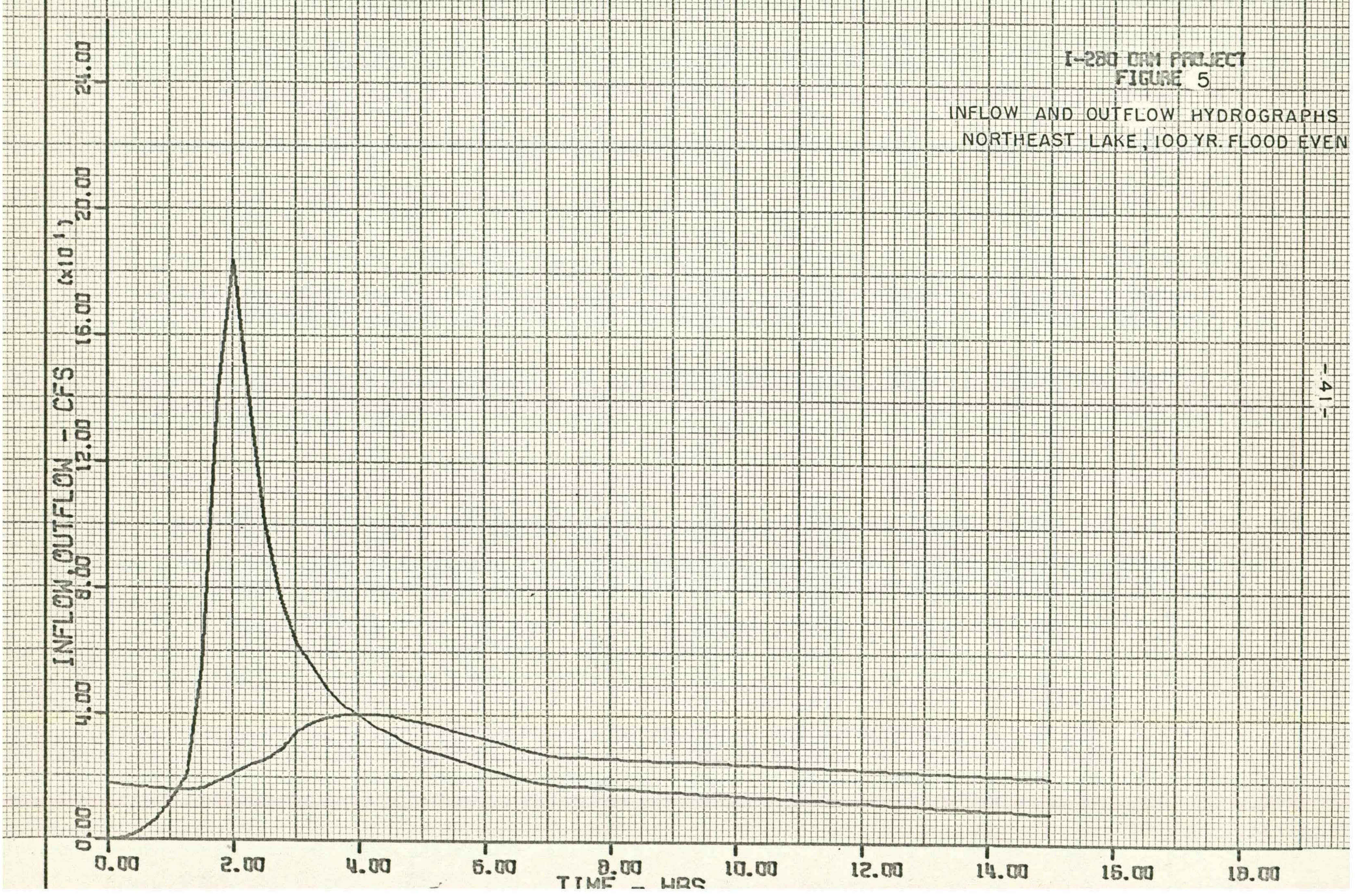
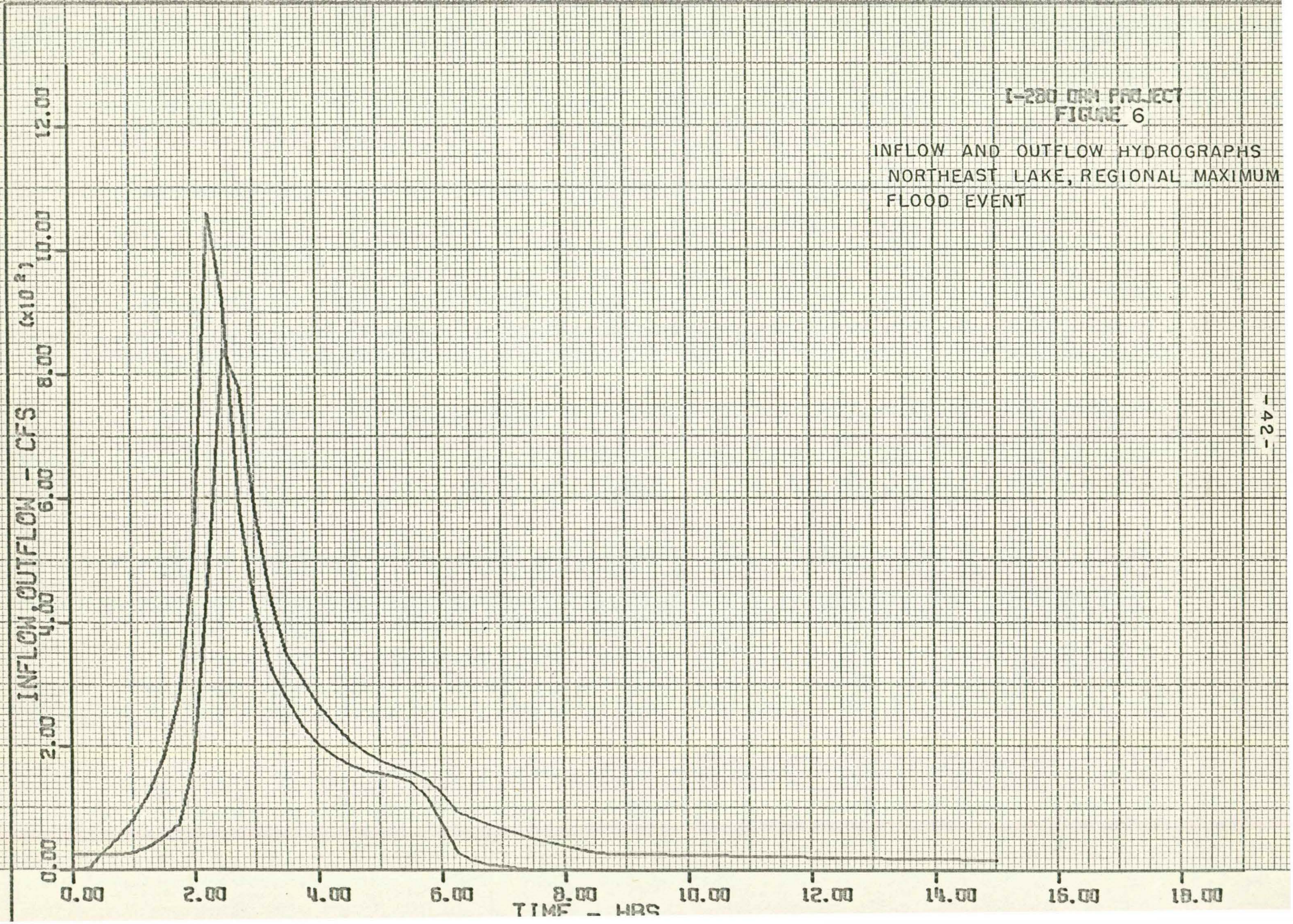


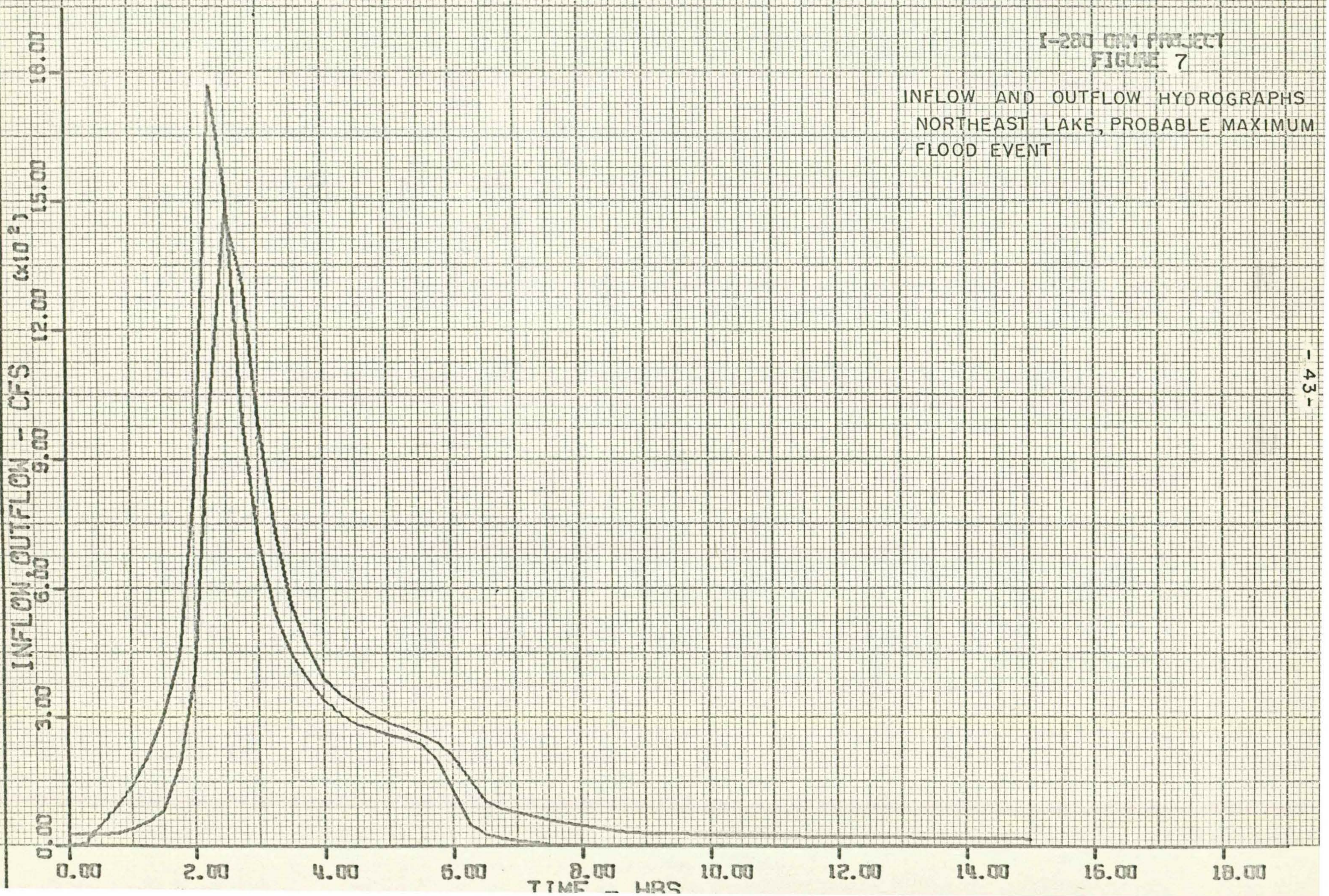
FIGURE 4
I-280 DAM PROJECT
INFLOW AND OUTFLOW HYDROGRAPHS
NORTHEAST LAKE, 50 YR. FLOOD EVENT
INFLOW, OUTFLOW - CFS (x10¹)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00

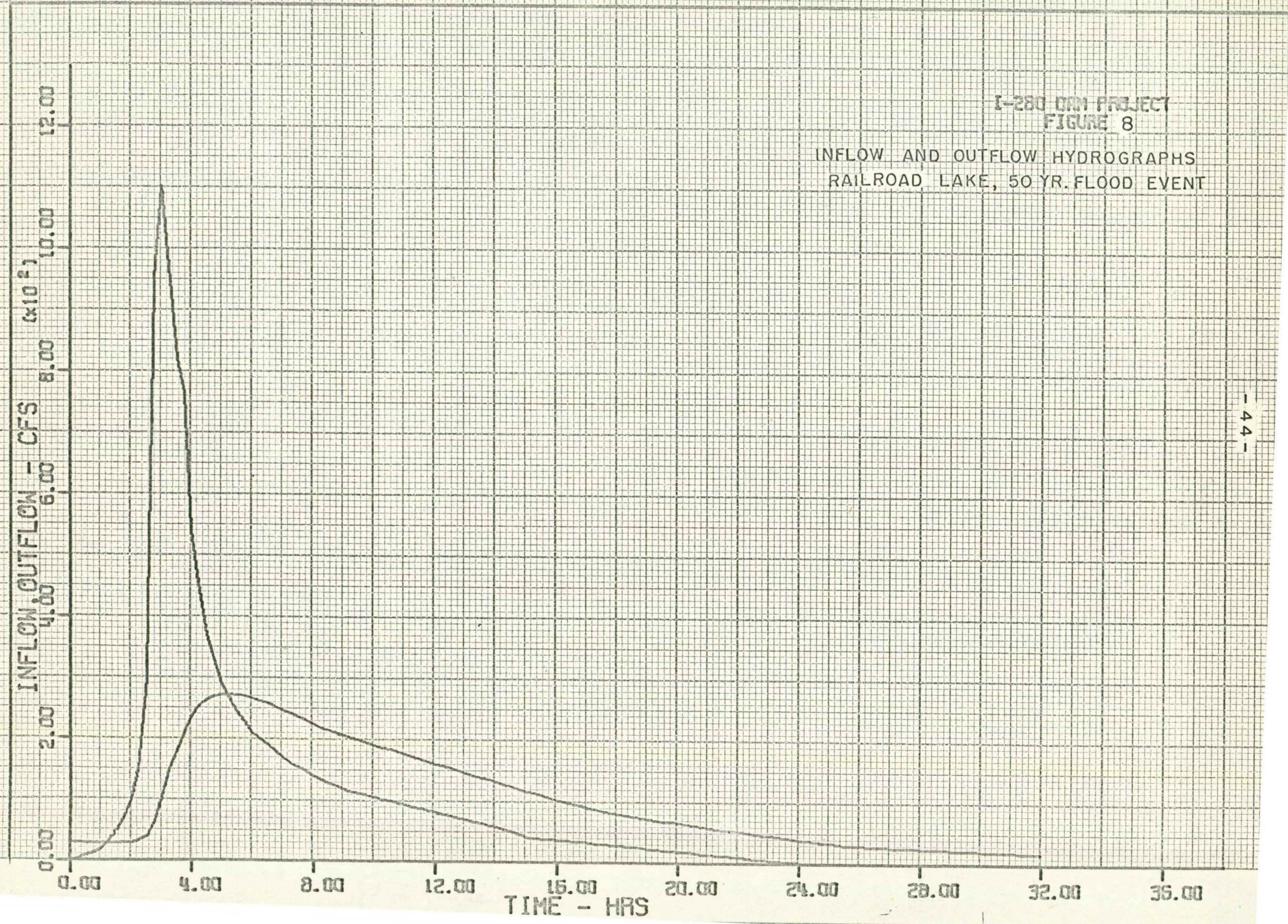

I-280 DAM PROJECT
FIGURE 5
INFLOW AND OUTFLOW HYDROGRAPHS
NORTHEAST LAKE, 100 YR. FLOOD EVEN
INFLOW, OUTFLOW - CFS (x10 ¹)
0.00
4.00
8.00
12.00
16.00
20.00
24.00
TIME - HRS
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00

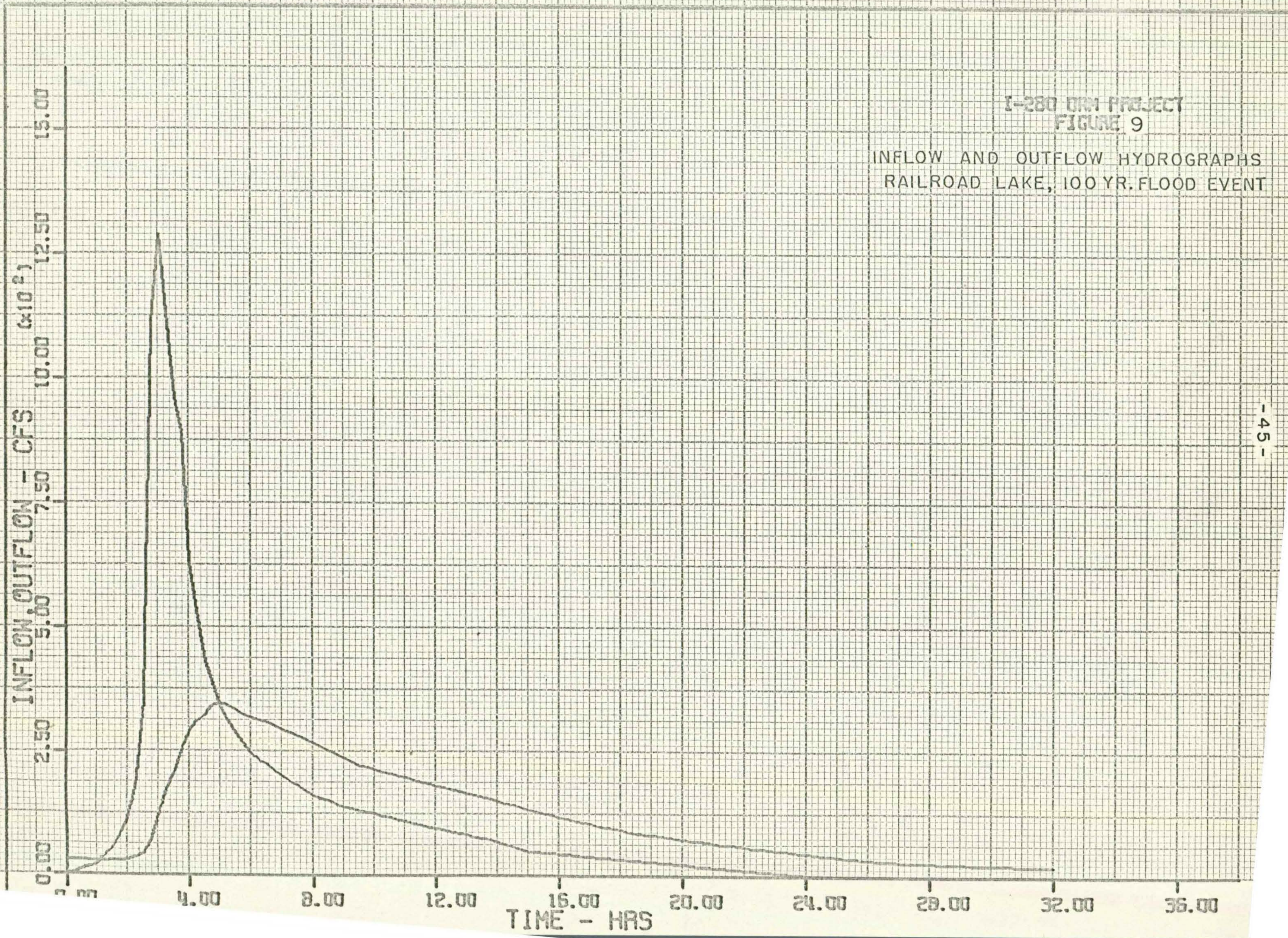
I-280 DAM PROJECT
FIGURE 6

INFLOW AND OUTFLOW HYDROGRAPHS
NORTHEAST LAKE, REGIONAL MAXIMUM
FLOOD EVENT



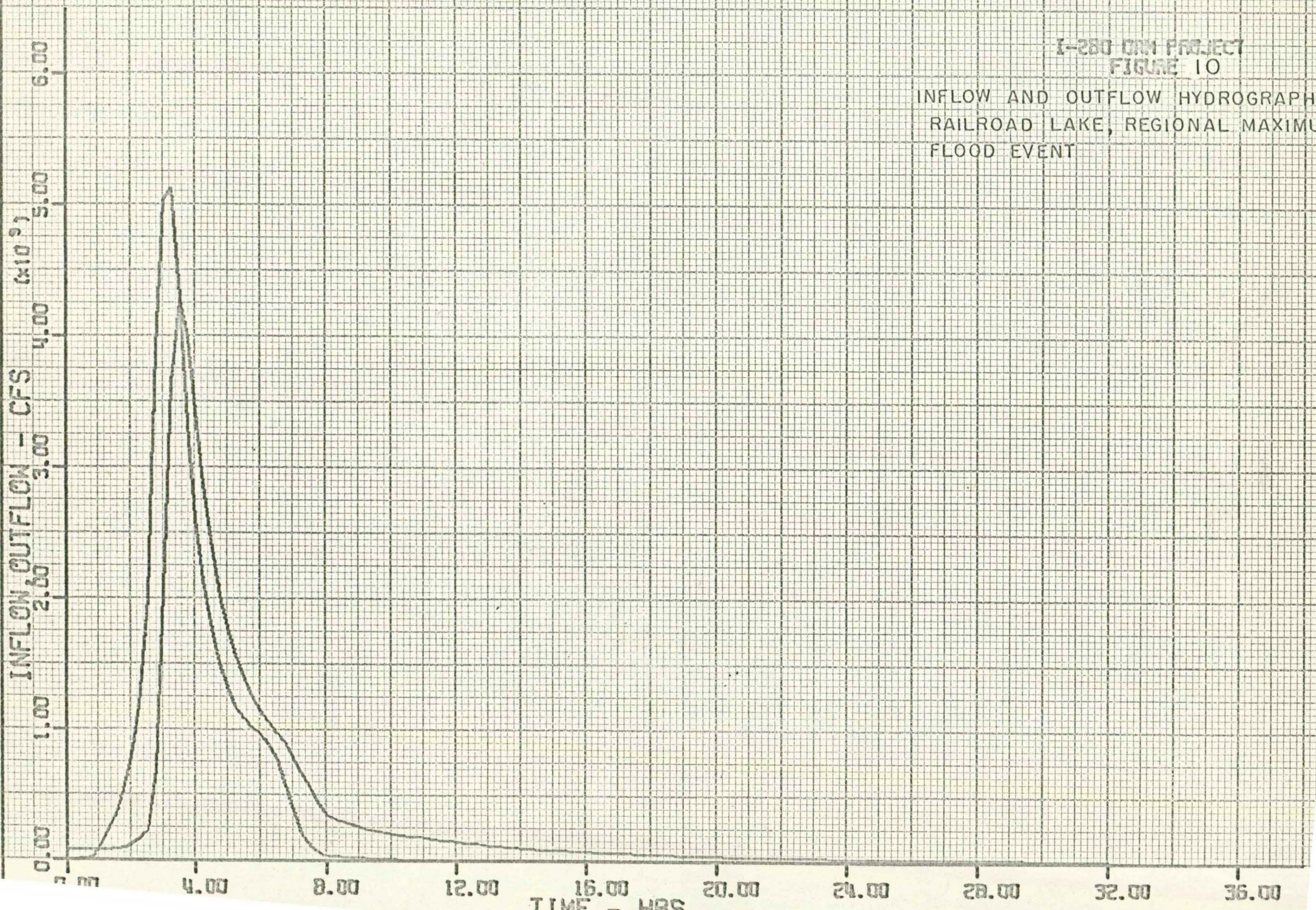

I-280 DAM PROJECT
FIGURE 7
INFLOW AND OUTFLOW HYDROGRAPHS
NORTHEAST LAKE, PROBABLE MAXIMUM
FLOOD EVENT
INFLOW, OUTFLOW - CFS (x10 2)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
TIME - HRS


I-280 DRN PROJECT
FIGURE 8
INFLOW AND OUTFLOW HYDROGRAPHS
RAILROAD LAKE, 50 YR. FLOOD EVENT
INFLOW,OUTFLOW - CFS (x10 2)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
TIME - HRS

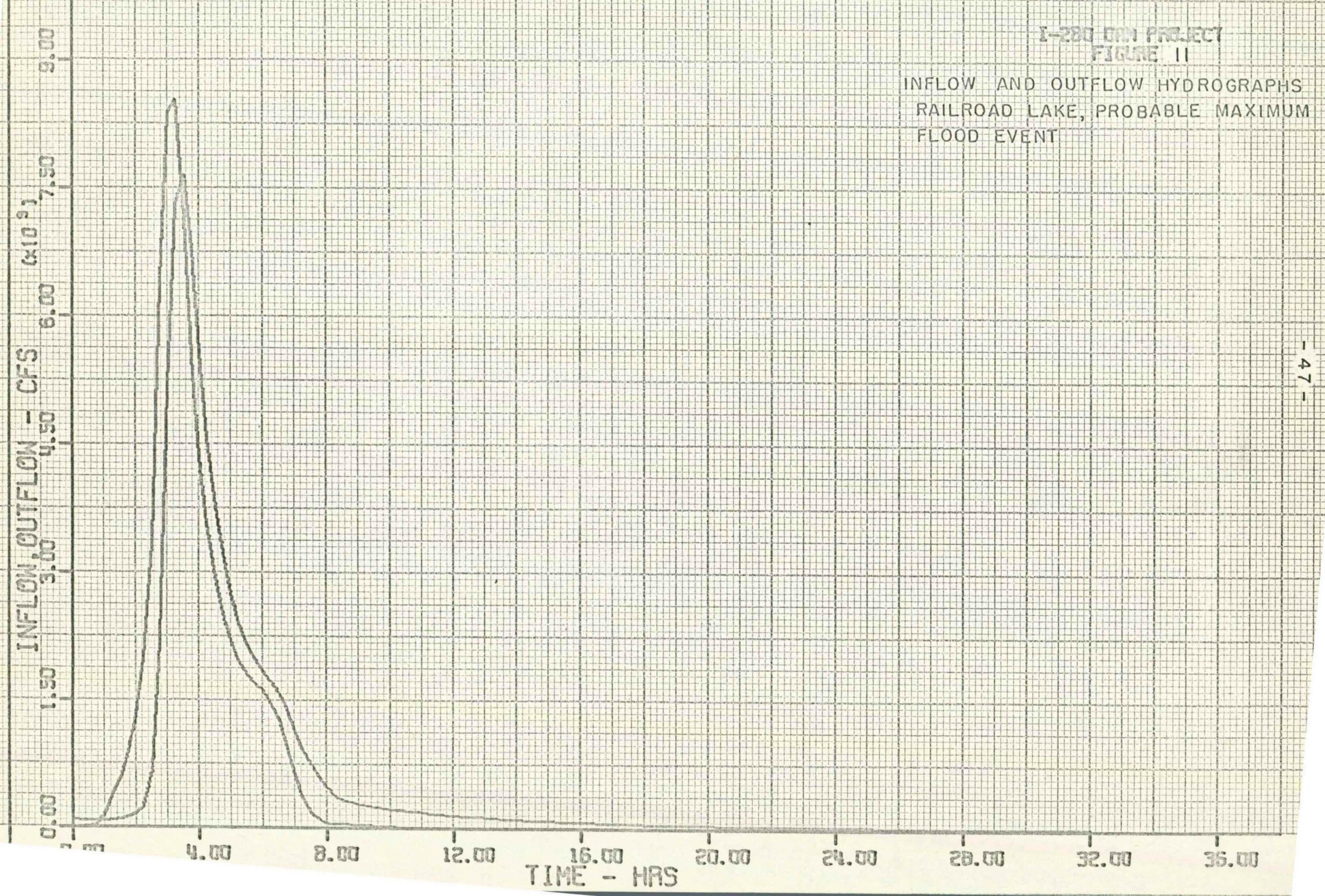


I-280 DRM PROJECT
FIGURE 9

INFLOW AND OUTFLOW HYDROGRAPHS
RAILROAD LAKE, 100 YR. FLOOD EVENT

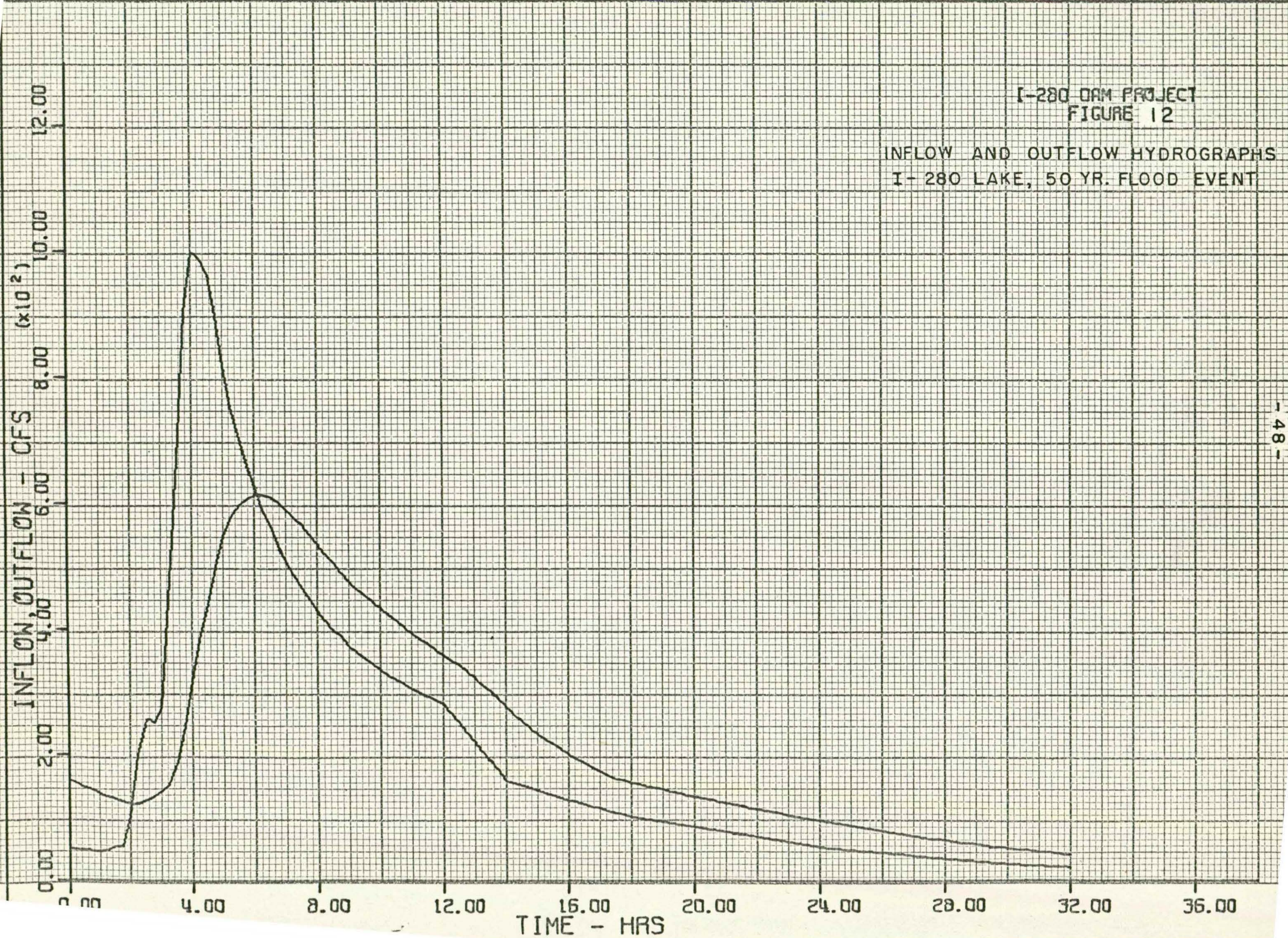


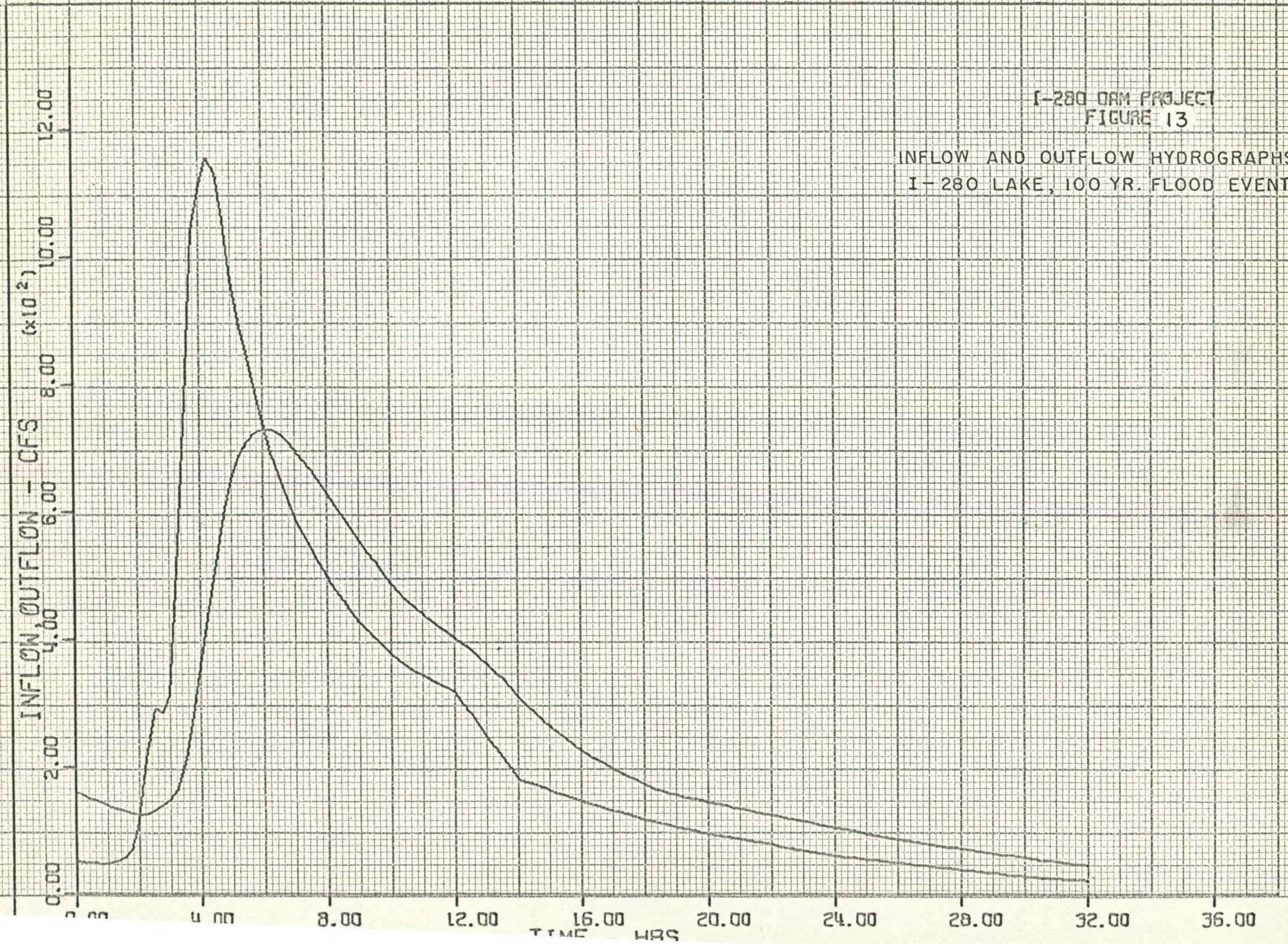
I-280 DAM PROJECT
FIGURE 10
INFLOW AND OUTFLOW HYDROGRAPHS
RAILROAD LAKE, REGIONAL MAXIMUM
FLOOD EVENT



I-280 DAM PROJECT
FIGURE II

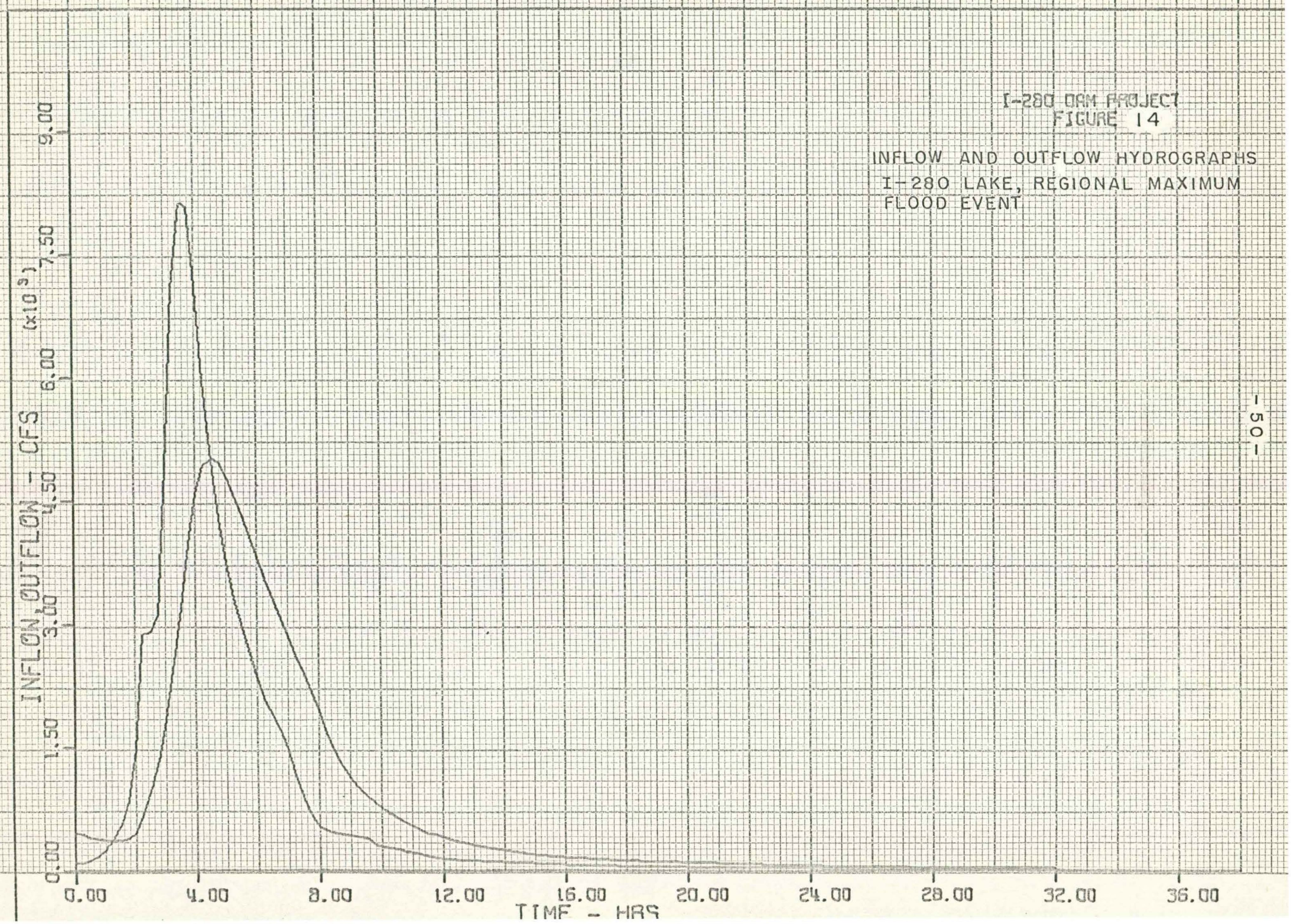
INFLOW AND OUTFLOW HYDROGRAPHS
RAILROAD LAKE, PROBABLE MAXIMUM
FLOOD EVENT

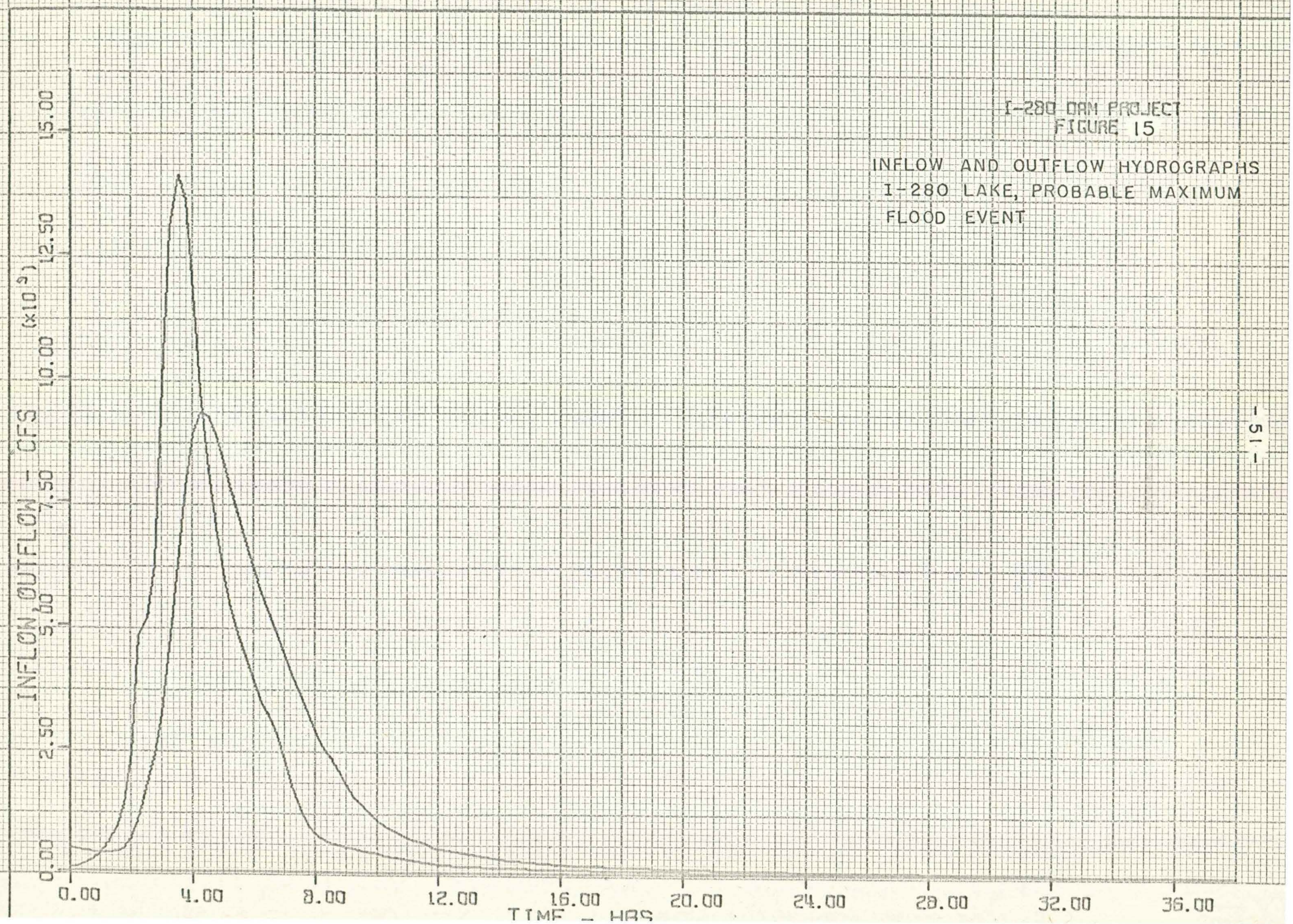

I-280 DAM PROJECT
FIGURE 12
INFLOW AND OUTFLOW HYDROGRAPHS
I- 280 LAKE, 50 YR. FLOOD EVENT
INFLOW, OUTFLOW - CFS (x10 2)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
TIME - HRS


I-280 DAM PROJECT
FIGURE 13
INFLOW AND OUTFLOW HYDROGRAPHS
I-280 LAKE, 100 YR. FLOOD EVENT
INFLOW, OUTFLOW - CFS (x10²)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
TIME - HRS

I-280 DAM PROJECT
FIGURE 14

INFLOW AND OUTFLOW HYDROGRAPHS
I-280 LAKE, REGIONAL MAXIMUM
FLOOD EVENT




I-280 DAM PROJECT
FIGURE 15
INFLOW AND OUTFLOW HYDROGRAPHS
I-280 LAKE, PROBABLE MAXIMUM
FLOOD EVENT
INFLOW, OUTFLOW - CFS (x10³)
0.00
2.50
5.00
7.50
10.00
12.50
15.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
TIME - HRS

degree of flood control achieved. Complete control, or a very high reduction of peak flood discharges was not expected, because only a limited flood surcharge volume was permitted. However, the results of the flood routing studies indicate a substantial attenuation of the peak inflows into each impoundment. The reductions are tabulated and evaluated in Table 8. The peak flood discharge, or inflow peak, for the total design watershed of 1755 acres was estimated for the 50-yr and 100-yr floods, using the hydrographs in Tables 4 and 5. As indicated in Table 8, a 64 to 65 percent reduction is obtained for these flood events, and this represents the overall capability of the proposed lake system to attenuate flood discharges which may occur in the future.

Inspection of the topographic map of the watershed indicates that additional flood control reservoirs could be located on four additional small tributaries in the Black Hawk Creek watershed downstream of the proposed lake system. The potential exists within the watershed of being able to control floods to a high degree, if additional planning and development is considered in the future before urbanization occupies the additional reservoir sites.

Table 8. Reduction of Peak Flood Discharges

Item	Flood Event	Discharge, cfs, at peak inflow and outflow for indicated lake		
		Northeast Lake	Railroad Lake	I-280 Lake
Inflow	50-yr.	158	1105	1000
Outflow	50-yr.	44	274	613
Percent Reduction		72%	75%	39%
Inflow	100-yr.	184	1290	1160
Outflow	100-yr.	50	348	730
Percent Reduction		73%	73%	37%
Inflow	Regional Max.	1060	5130	8140
Outflow	Regional Max.	831	4267	5030
Percent Reduction		22%	17%	38%
Inflow	P.M.P.	1770	8550	14120
Outflow		1467	7670	9305
Percent Reduction		17%	10%	34%
Total Watershed				
Composite inflow,	50-yr.			1750
Outflow, I-280				613
Percent Reduction, overall				65%
Total Watershed				
Composite inflow,	100-yr.			2000
Outflow, I-280				730
Percent Reduction, overall				64%

V. Hydraulic Design of Proposed Spillways

16. Principal and Auxiliary Spillways for the Northeast Lake.

The proposed I-280 embankment would serve as the dam for this impoundment, with the outflow diverted to the proposed I-280 Lake rather than being carried through the I-280 embankment to the existing channel. The proposed principal spillway is a straight drop spillway of reinforced concrete with a crest length of six feet. Standard plans are available for this type of structure. The discharge rating curve is based on critical depth conditions. Selection of a design head of 2.5 feet, slightly more than required by the flood routing of the 100-yr flood hydrograph, enables the weir notch, sidewalls, and headwall extensions to be constructed to El. 703.0, the elevation of the auxiliary spillway crest. Hydraulic jump requirements, for the weir flow as it plunges to the apron downstream of the weir, approach a height of four feet. Accordingly, the elevation of the apron is established at El. 691, making a total drop from crest to apron of nine feet. The length of the apron required for proper hydraulic performance is 18 feet. An endsill of approximately one foot of height is recommended to assist in controlling scour at the outlet of the spillway. The total distance between the sidewalls is seven feet, providing a six inch weir notch offset at the downstream side of the crest to permit aeration of the discharging nappe of water. Headwall extensions of 15 feet in length provide an impervious cutoff at the sides of the spillway. Toewalls and a cutoff at the crest beneath the apron complete the requirements for the reinforced concrete structure.

The drawdown facilities, to permit release of water to the I-280 Lake during drought periods, could be constructed as part of the straight-drop spillway. A circular pipe conduit would convey water from the lake to a wet well which would be constructed on the upstream face of the headwall extension of the spillway. A vertical slide gate, with an operating platform located on top of the abutment, would permit releases to be made through a box outlet, discharging to the apron downstream of the weir notch.

The auxiliary spillway requires a 100-ft crest length, at El. 703, and can be shaped to design grade and alignment as borrow is removed from the ridge area. Approach channel slopes and alignment as well as exit channel slopes can be determined after detailed site surveys are made. The discharge rating curve was adopted from standard designs developed by the Soil Conservation Service.

17. Principal and Auxiliary Spillways for the Railroad Lake.

The flood routings indicated that the proposed twin 5x5 culvert spillway would be adequate to discharge normal floods through the proposed dam. The proposed design for this culvert spillway would follow closely the Highway Commission culvert criteria for box culverts with flume outlets. Water surface profiles for the 50-yr and 100-yr flood discharges were computed for the culvert spillway.

A computer program was written to perform the water surface profile computations for open channels on hydraulically steep slopes, such as the proposed spillways for the Railroad Lake and the I-280 Lake. The program utilizes the hydraulic principles of Bernoulli's equation of conservation of energy of the flowing water, permitting the water surface to be determined at a selected station when invert elevations, channel slopes, and hydraulic conditions at the next upstream station are known, or have been computed previously. Friction losses are calculated using Manning's equation. The following formulas result:

$$z_1 + d_1 \cos\theta + \alpha \frac{v_1^2}{2g} = z_2 + d_2 \cos\theta + \alpha \frac{v_2^2}{2g} + H_f$$

$$H_f = S_f L = \left(\frac{n\,v}{1.49\,R^{0.67}} \right)^2 L$$

in which

z = elevation of invert of channel

d = depth of water normal to channel bottom

θ = angle channel bottom makes with horizontal (theta)

α = velocity head correction coefficient, (alpha)
 = 1.0 for selected design channels

g = acceleration of gravity, 32.16 feet per second

H_f = friction loss between sections, in feet of fluid flowing.

S_f = friction slope, feet per foot

L = length of channel between sections

n = Manning's roughness coefficient

R = hydraulic radius (area/wetted perimeter)

The computer program as written computes the water surface profile for one representative barrel of multiple barrel culverts, using the appropriate portion of the total discharge and total width. This then includes the decreased hydraulic radius in multiple barrel culverts.

For the proposed principal spillway structures, Manning's "n" values of 0.012 and 0.015 were selected. These represemt average values being used in the design of concrete structures. Lower values yield estimates of maximum velocity, the higher values yield estimates of maximum depths to be expected.

The results are listed in Appendix B, part 2, for the culvert spillway at the Railroad Lake. Dimensions of the proposed spillway were evaluated using a nominal 18-foot top width at El. 715, for the top of the dam, and one on three foreslopes and backslopes for the embankment. This required a culvert barrel length of 46 feet, for the adopted two per-cent slope of the invert. A standard flume outlet with an apron eleva-tion of 690.0 would convey flows from the barrel section down the flume chute to the standard flume outlet. Hydraulic jump requirements are met with the water surface in the downstream I-280 Lake at El. 697, two feet above normal lake stage. It is assumed that in the event of a large flood in the north watershed, sufficient inflow from the south watershed would cause some rise in the I-280 Lake. This permits leaving the apron of the flume outlet at a slightly higher elevation, and it is believed that the five foot of normal submergence is as much as should be tolerated because of weathering, freezing and thawing, etc., in the submerged outlet. The standard highway box culvert plans would be modified to provide additional cutoffs and drainage under the barrel and outlet sections.

Separate facilities would be required for drawdown requirements. It is recommended that an inlet circular pipe conduit, a gate well in the dam near the edge of the lake, and an outfall conduit be provided to meet the drawdown requirements.

The auxiliary spillway requires a 250-foot crest length, at El. 710, and as in the case of the Northeast Lake can be located in the west abutment in a proposed borrow area. Additional details for alignment and grade can be determined after detailed site surveys are made.

The embankment of the county road would be reconstructed to permit traffic to continue to cross the proposed Railroad Lake. The inlet of the existing box culvert through the county road embankment would be extended, with the invert raised to an elevation of 701 at the entrance. The outlet would be extended, and would operate as a submerged outlet.

18. Concrete Chute Spillway for the I-280 Lake.

This spillway is the most important structure in the proposed three-lake system. It is the most downstream of all the impoundments, and must provide adequate capacity to prevent overtopping and meet the high hazard conditions. To permit an economical structure to be developed, which could convey the high discharges through the proposed I-280 embankment, it was decided to incorporate the proposed ogee crest and chute spillway concepts with the conduit concepts of the box culverts used in highway design. This design concept would permit the spillway crest length of 50 feet to be reduced to a narrower chute width, enter the I-280 embankment with a multiple barrel box culvert on a hydraulically steep slope, and exit from the barrel section to a chute which would convey the flood discharges down the proposed one on three slopes to a stilling basin at the outlet.

A preliminary analysis using specific energy relationships showed that if the entrance to the multiple barrel box culvert section was established with an invert elevation of 685.0, ten feet lower than the crest elevation, the width of the spillway could be reduced to permit either triple 10-foot or triple 12-foot spans to be used. Initial computer analysis was made with a three percent slope from the ogee crest to the outlet of the barrel, and a one on three slope to the proposed stilling basin. The width of the interior walls of the culvert section was estimated at one foot for the hydraulic study, giving a 32-foot width upstream and downstream of the triple 10-foot culvert section, and a 38-foot width for the triple 12-foot culvert section.

This initial study showed that the water surface profiles were not acceptable, for the water surface was accelerating down the ogee crest to a minimum depth at the chute floor, then increased in both depth and water surface elevation as the flow proceeded downstream. This indicated that the discharges could not be squeezed down to the width of the triple 10-foot width culvert barrels, if actual three dimensional flow problems were considered.

As studied, the triple 10-foot culvert section gave a water surface depth of almost 12 feet at the entrance. The triple 12-foot culvert barrel gave a water surface depth of eight to nine feet at the entrance to the barrel, for the maximum probable flood event. This permitted a ten-foot barrel height to be considered, and a review of steel and concrete requirements showed that the material requirements would be almost the same as the triple 10x12 section. Final water surface profile studies were made using the triple 12-foot barrel section. In addition, a 12 percent slope was introduced from the ogee crest to the entrance of the culvert barrel, with the three percent slope continuing through the barrel to the outlet, then on a one on three slope to the stilling basin.

As finally developed, the proposed chute spillway would have the following characteristics:

1. Ogee crest, with a design head of nine feet. The equation of the parabolic crest shape is:

$$Y = 0.0814\ X^{1.835}$$

2. Chute floor slope of 12 percent, from El. 691.6 at the crest to El. 685 at the entrance to the triple barrel section, intersecting the ogee crest at about Station 08.9 and with Station 55.0 at the entrance. This contracting section has a central angle of 30 degrees.

3. A triple barrel culvert section, approximately 215 feet long for the grade requirements at I-280 Station 300+00, and one on three foreslope and backslope. The slope of the invert is three percent to permit a balance between normal depths of the four design flood discharges.

4. A modified flume outlet for the chute section, corresponding to the requirements for a ten foot culvert height, and on a one on three slope.

5. A stilling basin designed on the principles of the "Saint Anthony Falls" basin. Width of 38 feet, length of 24 feet to inside of endsill. Floor blocks and chute blocks of two foot width, with two foot spacing and alternate spacing of floor blocks and chute blocks. Height of blocks, three feet. Endsill height, 1.5 feet. Sidewall heights to meet hydraulic jump conditions for regional maximum flood, 18 feet, with stilling basin floor at El. 660.0. This height of wall might be modified by use of berms, etc.

6. Cutoff walls and underdrainage from the crest to the stilling basin,

using 30-foot section lengths.

7. Anchorage of the stilling basin for possible uplift due to unbalanced hydrostatic pressure conditions in the hydraulic jump.

The general features of the proposed chute spillway are shown in Figures 16 and 17. The computer output for the water surface profiles and other discharge data is included in Appendix B, part 1. Profiles are included for two values of Manning's roughness, "n", a value of 0.012 to yield estimates of maximum velocity and minimum depth relationships, and a value of 0.015 to represent maximum depth conditions, upon which sidewall heights can be based. It should be observed that within multiple barrel culverts, the computer program divides the flow equally between the barrels, and computes the water surface profile for one representative barrel.

Release or drawdown facilities would be provided for the I-280 Lake to permit a minimum of ten feet of drawdown. An inlet conduit, gate well, and outlet conduit would be located adjacent to the concrete spillway entrance, discharging into the barrel section of the spillway at approximate El. 685.

All of the proposed embankments would be protected with rock riprap, from an elevation five feet below design water surface elevation to a minimum of eight feet above design water surface elevation.

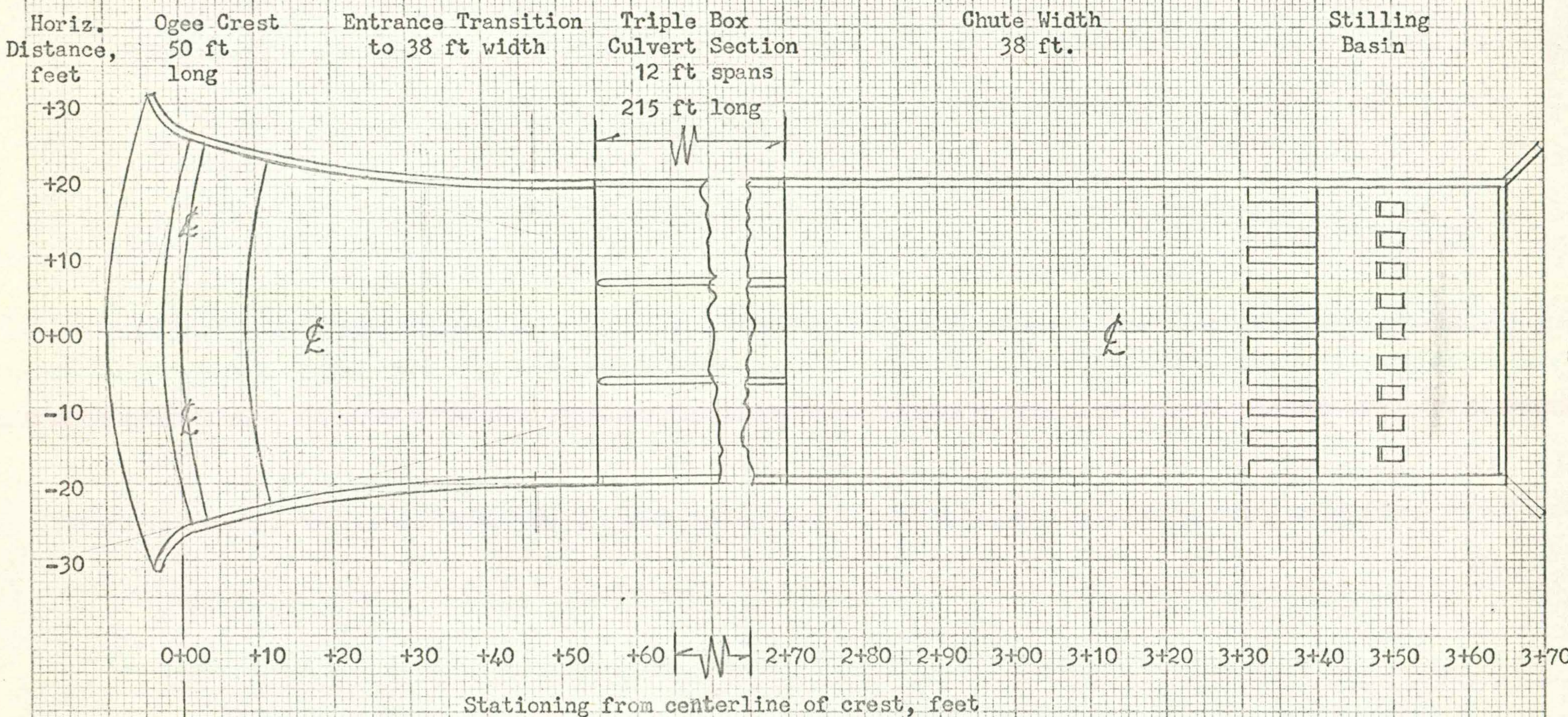


Figure 16. Plan View, Proposed Spillway for Lake I-280

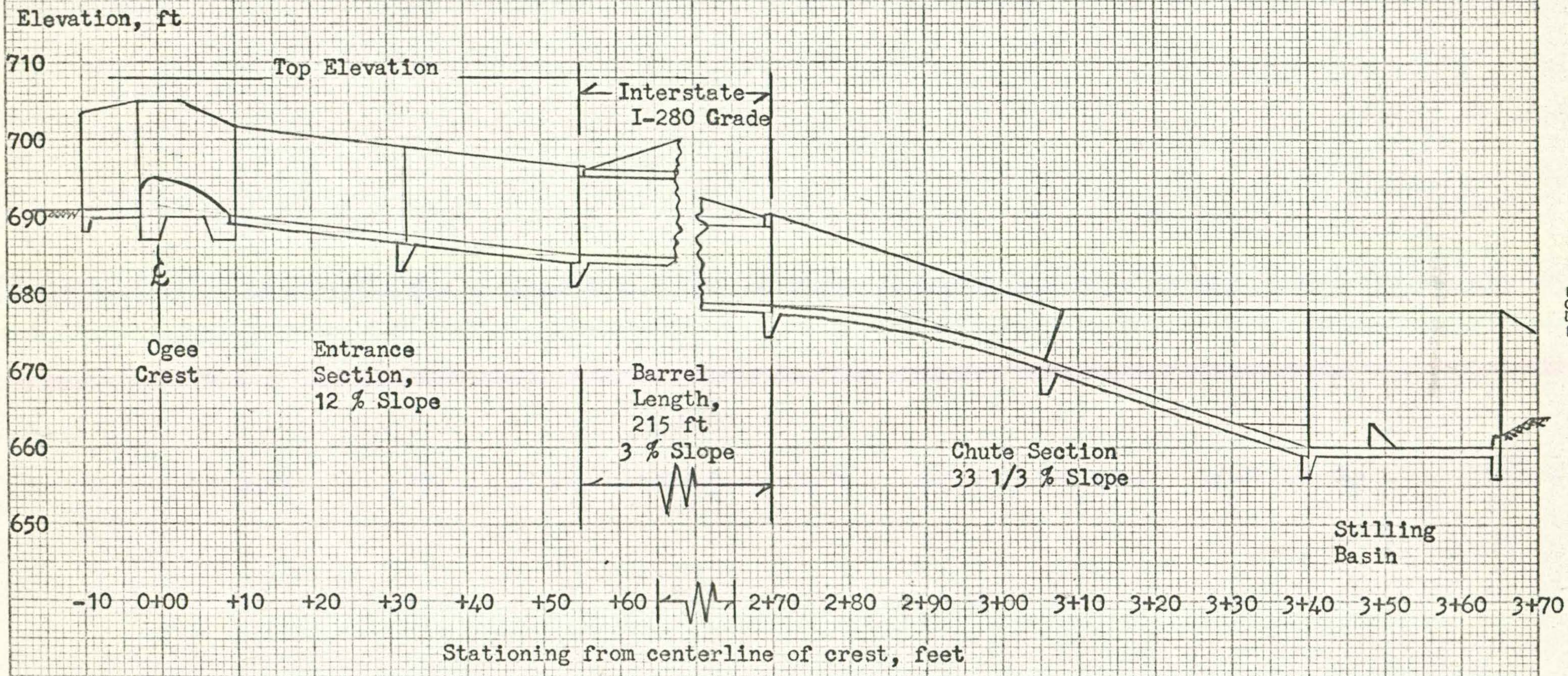


Figure 17. Profile View, Proposed Spillway for Lake I-280

VI. Conclusions

19. Summary and Conclusions.

The hydrologic and hydraulic studies have confirmed that the watershed of Black Hawk Creek upstream of the proposed I-280 highway route has the capability to support a proposed three-lake recreational development. A total of 95 acres of public water areas can be obtained in the proposed development.

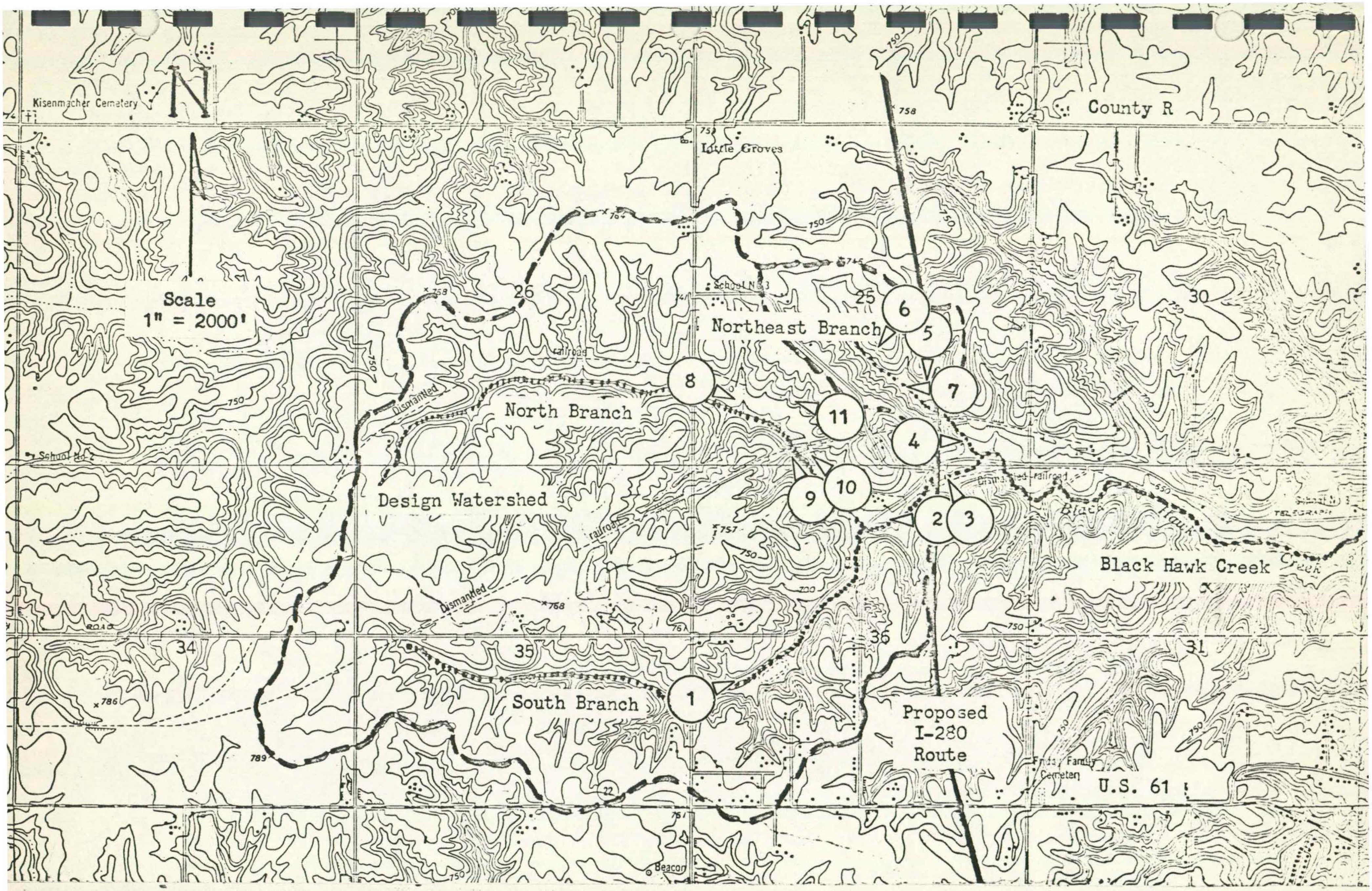
The three proposed lakes, consisting of the Northeast Lake, the Railroad Lake, and the I-280 Lake, would permit separation of various types of waterborne recreation, reducing the problems of zoning, enforcement, etc. In addition, drawdown facilities at the two upstream impoundments would permit the I-280 Lake to remain full at all times. The proposed park and lake development provides an optimum recreational area for Scott County residents, closely adjacent to a large urban area which can make full use of its facilities.

The proposed three-lake development provides additional flood control benefits by temporarily storing the flood waters as the hydraulic structures discharge the attenuated inflow. Additional consideration of potential flood control reservoirs downstream by the responsible agencies would permit a substantial amount of flood control to be realized in the Black Hawk Creek Watershed.

Economical spillway structures can be provided at the smaller impoundments, using the concepts of a principal spillway to discharge floods of normal frequency of recurrence, and providing an auxiliary spillway to prevent more rare events from overtopping the proposed dams. A concrete chute spillway, incorporating a triple barrel culvert section, is proposed to convey all flood flows through the proposed I-280 embankment. The urban developments located on the flood plain downstream of the proposed lake system makes a high hazard design necessary, requiring the relatively large size of spillway for the watershed area of less than three square miles. The proposed structure is considered to be the most economical type which will serve the assigned purposes, and would be much less expensive that a bridge structure across a standard chute spillway. Elevation limitations prevent using more reservoir storage to decrease the spillway size below the design length.

It is concluded that the proposed park and lake development can be constructed to provide adequately for the desired water-borne activities. In addition, economical spillway structures can be provided to insure that the proposed development does not constitute a hazard to the flood prone areas located on the flood plain in the Black Hawk Creek valley downstream of the proposed I-280 route. The results of the hydrology and hydraulic studies can be used for economic evaluation of the proposed development, and provide the physical information from which cost and other evaluation studies can be made.

Photographs



Map Index for Identifying Photographs

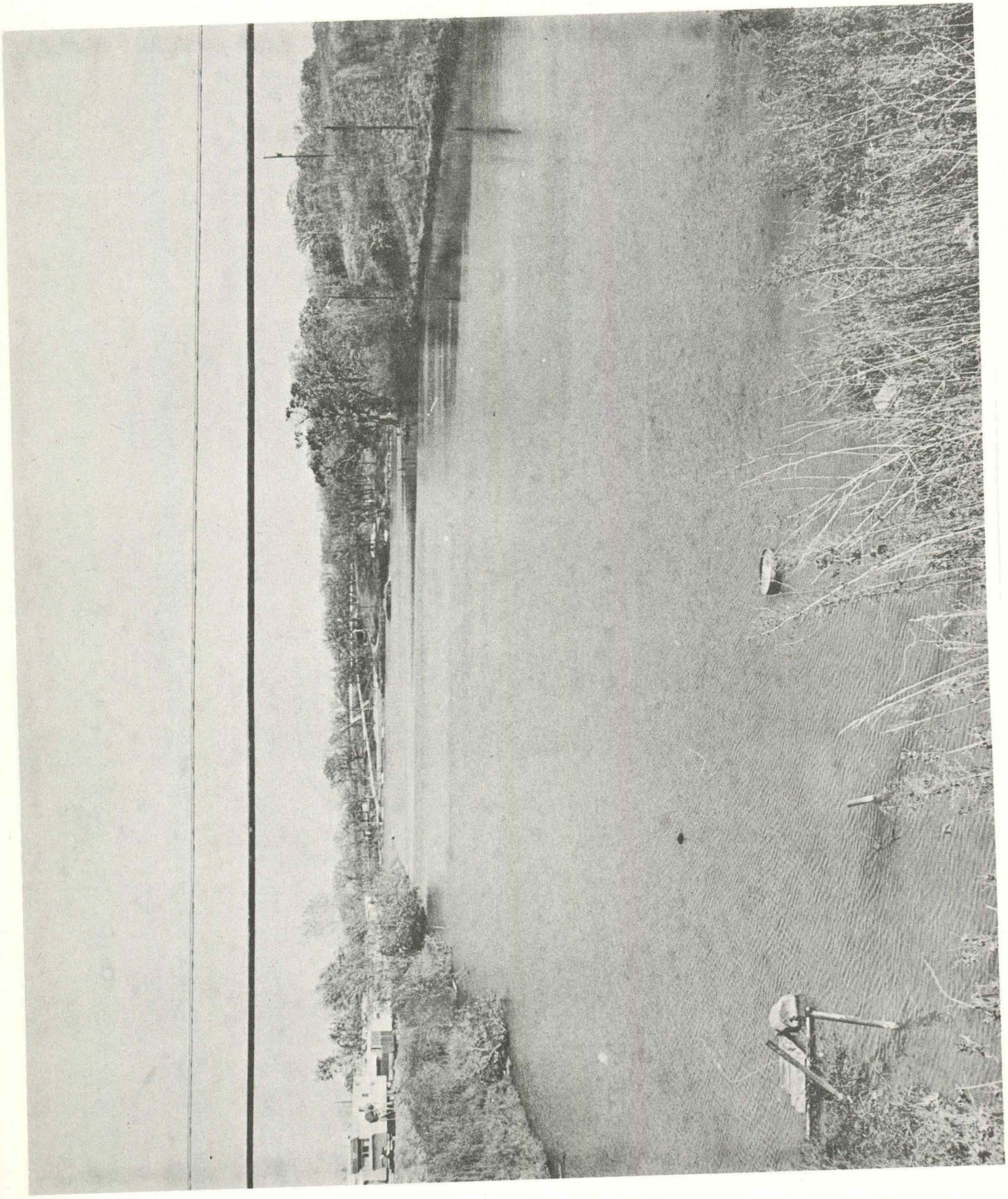


Photo No. 1. Existing Private Lake

Photo No. 2. Main impoundment area of proposed I-280 Lake.
View upstream from right abutment.

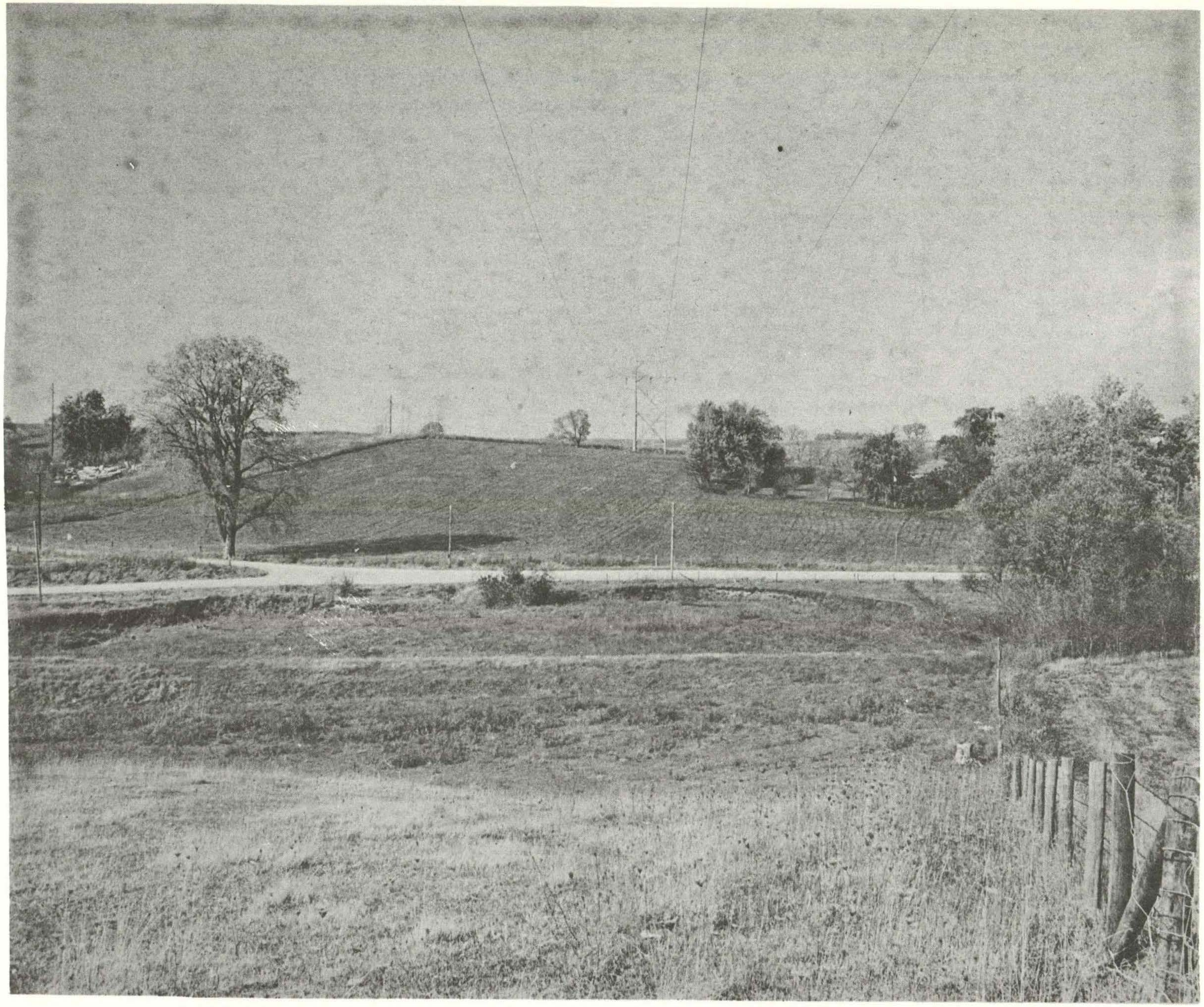


Photo No. 3. Centerline of I-280 at main embankment, I-280 Lake, looking north.

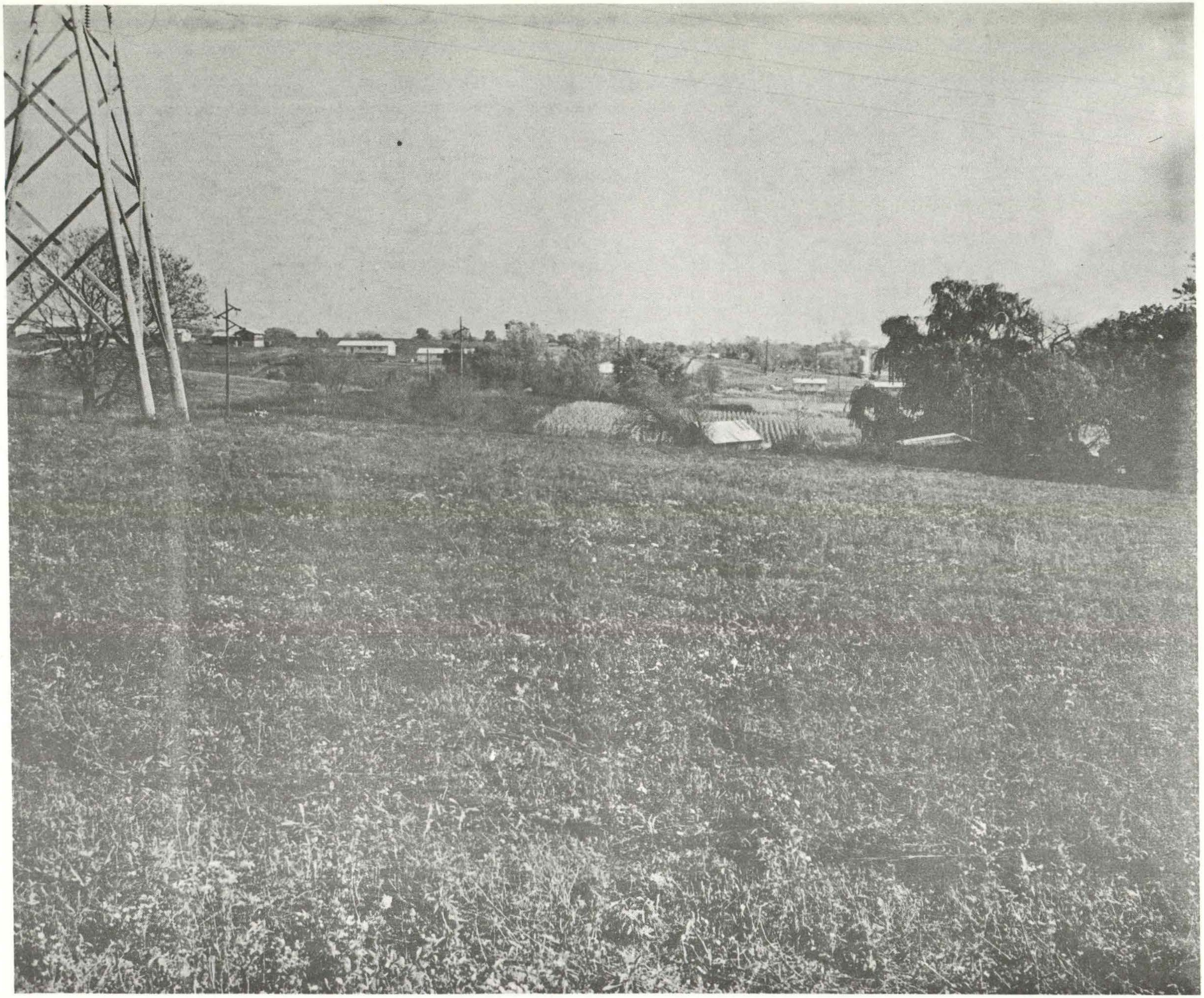


Photo No. 4. Centerline of proposed spillway, I-280 Lake, looking downstream.

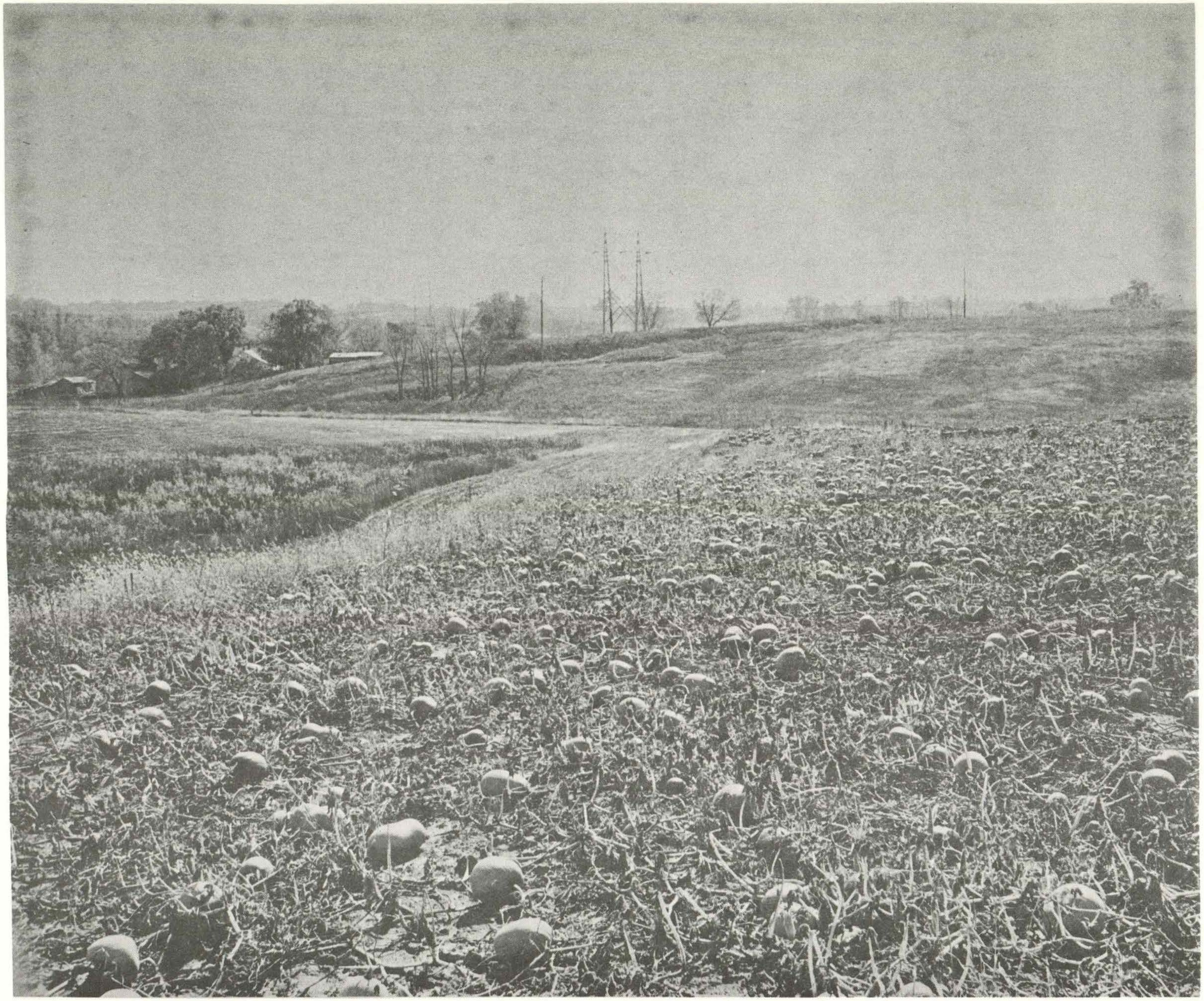


Photo No. 5. Centerline of I-280 at left abutment, Northeast Lake, looking south.

Photo No. 6. Northeast Lake impoundment area, looking south from north slope of bluff.

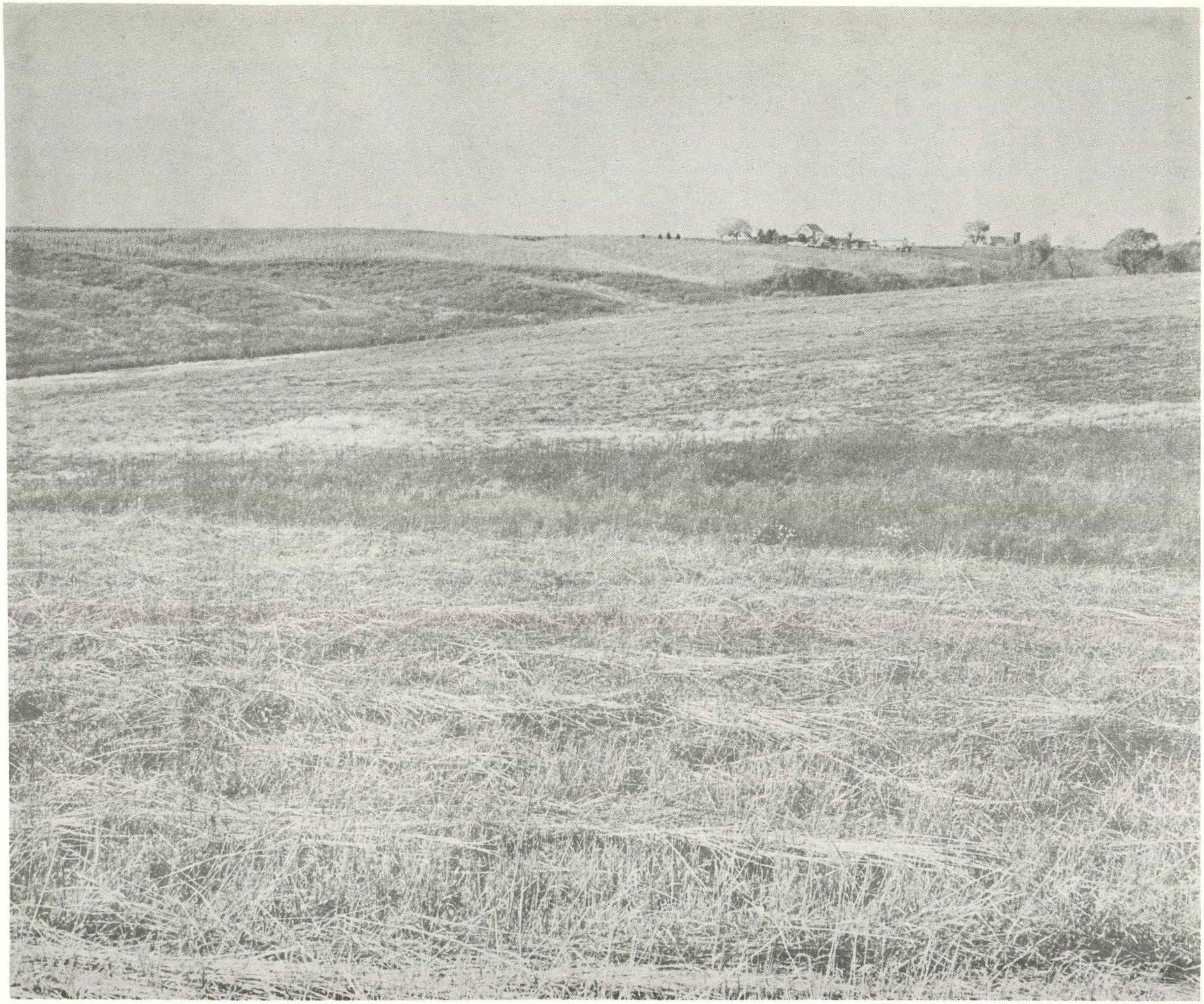


Photo No. 7. Rolling topography in watershed of Northeast Lake, at upstream end of proposed impoundment.

Photo No. 8. Railroad Lake impoundment area, looking southeast from the county road crossing.

Photo No. 9. Abandoned railroad embankment and culvert at proposed location of Railroad Lake dam.

Photo No. 10. Former underpass for second abandoned railroad, and proposed location for culvert spillway for Railroad Lake.

Photo No. 11. Proposed Railroad Lake impoundment area with county road crossing and culvert in background.

Appendix A

Computer Results of Flood Routing Studies

Part 1.

Northeast Lake Results

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,NE LAKE,50-YR. FLOOD (3.2 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
675.00	0
685.00	5
690.00	18
695.00	40
700.00	75
705.00	124
710.00	193
715.00	282

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
700.00	0
701.00	18
702.00	51
703.00	94
704.00	364
705.00	881
706.00	1615
707.00	2514
708.00	3507

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	0
0.25	1
0.50	3
0.75	6
1.00	11
1.25	18
1.50	47
1.75	123
2.00	158
2.25	119
2.50	86
2.75	66
3.00	54
3.25	47
3.50	42
3.75	37
4.00	34

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,NE LAKE,50-YR. FLOOD (3.2 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
4.25	31
4.50	29
4.75	27
5.00	25
5.50	22
6.00	20
6.50	17
7.00	15
24.00	0
100.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 701.00 FT.
CALCULATIONS END AT EITHER 20.00 HRS OR AT A ELEVATION OF 701.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,NE LAKE,50-YR. FLOOD (3.2 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	0	18	84	701.00
0.25	1	17	84	700.96
0.50	3	16	84	700.93
0.75	6	16	83	700.91
1.00	11	16	83	700.89
1.25	18	15	83	700.89
1.50	47	16	84	700.92
1.75	123	20	85	701.06
2.00	158	28	87	701.31
2.25	119	35	90	701.53
2.50	86	40	91	701.67
2.75	66	42	92	701.74
3.00	54	43	92	701.78
3.25	47	44	92	701.79
3.50	42	44	92	701.79
3.75	37	43	92	701.78
4.00	34	43	92	701.76
4.25	31	42	92	701.74
4.50	29	41	91	701.72
4.75	27	40	91	701.69
5.00	25	39	91	701.66
5.25	23	38	90	701.63
5.50	22	37	90	701.60
5.75	21	36	90	701.56
6.00	20	35	89	701.53
6.25	18	34	89	701.50
6.50	17	33	89	701.46
6.75	16	32	89	701.43
7.00	15	31	88	701.40
7.25	14	29	88	701.36
7.50	14	28	88	701.33
7.75	14	27	87	701.30
8.00	14	27	87	701.27
8.25	13	26	87	701.25
8.50	13	25	86	701.22
8.75	13	24	86	701.20
9.00	13	23	86	701.18
9.25	13	23	86	701.15
9.50	12	22	86	701.13
9.75	12	21	85	701.11
10.00	12	21	85	701.09
10.25	12	20	85	701.08
10.50	11	19	85	701.06
10.75	11	19	85	701.04
11.00	11	18	85	701.03
11.25	11	18	84	701.01
11.50	11	17	84	701.00
11.75	10	17	84	700.98

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,NE LAKE,50-YR. FLOOD (3.2 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	10	17	84	700.97
12.25	10	17	84	700.95
12.50	10	16	84	700.94
12.75	9	16	84	700.92
13.00	9	16	83	700.91
13.25	9	16	83	700.90
13.50	9	15	83	700.88
13.75	9	15	83	700.87
14.00	8	15	83	700.85
14.25	8	15	83	700.84
14.50	8	14	83	700.83
14.75	8	14	82	700.81
15.00	7	14	82	700.80
15.25	7	14	82	700.79
15.50	7	13	82	700.77
15.75	7	13	82	700.76
16.00	7	13	82	700.75
16.25	6	13	82	700.73
16.50	6	12	82	700.72
16.75	6	12	81	700.71
17.00	6	12	81	700.69
17.25	5	12	81	700.68
17.50	5	11	81	700.67
17.75	5	11	81	700.65
18.00	5	11	81	700.64
18.25	5	11	81	700.63
18.50	4	11	81	700.61
18.75	4	10	80	700.60
19.00	4	10	80	700.59
19.25	4	10	80	700.57
19.50	3	10	80	700.56
19.75	3	9	80	700.55
20.00	3	9	80	700.54

RUNOFF VOLUME = 398. CFS- HRS

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,NE LAKE,100-YR. FLOOD (3.7 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
675.00	0
685.00	5
690.00	18
695.00	40
700.00	75
705.00	124
710.00	193
715.00	282

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
700.00	0
701.00	18
702.00	51
703.00	94
704.00	364
705.00	881
706.00	1615
707.00	2514
708.00	3507

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	0
0.25	1
0.50	3
0.75	7
1.00	13
1.25	21
1.50	55
1.75	143
2.00	184
2.25	139
2.50	101
2.75	77
3.00	63
3.25	55
3.50	48
3.75	43
4.00	40

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,NE LAKE,100-YR. FLOOD (3.7 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
4.25	36
4.50	34
4.75	31
5.00	29
5.50	26
6.00	23
6.50	20
7.00	18
24.00	0
100.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 701.00 FT.
CALCULATIONS END AT EITHER 20.00 HRS OR AT A ELEVATION OF 701.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,NE LAKE,100-YR. FLOOD (3.7 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	0	18	84	701.00
0.25	1	17	84	700.96
0.50	3	16	84	700.93
0.75	7	16	83	700.91
1.00	13	16	83	700.89
1.25	21	16	83	700.90
1.50	55	16	84	700.94
1.75	143	21	85	701.11
2.00	184	31	88	701.40
2.25	139	39	91	701.66
2.50	101	45	92	701.83
2.75	77	48	93	701.92
3.00	63	49	94	701.96
3.25	55	50	94	701.98
3.50	48	50	94	701.98
3.75	43	50	94	701.97
4.00	40	49	94	701.95
4.25	36	48	93	701.93
4.50	34	47	93	701.90
4.75	31	46	93	701.87
5.00	29	45	93	701.84
5.25	27	44	92	701.80
5.50	26	43	92	701.77
5.75	24	42	91	701.73
6.00	23	40	91	701.69
6.25	21	39	91	701.65
6.50	20	38	90	701.62
6.75	19	37	90	701.58
7.00	18	35	90	701.54
7.25	17	34	89	701.50
7.50	17	33	89	701.47
7.75	17	32	89	701.44
8.00	16	31	88	701.40
8.25	16	30	88	701.37
8.50	16	29	88	701.35
8.75	16	28	87	701.32
9.00	15	27	87	701.29
9.25	15	26	87	701.27
9.50	15	26	87	701.25
9.75	15	25	87	701.22
10.00	14	24	86	701.20
10.25	14	24	86	701.18
10.50	14	23	86	701.16
10.75	14	22	86	701.14
11.00	13	22	86	701.13
11.25	13	21	85	701.11
11.50	13	21	85	701.09
11.75	12	20	85	701.08

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,NE LAKE,100-YR. FLOOD (3.7 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	12	20	85	701.06
12.25	12	19	85	701.05
12.50	12	19	85	701.03
12.75	11	18	84	701.02
13.00	11	18	84	701.00
13.25	11	17	84	700.99
13.50	11	17	84	700.98
13.75	10	17	84	700.96
14.00	10	17	84	700.95
14.25	10	16	84	700.93
14.50	10	16	84	700.92
14.75	9	16	83	700.91
15.00	9	16	83	700.89
15.25	9	15	83	700.88
15.50	9	15	83	700.87
15.75	8	15	83	700.85
16.00	8	15	83	700.84
16.25	8	14	83	700.82
16.50	7	14	82	700.81
16.75	7	14	82	700.80
17.00	7	14	82	700.78
17.25	7	13	82	700.77
17.50	6	13	82	700.75
17.75	6	13	82	700.74
18.00	6	13	82	700.73
18.25	6	12	81	700.71
18.50	5	12	81	700.70
18.75	5	12	81	700.68
19.00	5	12	81	700.67
19.25	5	11	81	700.66
19.50	4	11	81	700.64
19.75	4	11	81	700.63
20.00	4	11	80	700.61

RUNOFF VOLUME = 468. CFS- HRS

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,NE LAKE,REG. MAX. EXP. (12.7 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
675.00	0
685.00	5
690.00	18
695.00	40
700.00	75
705.00	124
710.00	193
715.00	282

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
700.00	0
701.00	18
702.00	51
703.00	94
704.00	364
705.00	881
706.00	1615
707.00	2514
708.00	3507

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	0
0.25	4
0.50	31
0.75	57
1.00	85
1.25	127
1.50	184
1.75	279
2.00	495
2.25	1060
2.50	920
2.75	580
3.00	425
3.25	326
3.50	279
3.75	232
4.00	204

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,NE LAKE,REG. MAX. EXP. (12.7 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
4.25	184
4.50	170
4.75	161
5.00	156
5.25	150
5.50	142
5.75	119
6.00	76
6.25	28
6.50	14
6.75	8
7.00	6
7.25	3
7.50	0
50.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 702.00 FT.
CALCULATIONS END AT EITHER 20.00 HRS OR AT A ELEVATION OF 701.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,NE LAKE,REG. MAX. EXP. (12.7 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	0	51	94	702.00
0.25	4	47	93	701.90
0.50	31	45	93	701.84
0.75	57	45	92	701.84
1.00	85	47	93	701.89
1.25	127	51	94	702.01
1.50	184	60	96	702.22
1.75	279	75	100	702.56
2.00	495	135	105	703.15
2.25	1060	452	115	704.17
2.50	920	831	123	704.90
2.75	580	774	121	704.79
3.00	425	582	118	704.42
3.25	326	436	115	704.14
3.50	279	350	113	703.95
3.75	232	308	112	703.79
4.00	204	268	110	703.65
4.25	184	235	109	703.52
4.50	170	209	108	703.43
4.75	161	190	107	703.36
5.00	156	176	107	703.30
5.25	150	165	107	703.27
5.50	142	157	106	703.23
5.75	119	145	106	703.19
6.00	76	124	105	703.11
6.25	28	93	104	702.99
6.50	14	87	102	702.85
6.75	8	80	101	702.69
7.00	6	74	99	702.54
7.25	3	68	98	702.40
7.50	0	62	97	702.27
7.75	0	57	95	702.14
8.00	0	52	94	702.03
8.25	0	48	93	701.92
8.50	0	45	92	701.82
8.75	0	42	91	701.73
9.00	0	39	91	701.65
9.25	0	36	90	701.57
9.50	0	34	89	701.49
9.75	0	31	88	701.42
10.00	0	29	88	701.36
10.25	0	27	87	701.30
10.50	0	25	87	701.24
10.75	0	24	86	701.19
11.00	0	22	86	701.14
11.25	0	21	85	701.09
11.50	0	19	85	701.05
11.75	0	18	84	701.01

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,NE LAKE,REG. MAX. EXP. (12.7 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	0	17	84	700.97
12.25	0	16	84	700.94
12.50	0	16	83	700.90
12.75	0	15	83	700.87
13.00	0	15	83	700.83
13.25	0	14	82	700.80
13.50	0	13	82	700.77
13.75	0	13	82	700.75
14.00	0	12	82	700.72
14.25	0	12	81	700.69
14.50	0	11	81	700.67
14.75	0	11	81	700.64
15.00	0	11	81	700.62
15.25	0	10	80	700.59
15.50	0	10	80	700.57
15.75	0	9	80	700.55
16.00	0	9	80	700.53
16.25	0	9	79	700.51
16.50	0	8	79	700.49
16.75	0	8	79	700.47
17.00	0	8	79	700.46
17.25	0	7	79	700.44
17.50	0	7	79	700.42
17.75	0	7	78	700.41
18.00	0	7	78	700.39
18.25	0	6	78	700.38
18.50	0	6	78	700.36
18.75	0	6	78	700.35
19.00	0	6	78	700.34
19.25	0	5	78	700.32
19.50	0	5	78	700.31
19.75	0	5	77	700.30
20.00	0	5	77	700.29

RUNOFF VOLUME = 1626. CFS- HRS

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,NE LAKE,PROB. MAX. (21.3 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
675.00	0
685.00	5
690.00	18
695.00	40
700.00	75
705.00	124
710.00	193
715.00	282

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
700.00	0
701.00	18
702.00	51
703.00	94
704.00	364
705.00	881
706.00	1615
707.00	2514
708.00	3507

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	0
0.25	7
0.50	52
0.75	94
1.00	141
1.25	212
1.50	306
1.75	448
2.00	825
2.25	1770
2.50	1530
2.75	990
3.00	710
3.25	540
3.50	448
3.75	386
4.00	339

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,NE LAKE,PROB. MAX. (21.3 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
4.25	306
4.50	283
4.75	269
5.00	259
5.25	250
5.50	236
5.75	198
6.00	127
6.25	47
6.50	24
6.75	14
7.00	9
7.25	5
7.50	0
50.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 702.00 FT.
CALCULATIONS END AT EITHER 20.00 HRS OR AT A ELEVATION OF 701.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,NE LAKE,PROB. MAX. (21.3 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	0	51	94	702.00
0.25	7	47	93	701.90
0.50	52	46	93	701.87
0.75	94	48	93	701.92
1.00	141	53	95	702.06
1.25	212	64	97	702.31
1.50	306	81	101	702.70
1.75	448	158	106	703.24
2.00	825	373	114	704.02
2.25	1770	1025	126	705.20
2.50	1530	1467	135	705.80
2.75	990	1320	132	705.60
3.00	710	987	125	705.14
3.25	540	731	121	704.71
3.50	448	564	117	704.39
3.75	386	460	116	704.19
4.00	339	391	114	704.05
4.25	306	350	113	703.95
4.50	283	325	112	703.86
4.75	269	303	112	703.78
5.00	259	286	111	703.71
5.25	250	272	110	703.66
5.50	236	259	110	703.61
5.75	198	240	109	703.54
6.00	127	206	108	703.41
6.25	47	153	106	703.22
6.50	24	101	104	703.03
6.75	14	88	103	702.87
7.00	9	81	101	702.71
7.25	5	75	100	702.56
7.50	0	68	98	702.42
7.75	0	62	97	702.28
8.00	0	57	96	702.15
8.25	0	52	94	702.03
8.50	0	48	93	701.93
8.75	0	45	92	701.83
9.00	0	42	92	701.74
9.25	0	39	91	701.65
9.50	0	36	90	701.57
9.75	0	34	89	701.50
10.00	0	32	88	701.43
10.25	0	29	88	701.36
10.50	0	27	87	701.30
10.75	0	26	87	701.24
11.00	0	24	86	701.19
11.25	0	22	86	701.14
11.50	0	21	85	701.09
11.75	0	19	85	701.05

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,NE LAKE,PROB. MAX. (21.3 IN. SRO)
6 FT. PRINCIPAL SPILLWAY,100 FT. EMERGENCY SPILLWAY

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	0	18	84	701.01
12.25	0	17	84	700.97
12.50	0	16	84	700.94
12.75	0	16	83	700.90
13.00	0	15	83	700.87
13.25	0	15	83	700.84
13.50	0	14	82	700.81
13.75	0	13	82	700.78
14.00	0	13	82	700.75
14.25	0	12	82	700.72
14.50	0	12	81	700.69
14.75	0	12	81	700.67
15.00	0	11	81	700.64
15.25	0	11	81	700.62
15.50	0	10	80	700.59
15.75	0	10	80	700.57
16.00	0	9	80	700.55
16.25	0	9	80	700.53
16.50	0	9	80	700.51
16.75	0	8	79	700.49
17.00	0	8	79	700.47
17.25	0	8	79	700.46
17.50	0	7	79	700.44
17.75	0	7	79	700.42
18.00	0	7	78	700.41
18.25	0	7	78	700.39
18.50	0	6	78	700.38
18.75	0	6	78	700.36
19.00	0	6	78	700.35
19.25	0	6	78	700.34
19.50	0	5	78	700.32
19.75	0	5	78	700.31
20.00	0	5	77	700.30

RUNOFF VOLUME = 2706. CFS- HRS

Appendix A

Computer Results of Flood Routing Studies

Part 2.

Railroad Lake Results

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,RR LAKE,50-YR. FLOOD (3.2-4.2 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
685.00	0
690.00	3
695.00	25
700.00	88
705.00	185
710.00	332
715.00	575
720.00	900

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
700.00	0
705.00	0
706.00	30
707.00	85
708.00	155
709.00	220
710.00	325
711.00	970
712.00	2180
713.00	3910
714.00	6050
715.00	8400

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	0
0.25	5
0.50	10
0.75	15
1.00	20
1.25	33
1.50	50
1.75	70
2.00	100
2.25	150
2.50	300
2.75	950
3.00	1105
3.25	970

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,RR LAKE,50-YR. FLOOD (3.2-4.2 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
3.50	820
3.75	765
4.00	540
4.50	370
5.00	290
5.50	245
6.00	210
7.00	170
8.00	140
9.00	118
10.00	106
11.00	94
12.00	82
13.00	70
14.00	58
15.00	41
24.00	0
100.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 706.00 FT.
CALCULATIONS END AT EITHER 32.00 HRS OR AT A ELEVATION OF 706.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,RR LAKE,50-YR. FLOOD (3.2-4.2 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	0	30	214	706.00
0.25	5	29	213	705.98
0.50	10	28	213	705.97
0.75	15	28	213	705.95
1.00	20	28	212	705.95
1.25	33	28	212	705.95
1.50	50	28	213	705.95
1.75	70	29	213	705.98
2.00	100	30	214	706.01
2.25	150	34	216	706.08
2.50	300	41	220	706.21
2.75	950	63	232	706.61
3.00	1105	104	251	707.27
3.25	970	148	270	707.91
3.50	820	182	285	708.42
3.75	765	209	297	708.84
4.00	540	235	306	709.14
4.25	455	253	312	709.32
4.50	370	265	315	709.43
4.75	330	271	316	709.49
5.00	290	273	317	709.51
5.25	267	274	317	709.52
5.50	245	272	317	709.50
5.75	227	270	316	709.48
6.00	210	266	315	709.44
6.25	200	262	314	709.40
6.50	190	257	313	709.36
6.75	180	252	311	709.31
7.00	170	246	310	709.26
7.25	162	241	308	709.20
7.50	155	235	306	709.15
7.75	147	229	305	709.09
8.00	140	223	303	709.03
8.25	134	218	301	708.97
8.50	129	214	300	708.91
8.75	123	210	298	708.85
9.00	118	206	296	708.79
9.25	115	202	294	708.73
9.50	112	198	292	708.67
9.75	109	194	291	708.61
10.00	106	190	289	708.55
10.25	103	186	287	708.49
10.50	100	183	285	708.43
10.75	97	179	284	708.37
11.00	94	175	282	708.32
11.25	91	171	280	708.26
11.50	88	168	279	708.20
11.75	85	164	277	708.15

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,RR LAKE,50-YR. FLOOD (3.2-4.2 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	82	160	275	708.09
12.25	79	157	274	708.04
12.50	76	153	272	707.98
12.75	73	149	271	707.93
13.00	70	146	269	707.87
13.25	67	142	267	707.82
13.50	64	138	266	707.77
13.75	61	135	264	707.71
14.00	58	131	263	707.66
14.25	53	127	261	707.61
14.50	49	124	260	707.56
14.75	45	120	258	707.51
15.00	41	116	257	707.45
15.25	39	113	255	707.40
15.50	38	109	254	707.35
15.75	37	106	252	707.30
16.00	36	102	251	707.25
16.25	35	99	249	707.21
16.50	34	96	248	707.16
16.75	33	93	247	707.12
17.00	31	90	246	707.08
17.25	30	87	244	707.04
17.50	29	84	243	707.00
17.75	28	82	242	706.96
18.00	27	80	241	706.92
18.25	26	78	240	706.89
18.50	25	76	239	706.85
18.75	23	74	238	706.81
19.00	22	72	237	706.78
19.25	21	70	236	706.74
19.50	20	68	235	706.71
19.75	19	67	234	706.68
20.00	18	65	233	706.64
20.25	17	63	232	706.61
20.50	15	61	231	706.58
20.75	14	59	230	706.54
21.00	13	58	229	706.51
21.25	12	56	228	706.48
21.50	11	54	227	706.45
21.75	10	53	226	706.42
22.00	9	51	225	706.39
22.25	7	49	225	706.36
22.50	6	48	224	706.33
22.75	5	46	223	706.30
23.00	4	45	222	706.27
23.25	3	43	221	706.25
23.50	2	42	220	706.22
23.75	1	40	220	706.19

FLOOD ROUTING OUTPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,RR LAKE,50-YR. FLOOD (3.2-4.2 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
24.00	0	38	219	706.16
24.25	0	37	218	706.14
24.50	0	36	217	706.11
24.75	0	34	216	706.09
25.00	0	33	216	706.06
25.25	0	32	215	706.04
25.50	0	30	214	706.02
25.75	0	29	214	706.00
26.00	0	29	213	705.97
26.25	0	28	213	705.95
26.50	0	28	212	705.93
26.75	0	27	211	705.92
27.00	0	26	211	705.90
27.25	0	26	210	705.88
27.50	0	25	210	705.86
27.75	0	25	209	705.84
28.00	0	24	209	705.82
28.25	0	24	208	705.81
28.50	0	23	208	705.79
28.75	0	23	207	705.77
29.00	0	22	207	705.76
29.25	0	22	206	705.74
29.50	0	21	206	705.73
29.75	0	21	205	705.71
30.00	0	20	205	705.70
30.25	0	20	205	705.68
30.50	0	20	204	705.67
30.75	0	19	204	705.65
31.00	0	19	203	705.64
31.25	0	18	203	705.63
31.50	0	18	203	705.61
31.75	0	18	202	705.60
32.00	0	17	202	705.59

RUNOFF VOLUME = 3196. CFS- HRS

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,RR LAKE,100-YR. FLOOD (3.7-4.8 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
685.00	0
690.00	3
695.00	25
700.00	88
705.00	185
710.00	332
715.00	575
720.00	900

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
700.00	0
705.00	0
706.00	30
707.00	85
708.00	155
709.00	220
710.00	325
711.00	970
712.00	2180
713.00	3910
714.00	6050
715.00	8400

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	0
0.25	6
0.50	12
0.75	18
1.00	23
1.25	39
1.50	58
1.75	82
2.00	115
2.25	175
2.50	350
2.75	1110
3.00	1290
3.25	1130

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,RR LAKE,100-YR. FLOOD (3.7-4.8 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
3.50	960
3.75	890
4.00	630
4.50	430
5.00	340
5.50	285
6.00	245
7.00	200
8.00	160
9.00	138
10.00	124
11.00	110
12.00	95
13.00	82
14.00	68
15.00	48
24.00	0
100.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 706.00 FT.
CALCULATIONS END AT EITHER 32.00 HRS OR AT A ELEVATION OF 706.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,RR LAKE,100-YR. FLOOD (3.7-4.8 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	0	30	214	706.00
0.25	6	29	213	705.98
0.50	12	29	213	705.97
0.75	18	28	213	705.96
1.00	23	28	212	705.95
1.25	39	28	213	705.95
1.50	58	29	213	705.97
1.75	82	29	214	706.00
2.00	115	32	215	706.04
2.25	175	36	217	706.12
2.50	350	45	222	706.28
2.75	1110	71	236	706.75
3.00	1290	121	259	707.52
3.25	1130	172	281	708.27
3.50	960	211	298	708.87
3.75	890	256	312	709.35
4.00	630	292	322	709.69
4.25	530	312	328	709.89
4.50	430	324	331	710.00
4.75	385	344	333	710.03
5.00	340	348	333	710.04
5.25	312	343	333	710.03
5.50	285	332	332	710.01
5.75	265	323	331	709.98
6.00	245	318	330	709.94
6.25	233	312	328	709.88
6.50	222	306	326	709.83
6.75	211	300	325	709.76
7.00	200	293	323	709.70
7.25	190	286	321	709.63
7.50	180	279	319	709.57
7.75	170	271	317	709.49
8.00	160	264	315	709.42
8.25	154	256	312	709.35
8.50	149	249	310	709.28
8.75	143	241	308	709.21
9.00	138	234	306	709.14
9.25	134	227	304	709.07
9.50	131	221	302	709.01
9.75	127	216	301	708.95
10.00	124	212	299	708.88
10.25	120	208	297	708.82
10.50	117	204	295	708.76
10.75	113	200	293	708.70
11.00	110	196	291	708.64
11.25	106	192	290	708.58
11.50	102	188	288	708.52
11.75	98	184	286	708.46

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,RR LAKE,100-YR. FLOOD (3.7-4.8 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	95	180	284	708.40
12.25	91	176	283	708.34
12.50	88	173	281	708.28
12.75	85	169	279	708.22
13.00	82	165	277	708.16
13.25	78	161	276	708.10
13.50	75	157	274	708.04
13.75	71	153	272	707.99
14.00	68	149	271	707.93
14.25	63	145	269	707.87
14.50	58	141	267	707.81
14.75	53	137	265	707.75
15.00	48	133	264	707.69
15.25	46	129	262	707.63
15.50	45	125	260	707.58
15.75	44	121	259	707.52
16.00	42	117	257	707.47
16.25	41	114	256	707.42
16.50	40	110	254	707.37
16.75	38	107	253	707.32
17.00	37	103	251	707.27
17.25	36	100	250	707.22
17.50	34	97	249	707.18
17.75	33	94	247	707.14
18.00	32	91	246	707.09
18.25	30	88	245	707.05
18.50	29	85	244	707.01
18.75	28	83	242	706.97
19.00	26	81	241	706.93
19.25	25	79	240	706.90
19.50	24	77	239	706.86
19.75	22	75	238	706.82
20.00	21	73	237	706.78
20.25	20	71	236	706.75
20.50	18	69	235	706.71
20.75	17	67	234	706.68
21.00	16	65	233	706.64
21.25	14	63	232	706.61
21.50	13	61	231	706.57
21.75	12	59	230	706.54
22.00	10	57	229	706.51
22.25	9	56	228	706.47
22.50	8	54	227	706.44
22.75	6	52	226	706.41
23.00	5	50	225	706.38
23.25	4	49	224	706.35
23.50	2	47	223	706.31
23.75	1	45	222	706.28

FLOOD ROUTING OUTPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,RR LAKE,100-YR. FLOOD (3.7-4.8 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
24.00	0	43	221	706.25
24.25	0	42	220	706.22
24.50	0	40	220	706.19
24.75	0	39	219	706.16
25.00	0	37	218	706.14
25.25	0	36	217	706.11
25.50	0	34	216	706.09
25.75	0	33	216	706.06
26.00	0	32	215	706.04
26.25	0	30	214	706.02
26.50	0	29	214	706.00
26.75	0	29	213	705.98
27.00	0	28	213	705.96
27.25	0	28	212	705.94
27.50	0	27	211	705.92
27.75	0	26	211	705.90
28.00	0	26	210	705.88
28.25	0	25	210	705.86
28.50	0	25	209	705.84
28.75	0	24	209	705.82
29.00	0	24	208	705.81
29.25	0	23	208	705.79
29.50	0	23	207	705.77
29.75	0	22	207	705.76
30.00	0	22	206	705.74
30.25	0	21	206	705.73
30.50	0	21	205	705.71
30.75	0	20	205	705.70
31.00	0	20	205	705.68
31.25	0	20	204	705.67
31.50	0	19	204	705.65
31.75	0	19	203	705.64
32.00	0	18	203	705.63

RUNOFF VOLUME = 3729. CFS- HRS

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,RR LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
685.00	0
690.00	3
695.00	25
700.00	88
705.00	185
710.00	332
715.00	575
720.00	900

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
700.00	0
705.00	0
706.00	30
707.00	85
708.00	155
709.00	220
710.00	325
711.00	970
712.00	2180
713.00	3910
714.00	6050
715.00	8400

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	0
0.25	3
0.50	6
0.75	24
1.00	90
1.25	220
1.50	350
1.75	540
2.00	805
2.25	1190
2.50	2010
2.75	3900
3.00	5040
3.25	5130

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,RR LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
3.50	4290
3.75	3320
4.00	2610
4.25	2130
4.50	1760
4.75	1500
5.00	1320
5.25	1170
5.50	1080
5.75	1010
6.00	970
6.25	895
6.50	770
6.75	570
7.00	380
7.25	200
7.50	100
7.75	50
8.00	30
8.50	25
9.00	18
9.50	12
10.00	6
10.50	0
100.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 707.00 FT.
CALCULATIONS END AT EITHER 32.00 HRS OR AT A ELEVATION OF 706.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,RR LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	0	85	243	707.00
0.25	3	81	242	706.94
0.50	6	78	240	706.89
0.75	24	76	239	706.85
1.00	90	75	238	706.83
1.25	220	78	240	706.89
1.50	350	86	244	707.03
1.75	540	104	251	707.27
2.00	805	131	263	707.66
2.25	1190	171	280	708.26
2.50	2010	244	309	709.23
2.75	3900	704	360	710.59
3.00	5040	2058	424	711.90
3.25	5130	3645	470	712.85
3.50	4290	4267	485	713.17
3.75	3320	3978	479	713.03
4.00	2610	3424	464	712.72
4.25	2130	2858	448	712.39
4.50	1760	2367	434	712.11
4.75	1500	2021	422	711.87
5.00	1320	1771	412	711.66
5.25	1170	1556	404	711.48
5.50	1080	1380	397	711.34
5.75	1010	1243	391	711.23
6.00	970	1139	387	711.14
6.25	895	1055	384	711.07
6.50	770	966	380	710.99
6.75	570	895	374	710.88
7.00	380	793	367	710.73
7.25	200	672	358	710.54
7.50	100	546	348	710.34
7.75	50	433	340	710.17
8.00	30	338	333	710.02
8.25	27	306	326	709.83
8.50	25	287	321	709.64
8.75	21	268	316	709.46
9.00	18	250	311	709.29
9.25	15	234	306	709.13
9.50	12	218	302	708.98
9.75	9	209	297	708.84
10.00	6	200	293	708.70
10.25	3	191	289	708.57
10.50	0	183	286	708.44
10.75	0	175	282	708.31
11.00	0	167	278	708.19
11.25	0	159	275	708.08
11.50	0	152	272	707.97
11.75	0	145	269	707.86

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,RR LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	0	138	266	707.76
12.25	0	131	263	707.67
12.50	0	125	260	707.58
12.75	0	119	258	707.49
13.00	0	113	255	707.41
13.25	0	108	253	707.33
13.50	0	103	251	707.26
13.75	0	98	249	707.19
14.00	0	93	247	707.12
14.25	0	88	245	707.06
14.50	0	84	243	707.00
14.75	0	81	241	706.94
15.00	0	78	240	706.88
15.25	0	75	238	706.83
15.50	0	72	237	706.77
15.75	0	69	235	706.72
16.00	0	67	234	706.68
16.25	0	64	232	706.63
16.50	0	62	231	706.59
16.75	0	59	230	706.54
17.00	0	57	229	706.50
17.25	0	55	227	706.46
17.50	0	53	226	706.42
17.75	0	51	225	706.39
18.00	0	49	224	706.35
18.25	0	47	223	706.32
18.50	0	45	222	706.29
18.75	0	43	221	706.25
19.00	0	42	220	706.22
19.25	0	40	220	706.19
19.50	0	39	219	706.17
19.75	0	37	218	706.14
20.00	0	36	217	706.11
20.25	0	34	217	706.09
20.50	0	33	216	706.06
20.75	0	32	215	706.04
21.00	0	31	214	706.02
21.25	0	29	214	706.00
21.50	0	29	213	705.98
21.75	0	28	213	705.96
22.00	0	28	212	705.94
22.25	0	27	211	705.92
22.50	0	26	211	705.90
22.75	0	26	210	705.88
23.00	0	25	210	705.86
23.25	0	25	209	705.84
23.50	0	24	209	705.83
23.75	0	24	208	705.81

FLOOD ROUTING OUTPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,RR LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
24.00	0	23	208	705.79
24.25	0	23	207	705.78
24.50	0	22	207	705.76
24.75	0	22	206	705.74
25.00	0	21	206	705.73
25.25	0	21	205	705.71
25.50	0	20	205	705.70
25.75	0	20	205	705.68
26.00	0	20	204	705.67
26.25	0	19	204	705.66
26.50	0	19	203	705.64
26.75	0	18	203	705.63
27.00	0	18	203	705.61
27.25	0	18	202	705.60
27.50	0	17	202	705.59
27.75	0	17	201	705.58
28.00	0	16	201	705.57
28.25	0	16	201	705.55
28.50	0	16	200	705.54
28.75	0	15	200	705.53
29.00	0	15	200	705.52
29.25	0	15	199	705.51
29.50	0	14	199	705.50
29.75	0	14	199	705.49
30.00	0	14	199	705.48
30.25	0	14	198	705.47
30.50	0	13	198	705.46
30.75	0	13	198	705.45
31.00	0	13	197	705.44
31.25	0	12	197	705.43
31.50	0	12	197	705.42
31.75	0	12	197	705.41
32.00	0	12	196	705.40

RUNOFF VOLUME =10900. CFS- HRS

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,RR LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
685.00	0
690.00	3
695.00	25
700.00	88
705.00	185
710.00	332
715.00	575
720.00	900

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
700.00	0
705.00	0
706.00	30
707.00	85
708.00	155
709.00	220
710.00	325
711.00	970
712.00	2180
713.00	3910
714.00	6050
715.00	8400

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	0
0.25	5
0.50	10
0.75	40
1.00	150
1.25	370
1.50	580
1.75	900
2.00	1340
2.25	1990
2.50	3350
2.75	6400
3.00	8400
3.25	8550

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,RR LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
3.50	7150
3.75	5520
4.00	4350
4.25	3550
4.50	2940
4.75	2510
5.00	2210
5.25	1960
5.50	1800
5.75	1690
6.00	1620
6.25	1490
6.50	1280
6.75	950
7.00	630
7.25	340
7.50	170
7.75	85
8.00	50
8.50	40
9.00	30
9.50	20
10.00	10
10.50	0
100.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 707.00 FT.
CALCULATIONS END AT EITHER 32.00 HRS OR AT A ELEVATION OF 706.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,RR LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	0	85	243	707.00
0.25	5	81	242	706.94
0.50	10	79	240	706.89
0.75	40	77	239	706.85
1.00	150	77	239	706.87
1.25	370	84	243	706.99
1.50	580	103	251	707.26
1.75	900	133	264	707.70
2.00	1340	179	284	708.37
2.25	1990	260	313	709.39
2.50	3350	686	359	710.56
2.75	6400	2206	429	712.02
3.00	8400	5172	506	713.59
3.25	8550	7312	552	714.54
3.50	7150	7670	559	714.69
3.75	5520	6781	541	714.31
4.00	4350	5583	515	713.78
4.25	3550	4563	492	713.31
4.50	2940	3763	473	712.92
4.75	2510	3205	458	712.59
5.00	2210	2751	445	712.33
5.25	1960	2393	435	712.12
5.50	1800	2132	427	711.96
5.75	1690	1974	420	711.83
6.00	1620	1843	415	711.72
6.25	1490	1725	410	711.62
6.50	1280	1586	405	711.51
6.75	950	1393	397	711.35
7.00	630	1147	387	711.15
7.25	340	914	376	710.91
7.50	170	756	364	710.67
7.75	85	604	353	710.43
8.00	50	475	343	710.23
8.25	45	372	335	710.07
8.50	40	315	329	709.91
8.75	35	295	323	709.72
9.00	30	277	318	709.54
9.25	25	259	313	709.37
9.50	20	242	308	709.21
9.75	15	226	304	709.06
10.00	10	214	300	708.92
10.25	5	205	295	708.77
10.50	0	196	291	708.64
10.75	0	187	287	708.50
11.00	0	179	284	708.37
11.25	0	171	280	708.25
11.50	0	163	277	708.13
11.75	0	156	273	708.02

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,RR LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	0	148	270	707.91
12.25	0	141	267	707.81
12.50	0	134	264	707.71
12.75	0	128	262	707.62
13.00	0	122	259	707.53
13.25	0	116	257	707.45
13.50	0	110	254	707.37
13.75	0	105	252	707.29
14.00	0	100	250	707.22
14.25	0	95	248	707.15
14.50	0	91	246	707.09
14.75	0	86	244	707.02
15.00	0	83	242	706.97
15.25	0	79	241	706.91
15.50	0	76	239	706.85
15.75	0	73	237	706.80
16.00	0	71	236	706.75
16.25	0	68	234	706.70
16.50	0	65	233	706.65
16.75	0	63	232	706.61
17.00	0	61	230	706.56
17.25	0	58	229	706.52
17.50	0	56	228	706.48
17.75	0	54	227	706.44
18.00	0	52	226	706.41
18.25	0	50	225	706.37
18.50	0	48	224	706.33
18.75	0	46	223	706.30
19.00	0	44	222	706.27
19.25	0	43	221	706.24
19.50	0	41	220	706.21
19.75	0	39	219	706.18
20.00	0	38	218	706.15
20.25	0	36	218	706.13
20.50	0	35	217	706.10
20.75	0	34	216	706.08
21.00	0	32	215	706.05
21.25	0	31	215	706.03
21.50	0	30	214	706.01
21.75	0	29	214	705.99
22.00	0	29	213	705.97
22.25	0	28	212	705.95
22.50	0	27	212	705.93
22.75	0	27	211	705.91
23.00	0	26	211	705.89
23.25	0	26	210	705.87
23.50	0	25	210	705.85
23.75	0	25	209	705.83

FLOOD ROUTING OUTPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,RR LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
TWIN 5X5 CULVERT SPLWY. W/ 250 FT. EMERG. SPLWY.

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
24.00	0	24	209	705.82
24.25	0	23	208	705.80
24.50	0	23	208	705.78
24.75	0	23	207	705.77
25.00	0	22	207	705.75
25.25	0	22	206	705.74
25.50	0	21	206	705.72
25.75	0	21	205	705.70
26.00	0	20	205	705.69
26.25	0	20	204	705.68
26.50	0	19	204	705.66
26.75	0	19	204	705.65
27.00	0	19	203	705.63
27.25	0	18	203	705.62
27.50	0	18	202	705.61
27.75	0	17	202	705.60
28.00	0	17	202	705.58
28.25	0	17	201	705.57
28.50	0	16	201	705.56
28.75	0	16	201	705.55
29.00	0	16	200	705.54
29.25	0	15	200	705.52
29.50	0	15	200	705.51
29.75	0	15	199	705.50
30.00	0	14	199	705.49
30.25	0	14	199	705.48
30.50	0	14	198	705.47
30.75	0	13	198	705.46
31.00	0	13	198	705.45
31.25	0	13	198	705.44
31.50	0	13	197	705.43
31.75	0	12	197	705.43
32.00	0	12	197	705.42

RUNOFF VOLUME =18151. CFS- HRS

Appendix A

Computer Results of Flood Routing Studies

Part 3.

I-280 Lake Results

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,MAIN LAKE,50-YR FLOOD (3.2-4.2 IN. SRO)
50 FT. SPILLWAY CREST

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
665.00	0
670.00	5
675.00	35
680.00	105
685.00	229
690.00	416
695.00	661
700.00	965
705.00	1449
710.00	1946

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
695.00	0
696.00	160
697.00	465
698.00	885
699.00	1400
700.00	2010
701.00	2700
702.00	3470
703.00	4310
704.00	5210
705.00	6200
706.00	7260
707.00	8450
710.00	12200

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	50
0.25	48
0.50	48
0.75	47
1.00	47
1.25	51
1.50	56
1.75	56
2.00	105
2.25	200

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,MAIN LAKE,50-YR FLOOD (3.2-4.2 IN. SRO)
50 FT. SPILLWAY CREST

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
2.50	258
2.75	251
3.00	277
3.25	447
3.50	671
3.75	904
4.00	999
4.25	988
4.50	962
4.75	897
5.00	817
5.25	750
5.50	700
5.75	659
6.00	624
6.25	589
6.50	563
6.75	532
7.00	507
7.25	486
7.50	465
7.75	446
8.00	428
8.25	413
8.50	397
8.75	389
9.00	372
9.50	353
10.00	335
10.50	318
11.00	305
11.50	292
12.00	281
14.00	158
16.00	127
18.00	100
20.00	84
24.00	52
30.00	26
36.00	9

FLOOD ROUTING INPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,MAIN LAKE,50-YR FLOOD (3.2-4.2 IN. SRO)
50 FT. SPILLWAY CREST

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
42.00	0
100.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 696.00 FT.
CALCULATIONS END AT EITHER 32.00 HRS OR AT A ELEVATION OF 696.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,MAIN LAKE,50-YR FLOOD (3.2-4.2 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	50	160	721	696.00
0.25	48	154	719	695.96
0.50	48	148	717	695.93
0.75	47	143	715	695.89
1.00	47	138	713	695.86
1.25	51	133	711	695.83
1.50	56	129	710	695.81
1.75	56	125	708	695.78
2.00	105	122	707	695.77
2.25	200	124	708	695.78
2.50	258	130	710	695.81
2.75	251	136	712	695.85
3.00	277	143	715	695.90
3.25	447	154	719	695.97
3.50	671	190	727	696.10
3.75	904	248	739	696.29
4.00	999	318	753	696.52
4.25	988	384	766	696.74
4.50	962	442	778	696.93
4.75	897	499	787	697.08
5.00	817	547	794	697.20
5.25	750	578	799	697.27
5.50	700	597	801	697.32
5.75	659	608	803	697.34
6.00	624	613	804	697.35
6.25	589	612	803	697.35
6.50	563	607	803	697.34
6.75	532	599	802	697.32
7.00	507	588	800	697.29
7.25	486	576	798	697.27
7.50	465	563	796	697.23
7.75	446	548	794	697.20
8.00	428	533	792	697.16
8.25	413	518	790	697.13
8.50	397	503	788	697.09
8.75	389	488	786	697.06
9.00	372	474	783	697.02
9.25	362	461	781	696.99
9.50	353	451	779	696.95
9.75	344	441	777	696.92
10.00	335	431	775	696.89
10.25	326	421	773	696.86
10.50	318	411	771	696.82
10.75	311	402	770	696.79
11.00	305	392	768	696.76
11.25	298	383	766	696.73
11.50	292	375	764	696.71
11.75	286	366	762	696.68

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,MAIN LAKE,50-YR FLOOD (3.2-4.2 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	281	358	761	696.65
12.25	265	350	759	696.62
12.50	250	341	757	696.59
12.75	234	331	755	696.56
13.00	219	321	753	696.53
13.25	204	310	751	696.49
13.50	188	299	749	696.46
13.75	173	287	747	696.42
14.00	158	275	744	696.38
14.25	154	263	742	696.34
14.50	150	252	740	696.30
14.75	146	242	738	696.27
15.00	142	232	736	696.24
15.25	138	223	734	696.21
15.50	134	215	732	696.18
15.75	130	207	731	696.15
16.00	127	199	729	696.13
16.25	123	192	728	696.11
16.50	120	185	726	696.08
16.75	116	178	725	696.06
17.00	113	172	724	696.04
17.25	110	166	723	696.02
17.50	106	160	721	696.00
17.75	103	157	720	695.98
18.00	100	154	719	695.97
18.25	98	151	718	695.95
18.50	96	148	717	695.93
18.75	94	145	716	695.91
19.00	92	143	715	695.89
19.25	90	140	714	695.88
19.50	88	137	713	695.86
19.75	86	134	712	695.84
20.00	84	132	711	695.83
20.25	82	129	710	695.81
20.50	80	127	709	695.79
20.75	78	124	708	695.78
21.00	76	122	707	695.76
21.25	74	119	706	695.75
21.50	72	117	705	695.73
21.75	70	114	704	695.72
22.00	68	112	703	695.70
22.25	66	109	702	695.69
22.50	64	107	701	695.67
22.75	62	105	700	695.66
23.00	60	102	700	695.64
23.25	58	100	699	695.63
23.50	56	98	698	695.61
23.75	54	95	697	695.60

FLOOD ROUTING OUTPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,MAIN LAKE,50-YR FLOOD (3.2-4.2 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
24.00	52	93	696	695.59
24.25	50	91	695	695.57
24.50	49	89	694	695.56
24.75	48	87	694	695.54
25.00	47	85	693	695.53
25.25	46	83	692	695.52
25.50	45	81	691	695.51
25.75	44	79	691	695.49
26.00	43	77	690	695.48
26.25	42	75	689	695.47
26.50	41	73	688	695.46
26.75	40	71	688	695.45
27.00	39	70	687	695.44
27.25	37	68	687	695.43
27.50	36	66	686	695.42
27.75	35	65	685	695.41
28.00	34	63	685	695.40
28.25	33	62	684	695.39
28.50	32	60	684	695.38
28.75	31	59	683	695.37
29.00	30	57	682	695.36
29.25	29	56	682	695.35
29.50	28	54	681	695.34
29.75	27	53	681	695.33
30.00	26	51	680	695.32
30.25	25	50	680	695.32
30.50	24	49	679	695.31
30.75	23	47	679	695.30
31.00	23	46	678	695.29
31.25	22	45	678	695.28
31.50	21	44	677	695.27
31.75	21	42	677	695.27
32.00	20	41	676	695.26

RUNOFF VOLUME = 6727. CFS- HRS

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,MAIN LAKE,100-YR FLOOD (3.7-4.8 IN. SRO)
50 FT. SPILLWAY CREST

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
665.00	0
670.00	5
675.00	35
680.00	105
685.00	229
690.00	416
695.00	661
700.00	965
705.00	1449
710.00	1946

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
695.00	0
696.00	160
697.00	465
698.00	885
699.00	1400
700.00	2010
701.00	2700
702.00	3470
703.00	4310
704.00	5210
705.00	6200
706.00	7260
707.00	8450
710.00	12200

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	50
0.25	48
0.50	48
0.75	47
1.00	48
1.25	52
1.50	58
1.75	70
2.00	115
2.25	215

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,MAIN LAKE,100-YR FLOOD (3.7-4.8 IN. SRO)
50 FT. SPILLWAY CREST

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
2.50	293
2.75	284
3.00	315
3.25	512
3.50	775
3.75	1043
4.00	1106
4.25	1156
4.50	1132
4.75	1057
5.00	962
5.25	898
5.50	841
5.75	788
6.00	739
6.25	692
6.50	655
6.75	622
7.00	591
7.25	567
7.50	542
7.75	518
8.00	498
8.25	479
8.50	461
8.75	443
9.00	427
9.50	400
10.00	376
10.50	356
11.00	342
11.50	329
12.00	316
14.00	178
16.00	144
18.00	114
20.00	92
24.00	58
30.00	26
36.00	10

FLOOD ROUTING INPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,MAIN LAKE,100-YR FLOOD (3.7-4.8 IN. SRO)
50 FT. SPILLWAY CREST

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
42.00	0
100.00	0

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 696.00 FT.
CALCULATIONS END AT EITHER 32.00 HRS OR AT A ELEVATION OF 696.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,MAIN LAKE,100-YR FLOOD (3.7-4.8 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	50	160	721	696.00
0.25	48	154	719	695.96
0.50	48	148	717	695.93
0.75	47	143	715	695.89
1.00	48	138	713	695.86
1.25	52	133	711	695.83
1.50	58	129	710	695.81
1.75	70	125	708	695.79
2.00	115	124	708	695.78
2.25	215	126	708	695.79
2.50	293	133	711	695.83
2.75	284	141	714	695.88
3.00	315	149	717	695.93
3.25	512	166	723	696.02
3.50	775	213	732	696.18
3.75	1043	281	746	696.40
4.00	1106	359	761	696.66
4.25	1156	435	776	696.90
4.50	1132	519	790	697.13
4.75	1057	596	801	697.31
5.00	962	651	809	697.44
5.25	898	688	814	697.53
5.50	841	712	818	697.59
5.75	788	725	820	697.62
6.00	739	730	821	697.63
6.25	692	728	820	697.63
6.50	655	721	819	697.61
6.75	622	710	818	697.58
7.00	591	696	816	697.55
7.25	567	680	813	697.51
7.50	542	664	811	697.47
7.75	518	646	808	697.43
8.00	498	627	806	697.39
8.25	479	609	803	697.34
8.50	461	590	800	697.30
8.75	443	572	798	697.26
9.00	427	554	795	697.21
9.25	413	536	792	697.17
9.50	400	519	790	697.13
9.75	388	502	788	697.09
10.00	376	486	785	697.05
10.25	366	471	783	697.01
10.50	356	458	781	696.98
10.75	349	448	779	696.94
11.00	342	438	777	696.91
11.25	335	428	775	696.88
11.50	329	418	773	696.85
11.75	322	409	771	696.82

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,MAIN LAKE,100-YR FLOOD (3.7-4.8 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	316	400	769	696.79
12.25	298	391	767	696.76
12.50	281	381	765	696.73
12.75	264	370	763	696.69
13.00	247	359	761	696.65
13.25	229	347	759	696.62
13.50	212	335	756	696.57
13.75	195	322	754	696.53
14.00	178	308	751	696.49
14.25	173	295	748	696.45
14.50	169	283	746	696.41
14.75	165	272	744	696.37
15.00	161	261	742	696.33
15.25	156	251	739	696.30
15.50	152	241	738	696.27
15.75	148	232	736	696.24
16.00	144	224	734	696.21
16.25	140	216	733	696.18
16.50	136	208	731	696.16
16.75	132	201	730	696.14
17.00	129	194	728	696.11
17.25	125	187	727	696.09
17.50	121	181	726	696.07
17.75	117	175	724	696.05
18.00	114	169	723	696.03
18.25	111	163	722	696.01
18.50	108	159	721	696.00
18.75	105	156	720	695.98
19.00	103	153	719	695.96
19.25	100	150	718	695.94
19.50	97	148	717	695.93
19.75	94	145	716	695.91
20.00	92	142	715	695.89
20.25	89	139	714	695.87
20.50	87	137	713	695.86
20.75	85	134	712	695.84
21.00	83	131	711	695.82
21.25	81	129	710	695.81
21.50	79	126	709	695.79
21.75	77	124	708	695.78
22.00	75	121	707	695.76
22.25	72	119	706	695.74
22.50	70	116	705	695.73
22.75	68	114	704	695.71
23.00	66	111	703	695.70
23.25	64	109	702	695.68
23.50	62	106	701	695.67
23.75	60	104	700	695.65

FLOOD ROUTING OUTPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,MAIN LAKE,100-YR FLOOD (3.7-4.8 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
24.00	58	101	699	695.64
24.25	56	99	698	695.62
24.50	55	97	697	695.61
24.75	54	95	697	695.59
25.00	52	92	696	695.58
25.25	51	90	695	695.57
25.50	50	88	694	695.55
25.75	48	86	693	695.54
26.00	47	84	693	695.53
26.25	46	82	692	695.52
26.50	44	80	691	695.50
26.75	43	78	690	695.49
27.00	42	76	690	695.48
27.25	40	74	689	695.47
27.50	39	72	688	695.46
27.75	38	71	688	695.44
28.00	36	69	687	695.43
28.25	35	67	686	695.42
28.50	34	65	686	695.41
28.75	32	64	685	695.40
29.00	31	62	684	695.39
29.25	30	60	684	695.38
29.50	28	59	683	695.37
29.75	27	57	682	695.36
30.00	26	55	682	695.35
30.25	25	54	681	695.34
30.50	24	52	681	695.33
30.75	24	51	680	695.32
31.00	23	49	679	695.31
31.25	22	48	679	695.30
31.50	22	46	678	695.29
31.75	21	45	678	695.28
32.00	20	44	677	695.28

RUNOFF VOLUME = 7696. CFS- HRS

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,MAIN LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
50 FT. SPILLWAY CREST

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
665.00	0
670.00	5
675.00	35
680.00	105
685.00	229
690.00	416
695.00	661
700.00	965
705.00	1449
710.00	1946

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
695.00	0
696.00	160
697.00	465
698.00	885
699.00	1400
700.00	2010
701.00	2700
702.00	3470
703.00	4310
704.00	5210
705.00	6200
706.00	7260
707.00	8450
710.00	12200

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	85
0.25	90
0.50	144
0.75	196
1.00	267
1.25	390
1.50	566
1.75	848
2.00	1481
2.25	2889

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,MAIN LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
50 FT. SPILLWAY CREST

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
2.50	2926
2.75	3134
3.00	4908
3.25	7095
3.50	8137
3.75	8070
4.00	7096
4.25	5948
4.50	4977
4.75	4283
5.00	3757
5.25	3314
5.50	2958
5.75	2641
6.00	2339
6.25	2069
6.50	1884
6.75	1705
7.00	1465
7.25	1170
7.50	876
7.75	661
8.00	518
8.50	443
9.50	385
9.50	329
10.00	290
10.50	249
11.00	212
11.50	170
12.00	138
14.00	93
16.00	67
18.00	49
20.00	36
22.00	28
24.00	23
30.00	14
42.00	0
100.00	0

FLOOD ROUTING INPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,MAIN LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
50 FT. SPILLWAY CREST

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 697.00 FT.
CALCULATIONS END AT EITHER 32.00 HRS OR AT A ELEVATION OF 696.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,MAIN LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	85	465	782	697.00
0.25	90	427	775	696.88
0.50	144	397	769	696.78
0.75	196	374	764	696.70
1.00	267	360	761	696.66
1.25	390	357	761	696.65
1.50	566	369	763	696.69
1.75	848	402	770	696.80
2.00	1481	482	785	697.04
2.25	2889	708	817	697.58
2.50	2926	1025	859	698.27
2.75	3134	1347	897	698.90
3.00	4908	1839	948	699.72
3.25	7095	2455	1027	700.65
3.50	8137	3211	1126	701.66
3.75	8070	3993	1218	702.62
4.00	7096	4601	1286	703.32
4.25	5948	4937	1322	703.70
4.50	4977	5029	1332	703.80
4.75	4283	4959	1325	703.72
5.00	3757	4795	1307	703.54
5.25	3314	4574	1283	703.29
5.50	2958	4322	1256	703.01
5.75	2641	4071	1227	702.72
6.00	2339	3811	1197	702.41
6.25	2069	3547	1167	702.09
6.50	1884	3303	1137	701.78
6.75	1705	3074	1108	701.49
7.00	1465	2848	1080	701.19
7.25	1170	2624	1051	700.89
7.50	876	2405	1020	700.57
7.75	661	2181	989	700.25
8.00	518	1945	958	699.89
8.25	480	1674	931	699.45
8.50	443	1447	908	699.08
8.75	428	1277	889	698.76
9.00	414	1140	873	698.50
9.25	399	1022	859	698.27
9.50	385	921	847	698.07
9.75	309	838	836	697.89
10.00	290	766	826	697.72
10.25	269	702	816	697.56
10.50	249	643	808	697.42
10.75	230	589	800	697.30
11.00	212	540	793	697.18
11.25	191	495	787	697.07
11.50	170	456	780	696.97
11.75	154	427	775	696.88

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,MAIN LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	138	399	769	696.79
12.25	132	373	764	696.70
12.50	126	349	759	696.62
12.75	121	327	755	696.55
13.00	115	307	751	696.48
13.25	109	287	747	696.42
13.50	104	270	743	696.36
13.75	98	253	740	696.31
14.00	93	237	737	696.26
14.25	89	223	734	696.21
14.50	86	210	731	696.16
14.75	83	197	729	696.12
15.00	80	186	727	696.09
15.25	76	175	724	696.05
15.50	73	165	722	696.02
15.75	70	158	721	695.99
16.00	67	153	719	695.96
16.25	64	148	717	695.93
16.50	62	144	715	695.90
16.75	60	139	714	695.87
17.00	58	135	712	695.85
17.25	55	131	710	695.82
17.50	53	127	709	695.80
17.75	51	123	707	695.77
18.00	49	119	706	695.75
18.25	47	115	705	695.72
18.50	45	112	703	695.70
18.75	44	108	702	695.68
19.00	42	105	700	695.66
19.25	40	101	699	695.64
19.50	39	98	698	695.62
19.75	37	95	697	695.60
20.00	36	92	696	695.58
20.25	35	89	694	695.56
20.50	34	86	693	695.54
20.75	33	83	692	695.52
21.00	32	80	691	695.51
21.25	31	78	690	695.49
21.50	30	75	689	695.47
21.75	29	73	688	695.46
22.00	28	70	687	695.44
22.25	27	68	687	695.43
22.50	26	66	686	695.42
22.75	26	64	685	695.40
23.00	25	62	684	695.39
23.25	24	60	683	695.38
23.50	24	58	683	695.37
23.75	23	56	682	695.35

FLOOD ROUTING OUTPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,MAIN LAKE,REG. MAX. EXP. (12.7-14.0 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
24.00	23	54	681	695.34
24.25	22	53	681	695.33
24.50	22	51	680	695.32
24.75	21	49	679	695.31
25.00	21	48	679	695.30
25.25	21	47	678	695.29
25.50	20	45	678	695.29
25.75	20	44	677	695.28
26.00	20	43	677	695.27
26.25	19	41	676	695.26
26.50	19	40	676	695.25
26.75	18	39	676	695.25
27.00	18	38	675	695.24
27.25	18	37	675	695.23
27.50	17	36	674	695.23
27.75	17	35	674	695.22
28.00	17	34	674	695.21
28.25	16	33	673	695.21
28.50	16	32	673	695.20
28.75	15	31	673	695.20
29.00	15	30	672	695.19
29.25	15	30	672	695.19
29.50	14	29	672	695.18
29.75	14	28	671	695.18
30.00	14	27	671	695.17
30.25	13	26	671	695.17
30.50	13	26	670	695.16
30.75	13	25	670	695.16
31.00	12	24	670	695.16
31.25	12	24	670	695.15
31.50	12	23	669	695.15
31.75	11	23	669	695.14
32.00	11	22	669	695.14

RUNOFF VOLUME =24230. CFS- HRS

FLOOD ROUTING INPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,MAIN LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
50 FT. SPILLWAY CREST

ELEVATION-STORAGE RELATIONSHIP

ELEVATION FT	STORAGE AC-FT
665.00	0
670.00	5
675.00	35
680.00	105
685.00	229
690.00	416
695.00	661
700.00	965
705.00	1449
710.00	1946

ELEVATION-DISCHARGE RELATIONSHIP

ELEVATION FT	OUTFLOW CFS
695.00	0
696.00	160
697.00	465
698.00	885
699.00	1400
700.00	2010
701.00	2700
702.00	3470
703.00	4310
704.00	5210
705.00	6200
706.00	7260
707.00	8450
710.00	12200

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
0.0	85
0.25	96
0.50	189
0.75	277
1.00	397
1.25	604
1.50	903
1.75	1373
2.00	2429
2.25	4790

FLOOD ROUTING INPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,MAIN LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
50 FT. SPILLWAY CREST

INFLOW HYDROGRAPH DATA

TIME HRS	INFLOW CFS
2.50	5156
2.75	6256
3.00	9922
3.25	13062
3.50	14120
3.75	13601
4.00	11703
4.25	9713
4.50	8113
4.75	6975
5.00	6061
5.25	5323
5.50	4762
5.75	4304
6.00	3843
6.25	3415
6.50	3116
6.75	2743
7.00	2267
7.25	1744
7.50	1306
7.75	984
8.00	775
8.50	575
9.00	502
9.50	427
10.00	364
10.50	306
11.00	254
11.50	193
12.00	148
14.00	100
16.00	71
18.00	52
20.00	38
22.00	29
24.00	24
30.00	14
42.00	0
100.00	0

FLOOD ROUTING INPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,MAIN LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
50 FT. SPILLWAY CREST

CALCULATIONS BEGIN AT 0.0 HRS AT AN ELEVATION OF 697.00 FT.
CALCULATIONS END AT EITHER 32.00 HRS OR AT A ELEVATION OF 696.00 FT.
TIME INCREMENT IS 0.25 HRS.

FLOOD ROUTING OUTPUT DATA---PAGE 1

I-280 DAM IN SCOTT CO.,MAIN LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
0.0	85	465	782	697.00
0.25	96	428	775	696.88
0.50	189	400	769	696.79
0.75	277	383	766	696.73
1.00	397	379	765	696.72
1.25	604	390	767	696.76
1.50	903	426	774	696.87
1.75	1373	507	788	697.10
2.00	2429	693	815	697.54
2.25	4790	1121	871	698.46
2.50	5156	1797	943	699.65
2.75	6256	2390	1018	700.55
3.00	9922	3220	1127	701.68
3.25	13062	4575	1283	703.29
3.50	14120	6239	1452	705.04
3.75	13601	7803	1593	706.46
4.00	11703	8887	1682	707.35
4.25	9713	9305	1715	707.68
4.50	8113	9215	1708	707.61
4.75	6975	8831	1678	707.31
5.00	6061	8306	1635	706.88
5.25	5323	7732	1587	706.40
5.50	4762	7152	1538	705.90
5.75	4304	6633	1489	705.41
6.00	3843	6129	1442	704.93
6.25	3415	5651	1395	704.45
6.50	3116	5197	1350	703.99
6.75	2743	4800	1308	703.55
7.00	2267	4399	1264	703.10
7.25	1744	4000	1219	702.63
7.50	1306	3593	1172	702.15
7.75	984	3212	1126	701.67
8.00	775	2859	1081	701.21
8.25	675	2551	1040	700.78
8.50	575	2287	1003	700.40
8.75	538	2050	970	700.06
9.00	502	1778	941	699.62
9.25	464	1535	917	699.22
9.50	427	1341	897	698.89
9.75	395	1191	879	698.60
10.00	364	1061	864	698.34
10.25	335	946	850	698.12
10.50	306	852	838	697.92
10.75	280	778	827	697.75
11.00	254	710	818	697.58
11.25	223	647	809	697.43
11.50	193	589	800	697.30
11.75	170	535	792	697.17

FLOOD ROUTING OUTPUT DATA---PAGE 2

I-280 DAM IN SCOTT CO.,MAIN LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
12.00	148	485	785	697.05
12.25	142	446	778	696.94
12.50	136	416	772	696.84
12.75	130	388	767	696.75
13.00	124	362	762	696.66
13.25	118	338	757	696.59
13.50	112	316	753	696.51
13.75	106	296	748	696.45
14.00	100	277	745	696.38
14.25	96	259	741	696.33
14.50	92	243	738	696.27
14.75	89	228	735	696.22
15.00	85	214	732	696.18
15.25	81	201	730	696.14
15.50	78	189	727	696.10
15.75	74	178	725	696.06
16.00	71	168	723	696.03
16.25	68	159	721	695.99
16.50	66	154	719	695.96
16.75	63	149	717	695.94
17.00	61	145	716	695.91
17.25	59	140	714	695.88
17.50	56	136	712	695.85
17.75	54	131	711	695.82
18.00	52	127	709	695.80
18.25	50	123	708	695.77
18.50	48	119	706	695.75
18.75	46	115	705	695.72
19.00	45	112	703	695.70
19.25	43	108	702	695.68
19.50	41	105	700	695.66
19.75	39	101	699	695.64
20.00	38	98	698	695.61
20.25	36	95	697	695.59
20.50	35	92	695	695.58
20.75	34	89	694	695.56
21.00	33	86	693	695.54
21.25	32	83	692	695.52
21.50	31	80	691	695.50
21.75	30	77	690	695.49
22.00	29	75	689	695.47
22.25	28	72	688	695.46
22.50	27	70	687	695.44
22.75	27	68	686	695.43
23.00	26	66	686	695.41
23.25	25	64	685	695.40
23.50	25	61	684	695.39
23.75	24	60	683	695.37

FLOOD ROUTING OUTPUT DATA---PAGE 3

I-280 DAM IN SCOTT CO.,MAIN LAKE,PROB. MAX. (21.3-22.9 IN. SRO)
50 FT. SPILLWAY CREST

TIME HRS	INFLOW CFS	OUTFLOW CFS	STORAGE AC-FT	ELEVATION FT
24.00	24	58	683	695.36
24.25	23	56	682	695.35
24.50	23	54	681	695.34
24.75	22	52	681	695.33
25.00	22	51	680	695.32
25.25	21	49	679	695.31
25.50	21	48	679	695.30
25.75	21	46	678	695.29
26.00	20	45	678	695.28
26.25	20	44	677	695.28
26.50	19	42	677	695.27
26.75	19	41	676	695.26
27.00	19	40	676	695.25
27.25	18	39	675	695.25
27.50	18	38	675	695.24
27.75	17	37	675	695.23
28.00	17	36	674	695.23
28.25	16	35	674	695.22
28.50	16	34	673	695.21
28.75	16	33	673	695.21
29.00	15	32	673	695.20
29.25	15	31	672	695.20
29.50	14	30	672	695.19
29.75	14	29	672	695.19
30.00	14	28	671	695.18
30.25	13	28	671	695.18
30.50	13	27	671	695.17
30.75	13	26	671	695.17
31.00	12	25	670	695.16
31.25	12	25	670	695.16
31.50	12	24	670	695.15
31.75	11	23	670	695.15
32.00	11	23	669	695.14

RUNOFF VOLUME =39929. CFS- HRS

Appendix B

Water Surface Profile Results

Part 1.

Chute Spillway for I-280 Lake

WATER SURFACE PROFILE CALCULATIONS FOR
50-YR. FLOOD,Q=613 CFS,@N@=0.012

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	695.00	696.54	50.00	1.54	7.05	0.77	697.31
0+ 8.9	690.53	691.13	46.40	0.67	19.59	5.96	697.11
0+15.0	689.80	690.48	44.00	0.69	20.20	6.34	696.84
0+30.0	688.00	688.70	40.00	0.70	21.81	7.39	696.10
0+46.8	685.98	686.67	38.00	0.69	23.39	8.50	695.15
0+55.0	685.00	685.70	12.00	0.71	23.95	8.91	694.62
0+70.0	684.55	685.28	12.00	0.73	23.19	8.36	693.64
0+90.0	683.95	684.71	12.00	0.76	22.34	7.76	692.47
1+10.0	683.35	684.13	12.00	0.79	21.64	7.28	691.43
1+30.0	682.75	683.55	12.00	0.81	21.09	6.91	690.47
1+50.0	682.15	682.97	12.00	0.82	20.63	6.61	689.59
1+70.0	681.55	682.39	12.00	0.84	20.24	6.37	688.76
1+90.0	680.95	681.80	12.00	0.85	19.93	6.17	687.98
2+10.0	680.35	681.21	12.00	0.86	19.69	6.03	687.23
2+30.0	679.75	680.62	12.00	0.87	19.45	5.88	686.50
2+50.0	679.15	680.03	12.00	0.88	19.28	5.78	685.81
2+70.0	678.55	679.44	12.00	0.89	19.12	5.68	685.13
2+85.5	678.08	678.92	38.00	0.84	19.15	5.70	684.62
3+ 0.0	673.25	673.85	38.00	0.64	25.33	9.98	683.81
3+20.0	666.58	667.08	38.00	0.53	30.48	14.44	681.54
3+39.7	660.02	660.47	38.00	0.48	33.67	17.62	678.09

WATER SURFACE PROFILE CALCULATIONS FOR
100-YR. FLOOD,Q=730 CFS,@N@=0.012

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	695.00	696.66	50.00	1.66	7.33	0.83	697.49
0+ 8.9	690.53	691.24	46.40	0.80	19.79	6.09	697.32
0+15.0	689.80	690.60	44.00	0.81	20.44	6.49	697.10
0+30.0	688.00	688.81	40.00	0.82	22.22	7.67	696.48
0+46.8	685.98	686.78	38.00	0.80	23.91	8.89	695.67
0+55.0	685.00	685.82	12.00	0.82	24.57	9.38	695.21
0+70.0	684.55	685.39	12.00	0.84	23.99	8.94	694.33
0+90.0	683.95	684.82	12.00	0.87	23.31	8.44	693.26
1+10.0	683.35	684.24	12.00	0.89	22.72	8.02	692.28
1+30.0	682.75	683.66	12.00	0.91	22.26	7.70	691.36
1+50.0	682.15	683.07	12.00	0.93	21.84	7.41	690.50
1+70.0	681.55	682.49	12.00	0.94	21.50	7.19	689.69
1+90.0	680.95	681.90	12.00	0.95	21.24	7.01	688.91
2+10.0	680.35	681.31	12.00	0.96	20.99	6.85	688.16
2+30.0	679.75	680.72	12.00	0.97	20.81	6.73	687.43
2+50.0	679.15	680.13	12.00	0.98	20.62	6.61	686.73
2+70.0	678.55	679.54	12.00	0.99	20.44	6.50	686.04
2+85.5	678.08	679.02	38.00	0.94	20.47	6.52	685.53
3+ 0.0	673.25	673.94	38.00	0.73	26.40	10.83	684.77
3+20.0	666.58	667.16	38.00	0.61	31.64	15.56	682.72
3+39.7	660.02	660.54	38.00	0.55	35.01	19.05	679.60

WATER SURFACE PROFILE CALCULATIONS FOR
REG. MAX. FLOOD,Q=5030 CFS,@N@=0.012

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	695.00	700.80	50.00	5.80	13.66	2.90	703.70
0+ 8.9	690.53	694.53	46.40	4.47	24.24	9.13	703.66
0+15.0	689.80	694.48	44.00	4.71	24.27	9.15	703.62
0+30.0	688.00	692.74	40.00	4.78	26.33	10.77	703.52
0+46.8	685.98	690.56	38.00	4.61	28.74	12.83	703.38
0+55.0	685.00	689.69	12.00	4.73	29.57	13.59	703.27
0+70.0	684.55	689.23	12.00	4.69	29.82	13.82	703.04
0+90.0	683.95	688.58	12.00	4.63	30.17	14.15	702.71
1+10.0	683.35	687.93	12.00	4.59	30.48	14.44	702.38
1+30.0	682.75	687.28	12.00	4.54	30.79	14.73	702.03
1+50.0	682.15	686.64	12.00	4.49	31.10	15.03	701.68
1+70.0	681.55	685.99	12.00	4.45	31.41	15.34	701.32
1+90.0	680.95	685.36	12.00	4.41	31.68	15.59	700.94
2+10.0	680.35	684.72	12.00	4.38	31.94	15.86	700.56
2+30.0	679.75	684.09	12.00	4.35	32.15	16.07	700.17
2+50.0	679.15	683.46	12.00	4.31	32.42	16.34	699.77
2+70.0	678.55	682.83	12.00	4.28	32.64	16.56	699.37
2+85.5	678.08	682.08	38.00	4.00	33.08	17.01	699.10
3+ 0.0	673.25	676.57	38.00	3.50	37.86	22.28	698.83
3+20.0	666.58	669.50	38.00	3.08	43.04	28.79	698.28
3+39.7	660.02	662.67	38.00	2.80	47.35	34.85	697.52

WATER SURFACE PROFILE CALCULATIONS FOR

ROB. MAX. FLOOD,Q=9300 CFS,@N@=0.012

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	695.00	703.40	50.00	8.40	16.45	4.21	707.61
0+ 8.9	690.53	697.59	46.40	7.90	25.37	10.01	707.58
0+15.0	689.80	698.49	44.00	8.75	24.15	9.07	707.56
0+30.0	688.00	696.79	40.00	8.86	26.25	10.71	707.51
0+46.8	685.98	694.36	38.00	8.44	29.01	13.08	707.43
0+55.0	685.00	693.62	12.00	8.68	29.75	13.75	707.36
0+70.0	684.55	693.13	12.00	8.58	30.10	14.08	707.20
0+90.0	683.95	692.37	12.00	8.42	30.67	14.62	706.97
1+10.0	683.35	691.62	12.00	8.28	31.19	15.12	706.74
1+30.0	682.75	690.90	12.00	8.16	31.67	15.59	706.49
1+50.0	682.15	690.18	12.00	8.03	32.16	16.08	706.24
1+70.0	681.55	689.47	12.00	7.92	32.60	16.52	705.97
1+90.0	680.95	688.78	12.00	7.83	32.99	16.91	705.70
2+10.0	680.35	688.08	12.00	7.74	33.38	17.31	705.42
2+30.0	679.75	687.39	12.00	7.65	33.77	17.73	705.12
2+50.0	679.15	686.71	12.00	7.57	34.14	18.12	704.82
2+70.0	678.55	686.03	12.00	7.49	34.49	18.49	704.52
2+85.5	678.08	685.02	38.00	6.94	35.26	19.32	704.32
3+ 0.0	673.25	679.02	38.00	6.08	40.23	25.16	704.16
3+20.0	666.58	671.69	38.00	5.38	45.46	32.13	703.82
3+39.7	660.02	664.67	38.00	4.91	49.89	38.68	703.36

WATER SURFACE PROFILE CALCULATIONS FOR
50-YR. FLOOD,Q=613 CFS,@N@=0.015

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	695.00	696.54	50.00	1.54	7.05	0.77	697.31
0+ 8.9	690.53	691.14	46.40	0.68	19.44	5.87	697.00
0+15.0	689.80	690.50	44.00	0.70	19.78	6.08	696.59
0+30.0	688.00	688.72	40.00	0.73	20.97	6.83	695.56
0+46.8	685.98	686.71	38.00	0.73	22.10	7.59	694.29
0+55.0	685.00	685.75	12.00	0.76	22.48	7.86	693.61
0+70.0	684.55	685.35	12.00	0.80	21.28	7.04	692.40
0+90.0	683.95	684.79	12.00	0.85	20.07	6.26	691.05
1+10.0	683.35	684.24	12.00	0.89	19.12	5.68	689.92
1+30.0	682.75	683.67	12.00	0.92	18.39	5.26	688.93
1+50.0	682.15	683.10	12.00	0.95	17.87	4.96	688.04
1+70.0	681.55	682.52	12.00	0.98	17.42	4.71	687.23
1+90.0	680.95	681.94	12.00	0.99	17.09	4.54	686.47
2+10.0	680.35	681.36	12.00	1.01	16.83	4.40	685.75
2+30.0	679.75	680.77	12.00	1.02	16.63	4.30	685.07
2+50.0	679.15	680.18	12.00	1.03	16.48	4.22	684.40
2+70.0	678.55	679.59	12.00	1.04	16.34	4.15	683.75
2+85.5	678.08	679.06	38.00	0.98	16.48	4.22	683.27
3+ 0.0	673.25	673.90	38.00	0.69	23.34	8.47	682.36
3+20.0	666.58	667.12	38.00	0.57	28.32	12.46	679.61
3+39.7	660.02	660.51	38.00	0.52	31.01	14.95	675.44

WATER SURFACE PROFILE CALCULATIONS FOR
100-YR. FLOOD,Q=730 CFS,@N@=0.015

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	695.00	696.66	50.00	1.66	7.33	0.83	697.49
0+ 8.9	690.53	691.25	46.40	0.80	19.65	6.00	697.23
0+15.0	689.80	690.62	44.00	0.82	20.13	6.30	696.89
0+30.0	688.00	688.84	40.00	0.85	21.48	7.17	696.01
0+46.8	685.98	686.82	38.00	0.84	22.80	8.08	694.90
0+5$.0	685.00	685.86	12.00	0.87	23.27	8.41	694.28
0+70.0	684.55	685.46	12.00	0.91	22.27	7.71	693.17
0+90.0	683.95	684.90	12.00	0.95	21.22	7.00	691.88
1+10.0	683.35	684.34	12.00	1.00	20.34	6.43	690.77
1+30.0	682.75	683.78	12.00	1.03	19.63	5.99	689.78
1+50.0	682.15	683.20	12.00	1.06	19.14	5.69	688.88
1+70.0	681.55	682.63	12.00	1.08	18.72	5.44	688.05
1+90.0	680.95	682.05	12.00	1.11	18.31	5.21	687.28
2+10.0	680.35	681.47	12.00	1.12	18.08	5.08	686.54
2+30.0	679.75	680.88	12.00	1.13	17.87	4.96	685.84
2+50.0	679.15	680.29	12.00	1.14	17.71	4.88	685.15
2+70.0	678.55	679.70	12.00	1.15	17.56	4.79	684.49
2+85.5	678.08	679.17	38.00	1.09	17.65	4.84	684.00
3+ 0.0	673.25	674.00	38.00	0.79	24.28	9.16	683.15
3+20.0	666.58	667.20	38.00	0.65	29.43	13.46	680.65
3+39.7	660.02	660.58	38.00	0.59	32.35	16.27	676.85

WATER SURFACE PROFILE CALCULATIONS FOR
REG. MAX. FLOOD,Q=5030 CFS,@N@=0.015

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	695.00	700.80	50.00	5.80	13.66	2.90	703.70
0+ 8.9	690.53	694.54	46.40	4.48	24.18	9.09	703.64
0+15.0	689.80	694.49	44.00	4.72	24.21	9.11	703.58
0+30.0	688.00	692.77	40.00	4.80	26.18	10.65	703.42
0+46.8	685.98	690.60	38.00	4.65	28.47	12.60	703.20
0+55.0	685.00	689.74	12.00	4.78	29.26	13.30	703.05
0+70.0	684.55	689.31	12.00	4.76	29.35	13.39	702.69
0+90.0	683.95	688.68	12.00	4.74	29.49	13.52	702.21
1+10.0	683.35	688.06	12.00	4.72	29.64	13.65	701.72
1+30.0	682.75	687.44	12.00	4.69	29.78	13.79	701.23
1+50.0	682.15	686.81	12.00	4.67	29.93	13.92	700.73
1+70.0	681.55	686.20	12.00	4.65	30.02	14.01	700.22
1+90.0	680.95	685.58	12.00	4.63	30.17	14.15	699.71
2+10.0	680.35	684.96	12.00	4.62	30.27	14.24	699.19
2+30.0	679.75	684.35	12.00	4.60	30.36	14.33	698.67
2+50.0	679.15	683.73	12.00	4.59	30.46	14.42	698.14
2+70.0	678.55	683.12	12.00	4.57	30.56	14.51	697.61
2+85.5	678.08	682.35	38.00	4.27	30.97	14.91	697.26
3+ 0.0	673.25	676.73	38.00	3.67	36.05	20.20	696.91
3+20.0	666.58	669.62	38.00	3.20	41.34	26.56	696.16
3+39.7	660.02	662.77	38.00	2.90	45.61	32.34	695.11

WATER SURFACE PROFILE CALCULATIONS FOR

ROB. MAX. FLOOD,Q=9300 CFS,@N@=0.015

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	695.00	703.40	50.00	8.40	16.45	4.21	707.61
0+ 8.9	690.53	697.60	46.40	7.91	25.33	9.97	707.57
0+15.0	689.80	698.50	44.00	8.77	24.11	9.03	707.53
0+30.0	688.00	696.84	40.00	8.90	26.11	10.60	707.45
0+46.8	685.98	694.42	38.00	8.50	28.81	12.90	707.33
0+55.0	685.00	693.68	12.00	8.75	29.54	13.56	707.23
0+70.0	684.55	693.23	12.00	8.69	29.74	13.74	706.98
0+90.0	683.95	692.51	12.00	8.57	30.14	14.12	706.64
1+10.0	683.35	691.80	12.00	8.46	30.55	14.51	706.29
1+30.0	682.75	691.11	12.00	8.37	30.86	14.80	705.93
1+50.0	682.15	690.42	12.00	8.27	31.23	15.16	705.56
1+70.0	681.55	689.73	12.00	8.19	31.54	15.46	705.18
1+90.0	680.95	689.07	12.00	8.12	31.81	15.72	704.79
2+10.0	680.35	688.40	12.00	8.05	32.07	15.99	704.39
2+30.0	679.75	687.73	12.00	7.99	32.34	16.26	703.98
2+50.0	679.15	687.08	12.00	7.94	32.56	16.47	703.56
2+70.0	678.55	686.43	12.00	7.88	32.77	16.69	703.14
2+85.5	678.08	685.37	38.00	7.29	33.56	17.51	702.87
3+ 0.0	673.25	679.23	38.00	6.30	38.83	23.43	702.64
3+20.0	666.58	671.84	38.00	5.54	44.18	30.33	702.16
3+39.7	660.02	664.79	38.00	5.03	48.61	36.73	701.51

Appendix B

Water Surface Profile Results

Part 2.

Culvert Spillway for Railroad Lake

WATER SURFACE PROFILE CALCULATIONS FOR
RAILROAD LAKE SPILLWAY - 50 YR. FLOOD,@N@=0.012,Q=274 CFS

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	705.00	707.86	5.00	2.86	9.58	1.43	709.29
0+10.0	704.80	707.20	5.00	2.40	11.43	2.03	709.23
0+20.0	704.60	706.84	5.00	2.24	12.25	2.33	709.16
0+30.0	704.40	706.55	5.00	2.15	12.75	2.52	709.08
0+40.0	704.20	706.26	5.00	2.07	13.26	2.73	708.99
0+46.0	704.08	706.12	5.00	2.04	13.42	2.80	708.93
0+55.5	703.89	705.70	10.67	1.81	14.20	3.13	708.84
0+65.0	700.72	701.89	10.67	1.23	20.86	6.77	708.66
0+75.0	697.39	698.35	10.67	1.02	25.26	9.92	708.26
0+82.2	694.99	695.87	10.67	0.93	27.72	11.94	707.83
0+91.2	691.99	692.79	10.67	0.85	30.36	14.32	707.11
0+97.2	689.99	690.75	10.67	0.81	31.84	15.76	706.51

WATER SURFACE PROFILE CALCULATIONS FOR
RAILROAD LAKE SPILLWAY - 100 YR. FLOOD,@N@=0.012,Q=348 CFS

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	705.00	708.20	5.00	3.20	10.13	1.59	709.79
0+10.0	704.80	707.52	5.00	2.72	11.89	2.20	709.74
0+20.0	704.60	707.14	5.00	2.54	12.74	2.52	709.67
0+30.0	704.40	706.84	5.00	2.44	13.25	2.73	709.59
0+40.0	704.20	706.55	5.00	2.35	13.79	2.96	709.49
0+46.0	704.08	706.40	5.00	2.32	13.96	3.03	709.44
0+55.5	703.89	706.17	10.67	2.28	14.31	3.18	709.35
0+65.0	700.72	702.18	10.67	1.54	21.24	7.01	709.21
0+75.0	697.39	698.59	10.67	1.27	25.72	10.28	708.88
0+82.2	694.99	696.08	10.67	1.15	28.30	12.45	708.53
0+91.2	691.99	692.99	10.67	1.05	31.02	14.96	707.94
0+97.2	689.99	690.94	10.67	1.00	32.60	16.52	707.46

WATER SURFACE PROFILE CALCULATIONS FOR
RAILROAD LAKE SPILLWAY - 50 YR. FLOOD,@N@=0.015,Q=274 CFS

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	705.00	707.86	5.00	2.86	9.58	1.43	709.29
0+10.0	704.80	707.23	5.00	2.44	11.25	1.97	709.20
0+20.0	704.60	706.91	5.00	2.31	11.88	2.19	709.10
0+30.0	704.40	706.62	5.00	2.22	12.36	2.37	708.98
0+40.0	704.20	706.36	5.00	2.16	12.68	2.50	708.85
0+46.0	704.08	706.21	5.00	2.14	12.83	2.56	708.77
0+55.5	703.89	705.78	10.67	1.89	13.58	2.87	708.64
0+65.0	700.72	701.92	10.67	1.26	20.41	6.47	708.39
0+75.0	697.39	698.38	10.67	1.04	24.66	9.45	707.81
0+82.2	694.99	695.89	10.67	0.95	26.96	11.29	707.19
0+91.2	691.99	692.82	10.67	0.88	29.30	13.35	706.17
0+97.2	689.99	690.79	10.67	0.84	30.60	14.56	705.35

WATER SURFACE PROFILE CALCULATIONS FOR
RAILROAD LAKE SPILLWAY - 100 YR. FLOOD,@N@=0.015,Q=348 CFS

STATION	FLOOR	WS	WIDTH	D	V	VH	THL
0+ 0.0	705.00	708.20	5.00	3.20	10.13	1.59	709.79
0+10.0	704.80	707.52	5.00	2.72	11.89	2.20	709.71
0+20.0	704.60	707.22	5.00	2.62	12.37	2.38	709.60
0+30.0	704.40	706.92	5.00	2.52	12.88	2.58	709.48
0+40.0	704.20	706.65	5.00	2.45	13.21	2.71	709.35
0+46.0	704.08	706.50	5.00	2.42	13.37	2.78	709.27
0+55.5	703.89	706.28	10.67	2.40	13.62	2.88	709.16
0+65.0	700.72	702.21	10.67	1.56	20.84	6.75	708.95
0+75.0	697.39	698.62	10.67	1.30	25.18	9.86	708.47
0+82.2	694.99	696.11	10.67	1.18	27.63	11.87	707.96
0+91.2	691.99	693.02	10.67	1.08	30.12	14.10	707.11
0+97.2	689.99	690.97	10.67	1.03	31.54	15.46	706.43