Rocky Mountain Consultants Incorporated

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

MAPLE GROVE RESERVOIR DAM

JEFFERSON COUNTY, COLORADO

DIVISION I

DISTRICT 7

OWNER: CONSOLIDATED MUTUAL WATER COMPANY

IDENTIFICATION NUMBERS: ARMY CORPS OF ENGINEERS 203

STATE OF COLORADO 757

INSPECTED: AUGUST 6, 1979

BY: ROCKY MOUNTAIN CONSULTANTS, INC.

205 Park Lane

Estes Park, Colorado 80517

Job No. 2151

MAPLE GROVE
RESERVOIR
1

SUMMARY OF ASSESSMENT AND RECOMMENDATIONS

MAPLE GROVE RESERVOIR

I. D. NO. 203 (ARMY)

C-757 (COLORADO)

HAZARD POTENTIAL CATEGORY: 1

INSPECTED: August 6, 1979

1. Maple Grove Reservoir, due to its high hazard potential and the vandalism to the Fabridams on March 17, 1979, is probably the most closely monitored intermediate size dam in the State of Colorado. While it is in excellent condition, the following recommendations should be implemented to improve the structural integrity and operational adequacy of the project.
   a. The City of Lakewood, which has the maintenance responsibilities for W. 27th Avenue, should be notified in writing that the pavement surface is deteriorating and its resurfacing should be given a high priority on their schedule.
   b. A yearly maintenance program of backfilling eroded areas and stabilizing the upstream and downstream slopes should be implemented.
   c. A stability analysis should be prepared to assure that the steep downstream slope is stable for a maximum pool elevation.
   d. The upstream gate control on the outlet works should be secured in an open position to prevent unauthorized closure.
   e. The outlet works conduit and the Rocky Mountain Ditch culvert through the embankment should be periodically inspected to determine if any leakage is present. Soil resistivity in these areas should be checked to estimate the life expectancy of the pipe material.

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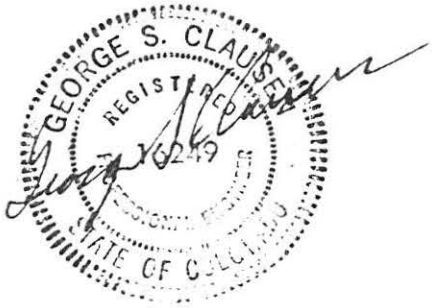
f. Efforts should continue on arranging an emergency power supply for operation of the Fabridams.

g. The location of a gaging station along Lena Gulch upstream of the reservoir as well as one at the spillway of the dam should be a high priority for The Consolidated Mutual Water Company and the Urban Drainage and Flood Control District. The limits of possible downstream flooding should be defined based upon the maximum amount of overtopping as determined in this report. These limits should be used for establishing an evacuation program. Evacuation procedures should be initiated by The Consolidated Mutual Water Company as soon as 500 cfs discharges from the spillway.

2. The hydraulic and hydrologic evaluation showed that 50 percent of the Probable Maximum Flood from the 6-hour storm as determined by the Corps of Engineers procedure can be passed without overtopping the dam. Therefore, the dam is not to be classified as unsafe even though the spillway cannot pass the full PMP and additional spillway and/or storage capacity is desirable.

3. A contingency plan for emergencies should be prepared and adopted to include the following: the existing operational manual on the Fabridams; the location of stockpile/barrow materials; the location of available construction equipment, the identification of remedies to problems such as increased seepage and/or erosion; notification procedures in case of emergency; evacuation procedures in case of an emergency; and training for emergencies.



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PERTINENT DATA

A. GENERAL

Name	Maple Grove
State	Colorado
Division	1
District	7
Stream	Lena Gulch (on channel)
Inventroy of Dams I.D. Numbers	Army Corps 203 Colorado C-757
Hazard Potential Classification	1 (High)
Owner	Consolidated Mutual Water Company

B. EMBANKMENT

Type	Earthfill
Crest Length	1100 Feet
Crest Width	40 Feet
Crest Elevation	5534.44 Feet (lowest el.)
Crest Height	Structural 59 Feet Hydraulic 51 Feet

C. SPILLWAY

Type	Ogee type under bridge
Location	Sta. 15 + 38 on original plans through right end of abutment
Side Slopes	Vertical
Crest Elevation	5520 (Top of concrete) 5526 (Top of 6' high Fabridam)

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Bottom Width.	70 Feet
Length.	249 Feet
Top Width	70 Feet
Freeboard	8.44 Feet (From top of 6' Fabridam) 14.44 Feet (From top of concrete)
Discharge Capacity.	13,365 cfs

D. OUTLET WORKS

Inlet Type.	Low level concrete box
Inlet Elevation	5496 Feet
Conduit Type.	Steel Pipe
Conduit Length.	254 Feet
Conduit Dimensions.	30 Inches I.D.
Outlet Invert Elevation	5476 Feet
Stilling Basin.	Connected directly to filter plant

E. RESERVOIR

Type of Storage	Domestic Water Supply
Storage Volume.	619.5 Ac-Ft. @ High Water Line El. 5525 655.4 Ac-Ft. @ Fabridam Crest El. 5526 958.5 Ac-Ft. @ Top of Dam El. 5534.44
Elevation (Gauge height in feet).	Zero on gauge is 28 Feet above intake @ El. 5524
Surface Area (in acres)	42.2 Ac. @ High Water-line El. 5525 44.3 Ac. @ Fabridam Crest El. 5526

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F. RESERVOIR INLET

Type	Earthcut ditch and natural stream
Elevation	5520 Feet

G. DRAINAGE BASIN

Total Drainage Area	10.9 Square Miles
Maximum Length of Drainage	7.77 Miles
Elevation Difference	2042 Feet to High Water Line

H. FLOODPLAIN

Distance (from dam to main stream)	2.8 Miles
Immediately Downstream	¼ Mile Undeveloped
Development	¼ Miles - 2½ Miles Intensive Residential and Commercial

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NATIONAL DAM SAFETY PROGRAM

MAPLE GROVE RESERVOIR

Map 1: Location and Topography

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
MAPLE GROVE RESERVOIR DAM
JEFFERSON COUNTY, COLORADO

1. GENERAL

A. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. This inspection was made in accordance with this authority.

B. Purpose of Inspection. The purpose of this inspection was to make a general assessment of the structural integrity and operational adequacy of the dam, reservoir and its appurtenant structures.

C. Scope of Report. The Phase 1 investigation was conducted to assess the general condition of the project with respect to safety, based on available data and visual inspection, to determine needs for emergency measures and to conclude if additional studies, investigations and analyses are warranted. All of these items are covered in this report.

11. PROJECT DESCRIPTION

A. Location. Maple Grove Reservoir is located in Section 29, Township 3S, Range 69W of the 6th Principal Meridian in Jefferson County, Colorado. The dam is located at approximately W. 27th Avenue and Youngfield Street, in the City of Lakewood, Colorado. The dam crest is traversed by W. 27th Avenue. The location of the dam is shown on Map 1.

B. Ownership and Purpose of the Dam. Maple Grove Reservoir is an on-channel (Lena Gulch) domestic water supply reservoir belonging to The Consolidated Mutual Water Company, 10075 W. Colfax Avenue, Lakewood, Colorado 80215.

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Water stored in the reservoir is treated at the company's filter plant, located adjacent to the downstream toe of the dam and distributed to 15,000 users in portions of Northwest Lakewood, Applewood, Wide Acres, Pleasant View and Sixth Avenue West. The dam face and reservoir area are closed to the public and are not used for any type of recreation.

C. Size, Type and Hazard Potential Classification.

1. Size. The hydraulic height of Maple Grove Dam is 51 feet and the structural height is approximately 59 feet. The storage capacity is 958.5 acre-ft. at the lowest elevation in the top of the dam (El. 5534.44). Based on its height, Maple Grove is classified as an intermediate-size dam.*

2. Type. Maple Grove is an earthfill dam composed of on-site materials, faced with imported riprap on the upstream slope.

3. Hazard Potential Classification. Maple Grove is classified as having a high potential for property damage or loss of life in the event of failure. The floodplain directly downstream from the dam and all the way to Lena Gulch's confluence with Clear Creek is an intensively developed urban residential area. Extensive property damage in this area, with possible loss of life could be expected if the dam was to fail.

D. Basin Description. The upstream drainage basin of Maple Grove Reservoir encompasses 10.9 square miles, with the longest course being 7.77 miles. The difference in elevation from the high point, at elevation 7567 to the spillway crest at elevation 5526 is 2041 feet.

The area immediately upstream from the reservoir is semi-intensive urban residential, merging into rural residential, and

*A dam higher than 40 feet but less than 100 feet or having a storage capacity greater than 1000 acre-feet but less than 50,000 acre-feet.

near the western limits of the basin, to undeveloped foothills topography. There are no cultivated lands to speak of in the drainage basin. Open lands between residential developments and the foothills area on the western edge of the basin are generally covered with native grass and sagebrush vegetation.

The reservoir is encircled on all sides except the crest by the Rocky Mountain Ditch which, at the northeast end of the dam, is routed through the embankment in an underground pipeline.

E. Inlet. There are four potential sources of water entering into Maple Grove Reservoir. The main source is Lena Gulch, the drainageway collecting runoff from the 10.9 square mile drainage basin upstream of the reservoir. Circling the reservoir on all but the north side is the Rocky Mountain Ditch. This ditch is elevated over the Lena Gulch inlet and at this location, there is a spillway and check to divert water from the Rocky Mountain Ditch into the reservoir. Under normal conditions, very little water is diverted however. In the southeast corner of the reservoir near the Lena Gulch inlet, there is an inlet from the Agricultural Ditch and in the northwest corner of the reservoir there is an inlet from the Lee, Stewart and Eskins ditch.

F. Geology and Soils. Maple Grove Reservoir is located on bedrock of claystone which is part of the Tertiary Denver formation. It is overlain by Piney Creek Alluvium from the Upper Holocene period. The overburden ranges in thickness from 5 to 20 feet and is composed of clay, medium stiff to stiff, sandy to very sandy, moist, brown to gray as shown from Appendix D - Plate 1 and the Test Hole Data on Appendix C - Plate 6.

There are no known faults underlying the dam or reservoir but there have been some reports of seismic activity centered in the area in modern times. (See Appendix D - Plate 2).

G. Embankment. The Maple Grove embankment is 1100 feet long, 51 feet high above the downstream invert of the outlet conduit and approximately 59 feet above the claystone bedrock to which the cutoff trench was excavated. The embankment has a crest width of 40 feet.

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The crest is traversed by W. 27th Avenue, an asphalt thoroughfare that is maintained by the City of Lakewood, Colorado. A 7-ft. wide concrete sidewalk parallels the street on the downstream side of the crest. A 6-ft. high chain link fence on the downstream side of the crest and a guardrail, plus a 4-strand barbwire fence on the upstream side of the crest restricts public access to the upstream and downstream slopes. (See Appendix B - Photo No. 1). The center line of the dam is straight between abutments. The centerline runs from east to west. Near the east abutment of the dam, the Rocky Mountain Ditch is conveyed through the embankment in a 12 gage multi-plate arch. This arch has a 10 foot span and a 3 feet 5-3/4 inch rise as shown in Appendix C - Plate 4.

1. Upstream Slope. The upstream slope is 1 vertical on 3 horizontal. Riprap slope protection is provided from the floor of the reservoir to the top of the dam. See Plate C-2 of Appendix C.

2. Downstream Slope. The downstream slope is 1 vertical on 1.75 horizontal. The embankment materials are clays and sandy clays. Foundation seepage is controlled by a cutoff trench with a bottom width of 10 feet, excavated to sound claystone, and having side slopes of 1:1. See Plate C-2 of Appendix C.

There is a service road around the left end of the embankment and paralleling the downstream toe that goes to the filter plant. (See Appendix B - Photo No. 6).

3. Filter Zone and Toe Drains. For a length of approximately 520 feet through the center part of the embankment, a filter zone nine feet in width extends from elevation 5500 down to the natural ground line at the time of the original construction. Maximum depth of the filter zone appears to be about 20 feet. A six inch perforated clay pipe is embedded in the bottom of the filter zone at every 100 feet on centers. Moisture is collected in the perforated section of pipe then conveyed through solid six inch clay pipe to the downstream toe of the embankment.

H. Outlet Works. The outlet works, located approximately 330 feet

from the eastern end of the embankment, consists of a low-level (El. 5496 feet) intake, a 254-ft. long, 30-inch diameter steel tube conduit and a reinforced concrete outlet box. The outlet works was installed in the 1956 original construction project and has not received any modification since that time. Details of the outlet works are shown on Appendix C - Plate 3.

1. Intake. The low-level intake is a concrete box structure measuring 5' - 4½" by 3' - 0" inside dimensions with 10 inch thick concrete walls. Flow into the structure is controlled by a 3-ft. square rising stem sluice gate, which is protected by a welded steel trashrack. The intake level is at elevation 5496.0 which is the bottom of the reservoir level.

2. Conduit. The 254-ft. long, 30-inch diameter steel tubular conduit rests on an outlet trench that was excavated to varying depths but with a consistent width of 10 feet and 1:1 sideslopes. The trench was backfilled and compacted in 6 inch lifts. Eight inch thick concrete cutoff walls measuring at least 5½ feet square were installed every 20 feet along the length of the conduit. The capacity of this conduit is approximately 102 cfs, with the pool at the top of the dam.

3. Control. Because the Maple Grove storage is used for a domestic water supply, the intake gate is left in the open position at all times. However, it may be closed via a 30 inch valve on the downstream end of the outlet tube or by a 24 inch valve on the supply line from the 30-inch outlet tube to the filter plant. The conduit may be operated manually by attaching a handle to an exposed gate screw, located on the upstream face of the dam, as shown on Appendix C - Plate 3 and in Appendix B - Photo No. 9.

4. Impact Structure and Stilling Basin. Although the released water flows directly into stilling basins within the filter plant, a secondary impact structure is located about 50 feet west of the filter plant.

Water can by-pass the filter plant and be directed into a subsidiary part of the Lena Gulch drainageway. Water is occasionally diverted this way to keep a conservation pool in this area for grazing purposes.

I. Spillway. The emergency spillway at Maple Grove is an ogee type, two-bay, concrete chute spillway located near the right end of the dam at about Sta. 15 + 38 on the original plans. The spillway is crossed by a 72-ft. long, concrete and steel bridge, with a clearance passing over of about 12.8 feet from the floor of the spillway to the underside of the bridge. Contained within the bays of the spillway are two inflatable Fabridams, which provide for the decreed amount of storage within the reservoir during times of normal operation. The 10 foot by 40 foot Fabridam in the west bay is owned by the Urban Drainage and Flood Control District and the 6 foot by 30 foot Fabridam in the east bay is owned by The Consolidated Mutual Water Company. Both are monitored and maintained by The Consolidated Mutual Water Company as per an agreement between the two entities. These Fabridams offer the advantage of regulating release of floodwaters through the spillway by controlled deflation. (See Appendix E - Attachment 2 for a description of the Fabridams and their operation).

Water released through the spillway would flow down the chute, through a stilling basin and into a riprapped, earth cut channel, which would carry it to Clear Creek. (See Appendix B - Photo No. 17).

The design capacity of the spillway with the Fabridams deflated, is 13,970 cfs.

J. Floodplain. The floodplain immediately below the Maple Grove dam, for a distance of 1/4 mile, is relatively undeveloped. Located on this immediate floodplain are the Maple Grove Filter Plant and a backwash water waste pond.

Beginning about 1/4 mile from the base of the dam and continuing along the 2.8 mile course of Lena Gulch, to its confluence with Clear Creek, the floodplain is intensively developed residential and commercial property.

III. CONSTRUCTION HISTORY

The Maple Grove Dam was constructed in 1956 to create a domestic water supply storage reservoir and to serve as a presedimentation facility for the water to be treated. Construction of the dam paralleled that of the Maple Grove Filter Plant, built on the downstream side, about midway at the axis east to west.

The construction plans called for an earthfill dam with a maximum height of 51 feet, between the low point at the upstream toe and the possible maximum height which at that time was set at elevation 5534. The plans also called for a crest length of1100 feet and a future crest width of 36 feet. Included in the plans were specifications for a cutoff trench 10 feet wide at the bottom and side slopes 1:1. The depth of the cutoff trench varied as it was to be "excavated to the top of sound claystone."

The spillway was designed as an earth cut, riprapped channel which passed through a box culvert under W. 27th Avenue, around the left end of the dam and down a riprapped, natural channel. This channel carried the released flow in a channel paralleling the service road and the toe of the downstream slope to Lena Gulch.

At the time of construction of the dam, the Lena Gulch floodplain downstream from the dam was generally undeveloped.

Construction of the dam required the abandonment of the existing W. 26th Avenue, which crossed Lena Gulch about 300 feet upstream of the proposed embankment, and realigning this road to be along the crest of the embankment.

All the work included in the original construction project is detailed in the plans shown as Appendix C - Plates 1-4.

In 1960, the emergency spillway was relocated because it presented a handicap to the access of the filter plant. The earthen channel and culvert at the left side of the embankment were filled in and a new 115 foot long, 7 foot diameter concrete pipe was installed through the right side of the embankment at about Sta. 15 + 36

on the original plans. A concrete headwall in front of the upstream end of the pipe maintained the high water elevation at 5523, same as the original high water line. A riprapped spillway channel led from the stilling basin to the Lena Gulch channel. Details of this relocated spillway are shown on Appendix C - Plate 5.

As shown in the Office of the State Engineer's chronology of events (Appendix E - Attachment 1) development in the floodplain below Maple Grove Reservoir was occurring and this led to some concern. On May 13, 1974, the Colorado Division of Water Resources sent a letter to The Consolidated Mutual Water Company requiring that the spillway be upgraded to pass the Army Corps of Engineer's Standard Project Flood. (See Appendix E - Attachment 1A).

Because the owners also were exploring methods of increasing storage in the reservoir, the decision was made to build a 2-bay, ogee type spillway, which would serve as the foundation and side support for two inflatable Fabridams.Numerous design considerations were involved as well as several governmental agencies in the development of the project. Appendix E - Attachment 3 described the final project which was completed on July 1, 1977. The Cities of Lakewood and Wheat Ridge, as well as Jefferson County and the Urban Drainage and Flood Control District all assisted The Consolidated Mutual Water Company in the project.

The new spillway was located at the east end of the dam in the same location of the relocated spillway that was constructed in 1960. The design of the new spillway called for a concrete structure with a clear opening of 70 feet, and approximately 14 feet of clearance from the floor of the spillway to the bottom of the bridge that would pass over the spillway.

Plans and specifications for construction of the spillway and installation of the Fabridams are included on Plates 6 - 9 - Appendix C and Attachment 2 - Appendix E.

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Early on the morning of March 17, 1979, the 6-ft. Fabridam in the east bay of the spillway was cut in two places (apparently the action of vandals) causing the dam to deflate. This deflation, which occurred over a period of time, as programed by the control panel, released a total of about 3.5 million gallons into the Lena Gulch channel.

The peak flow of water through the spillway chute was estimated at anywhere from 300 to 600 cfs. The flow was controlled approximately two hours later as a result of installing a sandbag cofferdam upstream of the spillway.

The released flow flooded the back yards of several residences along Lena Gulch. There was some minor damage done but no total estimate was ever prepared. There were no injuries or loss of life.

Repair of the Fabridam was made by installing patches on both the inside and outside of the Fabridam material. The water level was returned to the normal high water elevation.

Lawyers, representing the residents in the floodplain below the dam, contacted the State Engineer's Office regarding the safety of the dam. Engineers for The Consolidated Mutual Water Company proposed security measures in addition to the electronically monitored pressure system within the Fabridams and these measures are discussed in the draft response from the Governor's office shown as Appendix E - Attachment 4. These measures included increased on-site surveillance, security lighting, a Fabridam low pressure monitoring and alarm system and security fencing. Futhermore, a comprehensive system of four release valves within each Fabridam has been established that is all contingent upon water fluctuations in the reservoir. Depending upon an increase in the water surface elevation and the rate of increase and subsequent decrease, these valves are electronically opened and closed according to the sequence shown in Appendix E - Attachment 5. This sequence was established by The Consolidated Mutual Water Company and meets the intended purposes of the Urban Drainage and Flood Control

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District and of the Office of the State Engineer. Further discussion on the spillway design is included later in this report.

In addition to all the security measures already installed, The Consolidated Mutual Water Company is continuing to pursue an emergency power supply and are working with Public Service Company to determine the load and how it best can be provided. Consolidated Mutual is also negotiating with the Urban Drainage and Flood Control District to install gaging stations upstream of the reservoir and at the spillway of the dam to monitor what is happening in the upstream watershed and to know the relationship of the discharge from the spillway.

IV. OPERATION AND MAINTENANCE

The Maple Grove Reservoir, being an on-channel facility, is subject to inflow whenever there is runoff in Lena Gulch. Since it is used for supplying domestic water, it is in year round use. There is constant operation and supervision in the Maple Grove Filter Treatment plant located immediately downstream of the reservoir. There are several engineers on the staff of The Consolidated Mutual Water Company. Mr. Kurt A. Keim is Superintendent of Water Supply and it is his job to oversee the operation and maintenance at this facility. Following the vandalism incident, the Fabridams are observed at one-half hour intervals 24 hours per day 7 days per week.

The controls for the Fabridams are housed in a gate house by the spillway. (See Appendix B - Photo No. 12). The control valves for the Fabridams are all color coded as shown in Photo No. 13.

The Fabridam low pressure monitoring and alarm system went into operation on June 4, 1979. This system, while in the gate house, activates a visual and audio alert in the treatment plant anytime the pressure makeup system operates for longer than two minutes.

V. INSPECTION HISTORY

The Dam and reservoir are visited frequently by Virgil Hill, President of The Consolidated Mutual Water Company and several other Company personnel. In addition, the Fabridams are inspected every half-hour, 24 hours a day and 7 days a week.

The State Engineer's Office has been particularly interested in this project due to the high hazard potential with all the development in the downstream floodplain. In recent years the dam has been inspected annually by personnel from the State Engineer's Office.

VI. INSPECTION

A. General. The field inspection of Maple Grove Reservoir Dam was conducted on August 6, 1979, by the following persons:

Dr. George S. Clausen, P.E.	Rocky Mountain Consultants, Inc.
Ken Rollin, P.E.	Rocky Mountain Consultants, Inc.
Pat Jorgenson	Rocky Mountain Consultants, Inc.
Glen Whitten, Vice President Engineering and Operations	Consolidated Mutual Water Company
David Hahn, P.E., Staff Engineer	Consolidated Mutual Water Company

B. Reservoir Area. On the day of inspection the reservoir level was at 0.2 feet on the staff gauge. Zero on the gauge is 28 feet above the inlet elevation. Zero corresponds to elevation 5524. This level was 10.24 feet below the lowest elevation in the top of the dam and 1.8 feet below the top of the 6 foot high Fabridam and 5.8 feet below the 10 foot

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high Fabridam in the spillway. Since the dam's construction there has been considerable development of the upstream drainage basin, with additions of several thousand square feet of concrete, asphalt and roof tops, no doubt increasing the runoff characteristics of the basin.

There was no evidence of vandalism or abuse of the reservoir area, which is fenced to restrict access by the public.

C. Embankment. The length of the 1100 foot embankment was walked, with continuous and thorough observations of the crest, upstream and downstream slopes.

1. Crest. The crest is topped by a two-lane asphalt thoroughfare. Some breaking up of the asphalt was noted along the north side and a noticeable depression was noted at the abutment of the bridge over the spillway, as shown in Photos 1 and 2 of Appendix B.

2. Upstream Slope. Considerable settlement of the riprap was noted, with large pockets of unprotected slope evident all along the slope above the high water line, as shown in Photos No. 3. Several significant areas of erosion also were noted close to the crest on this slope, as shown in Photo No. 4.

Riprap protection on the east side, however, which sustains the most wave action, appeared to be in good condition, as shown in Photo No. 5.

3. Downstream Slope. In all areas the downstream slope had a cover of heavy grass and alfalfa vegetation, as shown in Photo No. 6. There was no indication of seepage through any part of the

dam and the toe drains were flowing only slightly, as shown in Photo No. 7. There was no evidence of any rodent activity on the upstream or the downstream slopes.

D. Inlet. On the day of the inspection water from the Lee, Stewart & Eskins Ditch was flowing into the reservoir through the concrete inlet located at the left end of the dam, as shown in Photo No. 8. No erosion was noted in the area of this inlet.

E. Outlet Works. On the day of inspection the outlet was open, as it is at all times, with water flowing through the conduit and into the stilling basins of the water filtration plant. Because this is a continuous use filter plant, it is not practical to close down the outlet completely unless signs of distress in the embankment would warrant a more thorough inspection. However, the manually operated gate screw located above the outlet conduit was exercised for several turns. The screw turned without difficulty, however, a common pipe wrench, rather than the gear handle had to be used due to the lack of space between the gear stem and the slope of the embankment. (See Photo No. 9).

There was no padlock on this manually operated gate screw and nothing to prevent unauthorized persons from operating the device with a pipe wrench or other tools.

F. Spillway. On the day of inspection the 6 foot high Fabridam located in the east bay of the ogee spillway was filled to capacity with 100 percent water. (See Photo No. 14). The 10-ft. high Fabridam located in the west bay of the spillway was filled with 60 percent water and 40 percent air. There were no signs of leakage through or around the Fabridams, with the patches made in March apparently holding well. (See Photos 15 and 16). The anchor bolts and other hardware that hold the Fabridams in place appeared to be in good condition. The stilling basin at the bottom of the spillway contained about 4 feet of water. This, according to Mr. Hahn, acts as a deterrent to unauthorized persons

who might want to gain access to the spillway and Fabridams. There is a drain in the bottom of the stilling basin that can allow the basin to be emptied of water. All concrete surfaces of the spillway were in excellent condition and the entire chute and channel were free of obstructions, as shown in Photo No. 17.

G. Floodplain. The floodplain immediately below the Maple Grove Dam was as described on page 10 of the Project Description. All debris from the March 17, 1979 spilling of the reservoir had been cleared away and there was no evidence of any new construction directly in the path of the outflow.

H. Emergency Plan. Following the March 17, 1979 vandalism of the Fabridams, extensive safety and emergency measures have been adopted to prevent a similar occurrence. An emergency procedure manual has been prepared on the operation of the Fabridam. Copies are located in the control house, the filter plant and copies are also available with the State Engineer's Office and the Urban Drainage and Flood Control District. Any minor changes in the internal pressures of the Fabridams caused by changes in the water surface elevation, are registered electronically and after a two minute duration an alarm is sounded in the filter plant where personnel are constantly on duty. They would notify the proper local and state authorities if warranted and it would be determined if evacuation of downstream areas was prudent. According to the State Engineer's Office, an evacuation plan is in operation where the discharge of 500 cfs or more from the spillway warrants the initiation of evacuation procedures for residents in the downstream flood plain.

Officers and directors of The Consolidated Mutual Water Company are:

William R. Cornelison	Chairman of Board
Leslie B. Arnold	Board of Directors
Conrad R. Becker	Board of Directors
Edward L. Northway	Board of Directors

William G. Purdy	Board of Directors
Virgil L. Hill	President & General Manager
Glen E. Whitten	Vice President, Engineering and Operations
John F. Meurer	Vice President, Administration and Finance
Martha Lee Lydick	Secretary-Treasurer

Company offices are located at 10075 W. Colfax Avenue, Lakewood, Colorado 80215

VII. HYDRAULIC AND HYDROLOGIC EVALUATION

A. General. The hydraulic and hydrologic analysis of the study requires that the storm inflow hydrograph be computed and routed through the dams using two different procedures: (1) The U. S. Bureau of Reclamation procedure, as detailed in their publication Design of Small Dams, 2nd Edition, dated 1973 (hereinafter referred to as DSD Procedure), and (2) the Corps of Engineers procedure as detailed in their publication Investigation of Dams, Hydrologic Analysis, Program 723-C1-410. The more severe of the two inflow flood hydrographs is to be used in assessing the capabilities of the existing facility. Furthermore, the DSD Procedure requires that the probable maximum flood for the 6-hour storm as well as the probable maximum flood for the 1-hour thunderstorm be computed and compared.

B. DSD Procedure.

1. PMP 6-Hour Storm

a. Design Precipitation. The probable maximum 6-hour precipitation for 10 square miles for the location of Maple Grove Reservoir is 22 inches as obtained from the U. S. Weather Bureau Publication, Technical Paper No. 40. Since the drainage area for Maple Grove Reservoir is 10.9 square miles, slightly greater than 10.0 square

miles, there is no reduction for drainage area. There is an adjustment, however, to provide for the improper storm fit. This adjustment is shown on Plate 5 - Appendix D.

b. Runoff Index. Runoff index for the drainage basin was determined to be CN = 83 as shown in the calculations contained in Plate 4 - Appendix D.

c. Unit Hydrograph Calculations. With the physical characteristics of the basin (See Plate 3 - Appendix D), the time of concentration was determined to be 1.86 hours. The time to peak, Tp, was 1.62 hours and the base time, Tb, was 4.33 hours. The peak discharge for the unitgraph Qp, was 3260 cubic feet per second. Based on this information, plus the design precipitation, and the runoff index, the amount of direct runoff was calculated and is shown in Plate 5 - Appendix D. This table shows that the total amount of runoff expected to be generated by the 22 inches of rainfall is 16.5 inches. From the values in the plotting table on this chart, the probable maximum flood from the PMP 6-hour storm has been plotted on Plate 6. This storm inflow hydrograph indicates that the peak runoff will be 34,300 cfs and that the entire storm will generate a total runoff volume of 9,590 acre-ft.

This storm inflow hydrograph was routed through Maple Grove Reservoir by using the Corps of Engineers' computer program. Ordinates from the plot of the inflow hydrograph were read off Plate 6 at 15 minute intervals and entered into the program. The storm was routed based on three operating conditions of the Fabridam: (1) the Fabridams operating properly; (2) the Fabridams inflated and

remaining inflated; and (3) the Fabridams completely deflated. These discharge relationships are shown on the plans, Appendix C - Plate 6 and in Appendix E - Attachment 2 - Sheet 11.

Plate 7A of Appendix D shows this routing with the Fabridams operating properly. This means that both Fabridams remain inflated until the water surface elevation reaches 5530.65. At this level, the 1" water release valve from the 6 foot Fabridam opens and the 6 foot Fabridam slowly begins to deflate. At elevation 5530.75, the 1/2 inch air release valve from the 10 foot Fabridam opens and begins to deflate. At elevation 5530.95 both Fabridams are deflating at maximum speed and will fully deflate if the water surface elevation continues to rise. This schedule is fully described in Appendix E - Attachment 5.

Plate 7A shows that 30 percent of the flood inflow hydrograph can be passed without overtopping the crest. Plate 7B is the same routing with the Fabridams fully inflated for the entire flood duration. This would only happen if each of the four valves on both of the Fabridams failed to open. Since there are syphons on each Fabridam which would operate as a "fail-safe" to deflate these dams at critical water levels, this condition is highly improbable. Should this happen, however, only 10 percent of the probable maximum flood could be passed without overtopping. With the other extreme, the Fabridams being completely deflated, the routing shows that 40 percent of the inflow hydrograph can be passed without overtopping (Plate 7C).

2. PMP 1-Hour (Thunderstorm).

a. Design Precipitation. Figure 20 in DSD shows that the probable maximum thunderstorm 1-hour point rainfall for the Maple Grove Reservoir site is 13 inches. Figure 21 in DSD is used to convert this point rainfall value to an

area rainfall value based on the drainage area. From this, the design precipitation was determined to be 11.6 inches.

b. Runoff Index. Table A-9, DSD, shows that for Zone III -- brush, sage, grass -- less than 50 percent the CN is 75.

c. Unit Hydrograph Calculations. Using a 15-minute unit-graph determination, the time to peak is 1.25 hours, base time is 3.34 hours and Qp is 4,220 cfs. (See calculations in Plate 4). The direct runoff table (Plate 8) shows that 11.9 inches of runoff are to be expected in this storm event. Plate 9 is the plot of the flood from the thunder-storm. The peak runoff is 39,900 cfs, and the total volume of runoff is 6,920 acre-ft. Ordinates from this inflow hydrograph were also read off the graph and entered into the computer. Plate 10A shows that with the Fabridams operating properly, only 20 percent of this inflow hydrograph can be passed without overtopping the crest. Only 10 percent of this flood can be passed with the Fabridams fully inflated (Plate 10B) and 30 percent of the flood can be passed with the Fabridams fully deflated. (Plate 10C)

C. Corps of Engineers Procedure

1. Unitgraph and Storm Data. Numerous options for obtaining these values are available in the Corps of Engineers program. For the unitgraph values, the option to compute Snyder's unitgraph was chosen. The area, length and length to the centroid of the basin were entered as well as a Cp value of 0.58 and Ct value of 0.72. The W50 and W75 values computed to be 2.60 hours and 1.50 hours, respectively. The computed Snyder's 0.25 hour unitgraph is shown as Plate 11. The PMP index entered was 22 inches with an initial loss of rainfall of 0.3 inches

and an infiltration rate of 0.3 inches per hour. The computed probable maximum flood is shown as Plate 12.

2. Reservoir Characteristics. Again, numerous options were available to the program user to enter the reservoir characteristics into the analysis. For the lake elevation--area--capacity data, ordinates for the capacity at each one foot increment of water surface elevation were read off the project plan shown as Appendix C - Plate 1 and entered into the program. The spillway discharge values at each foot of water surface elevation were read off the chart previously discussed. The outlet works discharge values were entered using the program option for computing the rating curve based upon physical characteristics. The top of dam rating was computed using the weir formula option. Plate 13 is the Lake Elevation, Storages and Discharge Rating Table which shows all these relationships based on the water surface elevation. The inflow hydrograph was routed through the reservoir and the results are shown on Plates 14A, B,and C. This analysis shows that the PMP produces 9,178 acre-ft. of total inflow. The respective percentages of the PMP that can be passed without overtopping the crest are 50, 20 and 50 for the Fabridams operating properly, being inflated and being deflated.

D. Conclusions and Recommendations. The hydraulics of Maple Grove Reservoir are very complex due to its residential location and the downstream floodplain. The Fabridams have been designed so that the four foot freeboard between the top of the 6 foot Fabridam and the top of the 10 foot Fabridam will pass a maximum of 1700 cfs. This is the 100 year frequency design amount for which the Lena Gulch channel is intended to be constructed downstream of the dam. As of this report writing, this channel improvement has not yet been accomplished. The 10 foot Fabridam is owned

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by the Urban Drainage and Flood Control District and its purpose is to store any inflow into the reservoir except the 1700 cfs in a 100 year flood. Once the water level exceeds the top of the 10 foot Fabridam by a small amount, both the 6 foot Fabridam and 10 foot Fabridam begin to deflate and will completely deflate if need be and the spillway will then pass a maximum of 13,970 cfs which corresponds to the Standard Project Flood.

This hydraulic and hydrologic analysis, however, requires that the Probable Maximum Flood be evaluated. The criteria for reviewing the hydrologic adequacy of a dam states that the spillway is considered "seriously inadequate" and the dam "unsafe" if the spillway is not capable of passing one-half of the Probable Maximum Flood as determined by the Corps of Engineers' procedure without overtopping the dam. Since 50% of this flood can be passed, the dam is not to be considered unsafe.

Plate 14A shows that for a starting pool elevation of 5525 feet (which is at the fold or low point of the 6 foot high Fabridam) the low point of the dam is overtopped 1.51 feet by the Probable Maximum Flood event with a duration of embankment overflow of 4.64 hours. During this time, the total volume of water that would spill over the top of the dam would be 2,745 acre-feet. Velocities of this water overtopping the embankment would be 5.69 feet per second at the crest and 18.01 feet per second at the toe. Since the crest is 40 feet wide at the top and has an asphalt paved city street running its length, it is highly unlikely that this anticipated overflow velocity would cause erosion at the crest. At the toe, erosion is more likely to occur, but with the thickness of the embankment and with the crest remaining in tact, it is extremely unlikely that a breach of the embankment would occur.

A breach of course would have severe impact to the downstream floodplain area. Since cross-sections of the downstream channel were not available for this study, it is not known

whether water overtopping the dam (without causing a breach failure) would cause significantly more damage than that caused by the maximum discharge from the spillway. Since the spillway can pass approximately 12,300 cfs prior to overtopping, there would be significant damage to the downstream floodplain as the Lena Gulch drainageway has been designed to accommodate only 1,700 cfs and the improvements to the channel to carry this discharge have not yet been accomplished.

Evacuation of the floodplain would be initiated as soon as 500 cfs was being discharged from the spillway. The installation of a gaging station along Lena Gulch upstream of the dam would greatly facilitate the prediction of when such a discharge might occur. The residential limits for evacuation should be established based upon the maximum discharge from the dam, which according to Plate 10A, could be 39,676 cfs. These limits should be agreed upon by the Urban Drainage and Flood Control District and coordinated with the local agencies who would actually supervise the evacuation. The Consolidated Mutual Water Company would have the responsibility to carefully monitor discharge from the spillway and to initiate the evacuation procedures if warranted.

The existing spillway is not to be considered "seriously inadequate" because it is capable of passing at least one half of the Probable Maximum Flood as determined by the Corps of Engineers procedure. It is, however, to be considered "inadequate" since it passes only 50% and additional spillway capacity and/or storage capacity is desirable.

VIII. STRUCTURAL AND GEOTECHNICAL EVALUATION

A. General. The evaluation of the structural stability for this dam is based on the visual inspection, available design data, construction records and history, operational procedures and conversations with people familiar with the project.

B. Embankments. W. 27th Avenue formerly did not have curb and gutter along its length to control surface runoff. Consequently, water drained off the pavement and eroded the embankment primarily on the upstream side. (See Photo No. 4). Curb and gutter have now been installed on both sides of the street.

The riprap on the upstream slope is generally very large and there is not a proper gradation in size. (See Photo No. 3). As a result, some slippage of the riprap has occurred.

The settlement in the pavement at the bridge abutment is not too excessive, but if allowed to continue, further deterioration of the pavement surface will occur.

Both the outlet works conduit and the Rocky Mountain Ditch culvert are metal structures that run through the embankment. Metal is subject to corrosion and possible leakage especially when a pipe is continually under pressure such as the outlet works conduit for this reservoir. Leakage from either of these pipe structures could be quite dangerous, especially for this dam since the downstream slope is so steep. (1 vertical on 1.75 horizontal slope.) This slope is steeper than that normally considered stable with embankment material of clays and sandy clays. Surface slides could be expected anytime the slope becomes saturated to any appreciable depth. A high pool could cause saturation of the downstream toe and a slide could result.

There is no information which indicates adverse effects on the embankment with water elevations at or near the top of the dam.

C. Spillway. The concrete spillway, chute and settling basin are all in excellent condition. As noted previously, the 6 foot high Fabridam was punctured in two locations by vandals. These holes have been repaired by the manufacturer's representative with a patch on the inside and a double patch on the outside. One of these patches is shown in Photo No. 16 and they are

both holding up very well.

The spillway was clear of any restrictions that might retard the discharge of floodwaters.

D. Outlet Works. There was no indication of leakage from the outlet conduit and no leakage was evident in the downstream control well. Due to the size and the fact that it was conveying water, the interior of the conduit was not inspected.

IX. ASSESSMENT AND RECOMMENDATIONS

A. General. Maple Grove Reservoir, due to its high hazard potential and the vandalism to the Fabridams in March of 1979, is probably the most closely monitored intermediate size dam in the State of Colorado. In addition, The Consolidated Mutual Water Company maintains a staff of highly qualified engineers to oversee the operation of the dam and the filter plant. While it is in excellent condition, the following recommendations should be implemented to improve the structural integrity and operational adequacy of the project.

B. Embankments. The City of Lakewood has maintenance responsibilities for W. 27th Avenue. They should inspect the condition of this roadway and schedule the rehabilitation of this pavement surface as soon as possible.

A yearly maintenance program of backfilling eroded areas and stabilizing the upstream and downstream slopes should be implemented.

A stability analysis should be conducted (if not already done) to assure that the steep downstream slope is stable for a maximum pool elevation.

C. Outlet Works. The upstream gate control should be secured in an open position to prevent unauthorized closure.

The outlet works conduit and the Rocky Mountain Ditch culvert through the embankment should be periodically inspected

to determine if any leakage is evident. Resistivity tests should be conducted to estimate the life expectancy of the pipe material. The portion of embankment above the outlet works conduit should especially be watched for wet spots which could indicate leakage.

D. Spillway. Efforts should continue on arranging an emergency power supply for operation of the Fabridams.

E. Flood Monitoring. As recommended by the State Engineer's Office, the location of a gaging station along Lena Gulch upstream of the dam, should be a high priority for The Consolidated Mutual Water Company and the Urban Drainage and Flood Control District.

The boundaries of the area to be evacuated should be established based upon the maximum discharge from the dam which has been shown to be 39,676 cfs. The Consolidated Mutual Water Company should be responsible for monitoring the discharge from their spillway and initiating evacuation procedures whenever an amount of 500 cfs is discharging.

F. Contingency Plan for Emergencies. It is recommended, as for all high hazard dams, that a contingency plan for emergencies be prepared and adopted by the owners of the facility and then reviewed and coordinated with local authorities. The Consolidated Mutual Water Company has a good beginning in their operational manual for the Fabridams. They should incorporate this into a formal plan which should include, but not be limited to, the following: the location of stockpile/barrow materials; the location of available construction equipment; the identification of remedies to problems such as developing seepage and/or erosion; notification procedures in case of an emergency; evacuation procedures in case of an emergency; and training for emergencies.

APPENDIX A

INSPECTION CHECKLIST

30 Dec 77

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam Maple Grove

State Located Colorado
County Located Jefferson
Stream Lena Gulch (off-channel South Platte)
Date of Inspection August 6, 1979

Brief assessment of general condition of dam with respect to safety and recommended action with degree of urgency. The assessment will describe any conditions found during the inspection that are considered to have adverse effect on dam safety and the assessment of the gravity of these conditions. If no such conditions are noted, this fact will be reported. Under no situation will the report imply a guarantee or assurance that the dam is "safe."

Signature and registration identification of the professional engineer who did the investigation and who was responsible for the evaluation.

GEORGE S. CLAUSEN
REGISTERED
PROFESSIONAL ENGINEER
STATE OF COLORADO

George S. Clausen

INSPECTION CHECKLIST

NAME OF DAM: Maple Grove
STATE: Colorado
COUNTY: Jefferson
INVENTORY NO.:
HAZARD CATEGORY: I
TYPE OF DAM: Earth fill

OWNER: The Consolidated Natural Water Co.
DATE INSPECTED: 8-6-79
WEATHER: Sunny, hot
TEMPERATURE: 90°
POOL ELEVATION: 28.2
TAILWATER ELEVATION: NA.

DIRECTIONS: Mark an "X" in the YES or NO column.
If an item does not apply, write "NA" in the REMARKS column.

ITEM	YES	NO	REMARKS
1. CREST.			
a. Any visual settlements?	X		Road washed out at edge of east bridge abutment (overspillway)
b. Misalignment?		X	
c. Cracking?	X		
2. UPSTREAM SLOPE.			
a. Adequate grass cover?	X		
b. Any erosion?		X	some where roadway drainage hits face.
c. Are trees growing on slope?		X	
d. Longitudinal cracks?		X	
e. Transverse cracks?		X	
f. Adequate riprap protection?		X	Needs more graded rip rap even though major direction of wind is not against this face. — Wind movement is towards east shore of res. — Rip rap placed here.
g. Any stone deterioration?		X	
h. Visual depressions or bulges?		X	
i. Visual settlements?		X	
3. DOWNSTREAM SLOPE.			
a. Adequate grass cover?	X		
b. Any erosion?		X	
c. Are trees growing on slope?		X	
d. Longitudinal cracks?		X	
e. Transverse cracks?		X	
f. Visual depressions or bulges?		X	
g. Visual settlements?		X	
h. Is the toe drain dry?		X	draining properly.
i. Are the relief wells flowing?			(NA)
j. Are boils present at the toe?		X	
k. Is seepage present?		X	toe drain intercepting
4. ABUTMENT CONTACTS.			
a. Any erosion?		X	
b. Visual differential movement?		X	
c. Any cracks noted?		X	
d. Is seepage present?		X	
5. INTAKE STRUCTURE.			Inaccessible
a. Do concrete surfaces show			
(1) Spalling?			
(2) Cracking?			
(3) Erosion?			
(4) Scaling?			
(5) Exposed reinforcement?			
(6) Other?			
b. Do the joints show			
(1) Displacement or offset?			
(2) Loss of joint material?			
(3) Leakage?			

c. Metal appurtenances?
(1) Corrosion present?
(2) Breakage present?
(3) Anchor system secure?

6. CONDUIT.
a. Is the conduit concrete?
b. Do concrete surfaces show
(1) Spalling?
(2) Cracking?
(3) Erosion?
(4) Scaling?
(5) Exposed reinforcement?
(6) Other?
c. Do the joints show
(1) Displacement or offset?
(2) Loss of joint material?
(3) Leakage?
d. Is the conduit metal?
(1) Corrosion present?
(2) Protective coatings adequate?
(3) Is the conduit misaligned?

7. STILLING BASIN.
a. Do concrete surfaces show
(1) Spalling?
(2) Cracking?
(3) Erosion?
(4) Scaling?
(5) Other?
(6) Exposed reinforcement?
b. Do the joints show
(1) Displacement or offset?
(2) Loss of joint material?
(3) Leakage?
c. Do the energy dissipating devices show
(1) Signs of deterioration?
(2) Are they covered with debris?
(3) Other?
d. Is the channel
(1) Eroding or backcutting?
(2) Sloughing?
(3) Obstructed?
e. Is released water
(1) Undercutting the toe of?
(2) Eroding the embankment?

8. SPILLWAY.
a. Does spillway concrete show
(1) Spalling?
(2) Cracking?
(3) Erosion?
(4) Scaling?
(5) Other?
(6) Exposed reinforcement?
b. Do the joints show
(1) Displacement or offset?
(2) Loss of joint material?
(3) Leakage?

Inaccessible

Inaccessible

M&I water flows directly into filter plant - only a small amount of irrigation water requires a stilling basin & ditch. — This is OK!

Spillway is only 2 or 3 yrs. old & in very good shape

ITEM	YES	NO	REMARKS
c. Do the energy dissipators show:			
(1) Signs of deterioration?		X	
(2) Are they covered with debris?		X	
(3) Other?		X	
d. Is the spillway earth cut?	X		downstream from spillway
(1) Are slopes eroding?	X		
(2) Are slopes sloughing?	X		
(3) Other?		X	
e. Is the channel:			
(1) Eroding or backcutting?		X	
(2) Obstructed?		X	
f. Has released water:			
(1) Eroded the embankment?			
(2) Undercut the outlet?			
(3) Other?			distorted gabions
g. Is weir in good condition?			
h. Is control at the weir?			
9. GATES			
a. Are the flood gates:			inflatable fabridams
(1) Broken or bent?		X	
(2) Corroded or rusted?		X	
(3) Periodically maintained?	X		
(4) Operational?	X		
(5) Pre-last operation:			periodically fabridams operational
b. Is there a log over gate?			
c. Is the low-level gate operational?			
10. RESERVOIR CONTROL			
a. Recent upstream development?	X		
b. Sudden increase in reservoir area?		X	
c. Change in reservoir operation?			yes at time of installation of fabridams
d. Large encroachment of stream?			
11. INSTRUMENTATION			
a. List type(s) of instrumentation:			
b. In good condition?			
c. Read periodically?			
d. Is data available?			

Other comments: Town of Lakewood is supposed to repair bridge crossing on dam crest. Road stormdrainage should be directed off upstream face. Rip rap all one size (large) some slipping because of this. Spillway is constructed in earth cut portion - spillway discharge would jump to east and erode a new channel during large flows. Sabotaged fabridams repaired & no leakage!

This dam was inspected by:

George A. Clausen P.E.

APPENDIX B

INSPECTION PHOTOGRAPHS

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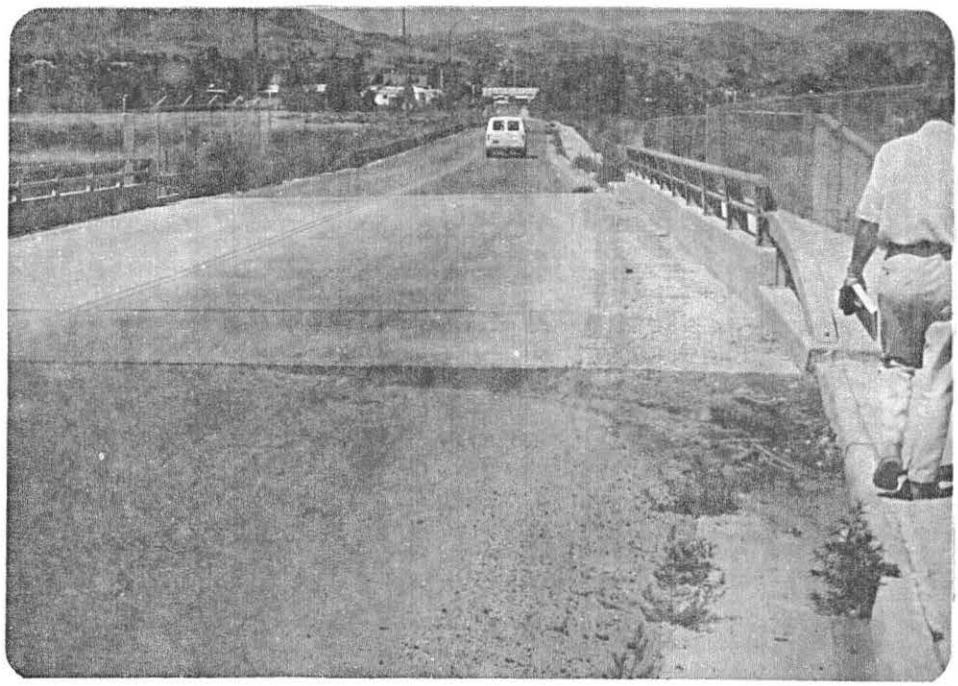

Photo No. 1 Crest of Maple Grove Dam, looking west.
Note erosion and depression at right bridge abutment.

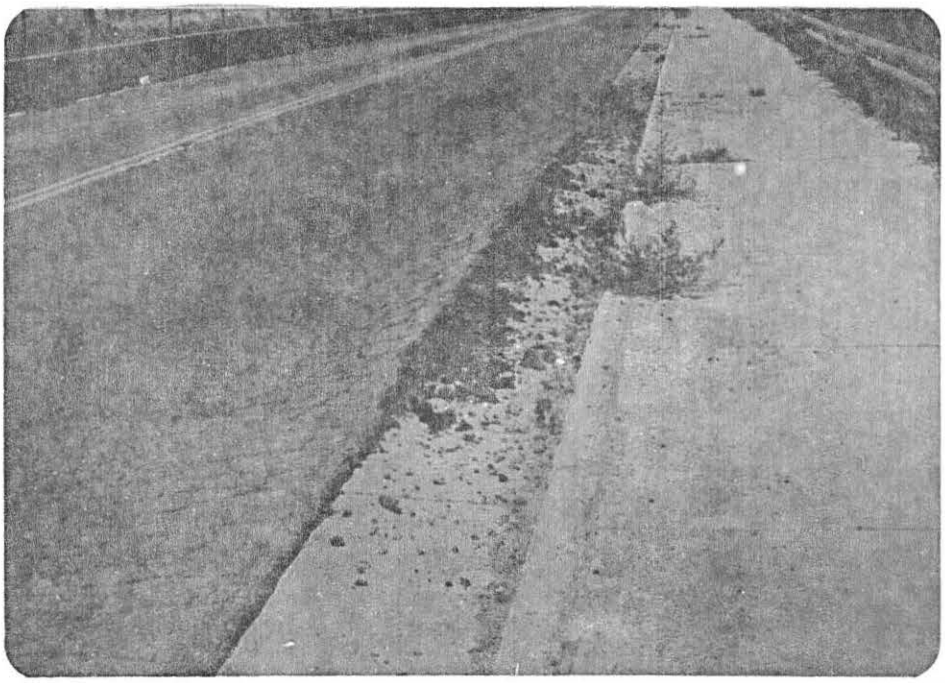

Photo No. 2 Pavement deterioration on north side of crest.

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Photo No. 3 Upstream slope, showing misgraded riprap. Typical of entire upstream slope.

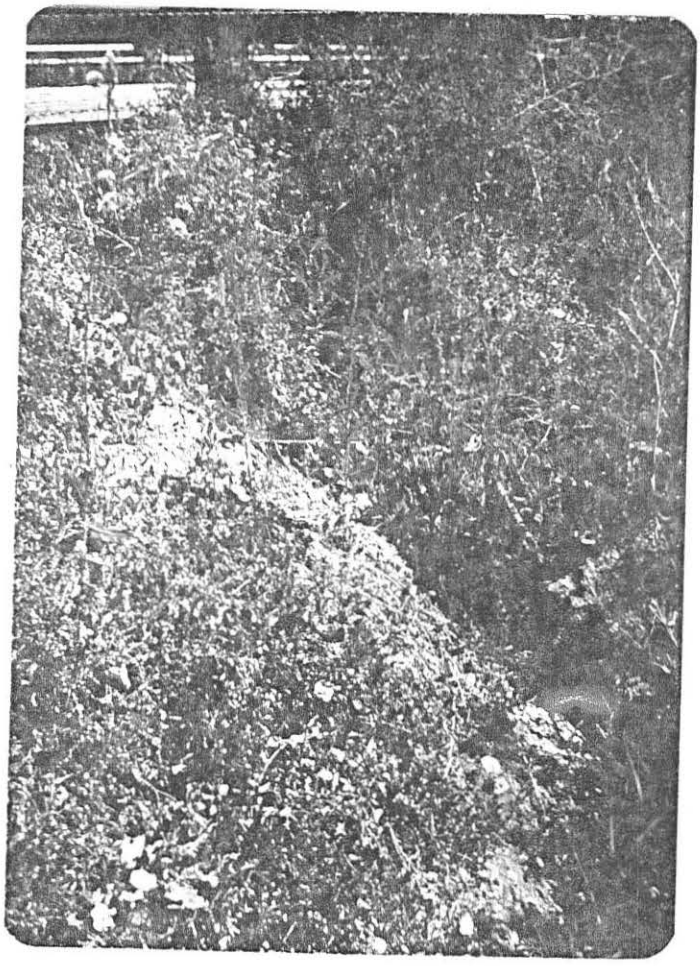

Photo No. 4
Eroded area on upstream slope near crest.

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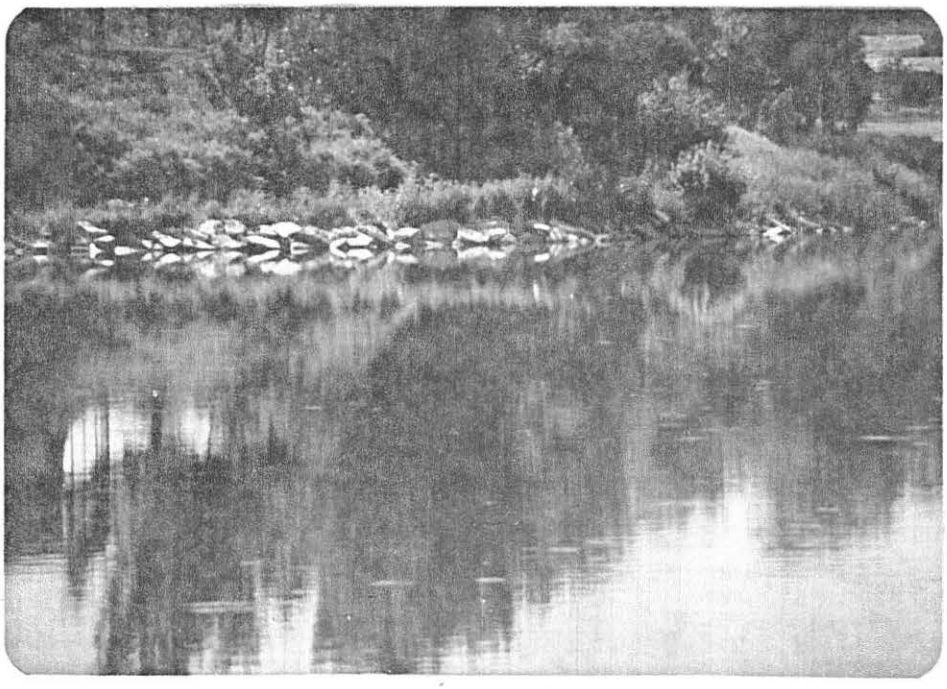

Photo No. 5 Riprapped eastern shore of reservoir.

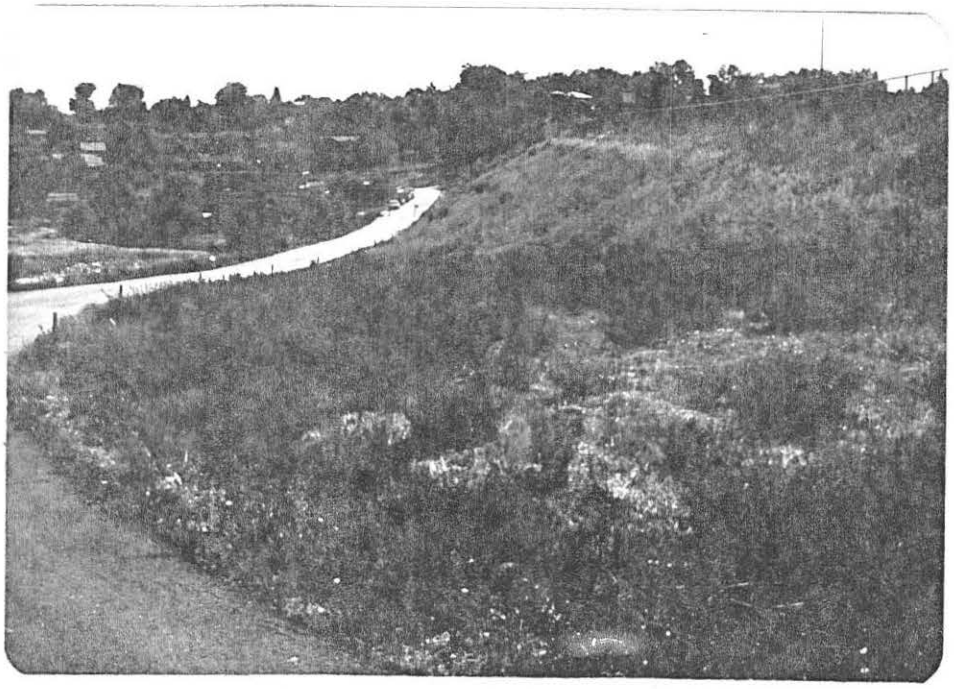

Photo No. 6 Downstream slope of embankment, with service road to filter plant at left.

RMC

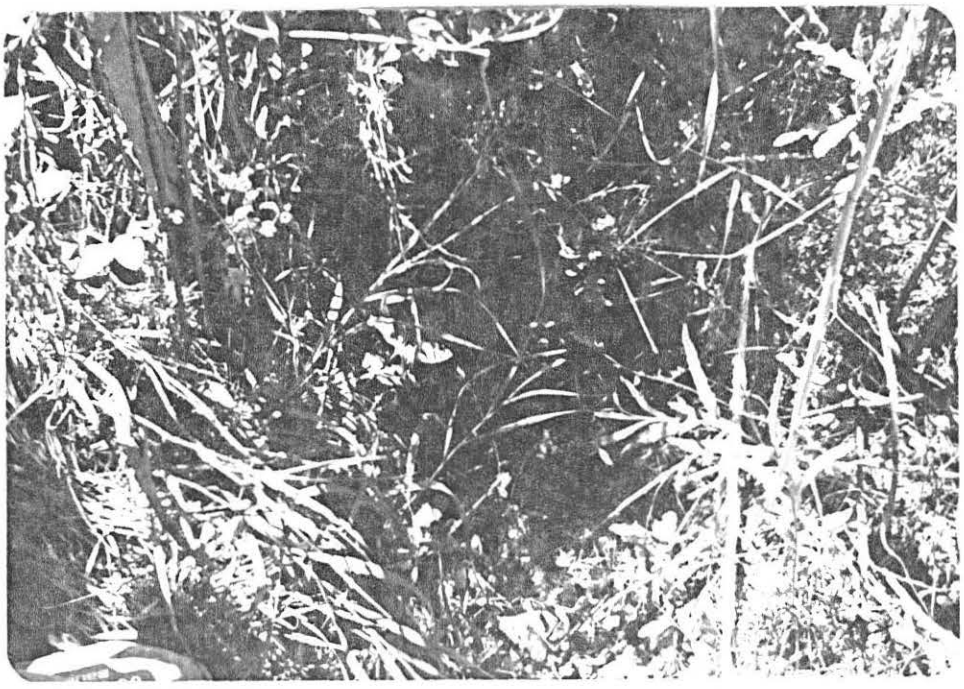

Photo No. 7 Toe drain downstream of left toe, with small amount of water flowing from drain. (Arrow)

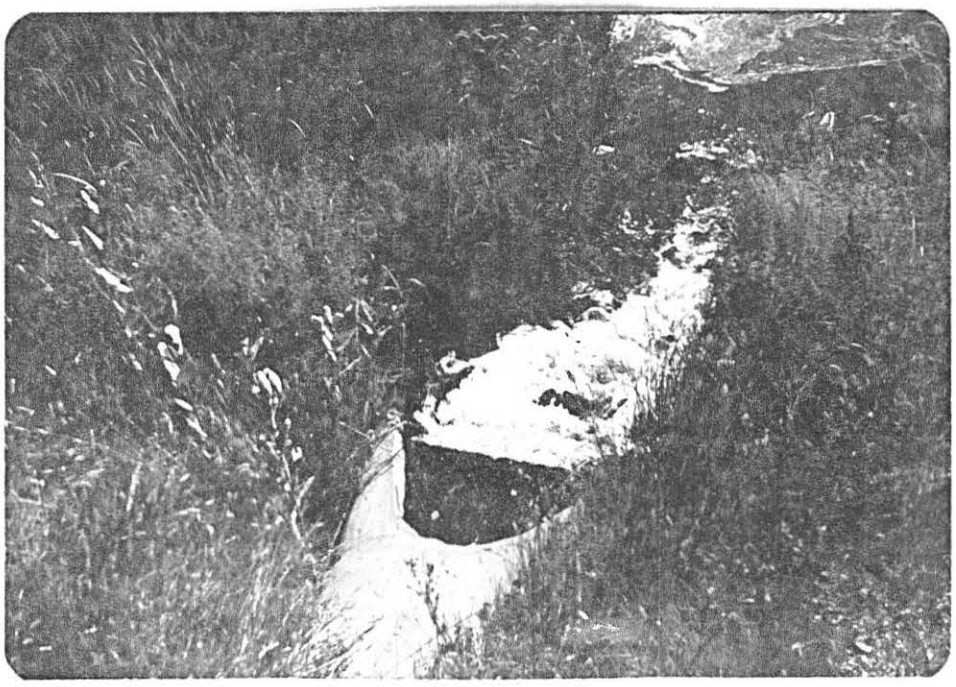

Photo No. 8 Lee, Stewart and Eskins inlet near the west end of the dam.

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Photo No. 9 Manual operation of the gate screw. Slope of the embankment prevents full turning of the gear with handle.

Photo No. 10 Interior of gate house for releases into filter plant and small irrigation ditch.

Photo No. 11
Irrigation ditch outlet and stilling basin adjacent to gate house.

RMC

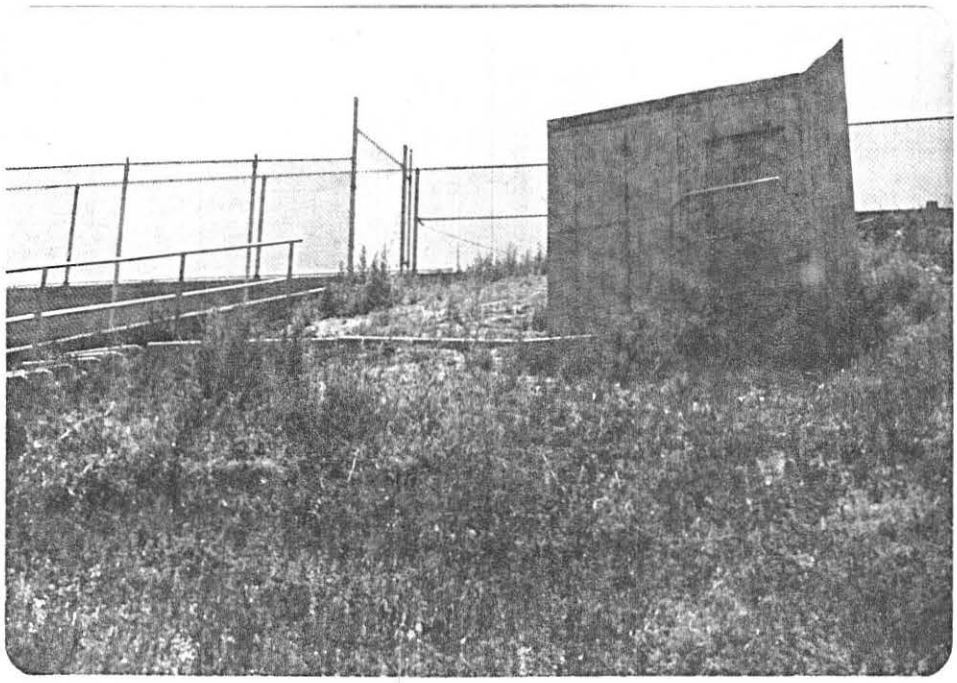

Photo No. 12 Exterior of Fabridam control tower with security fencing in background.

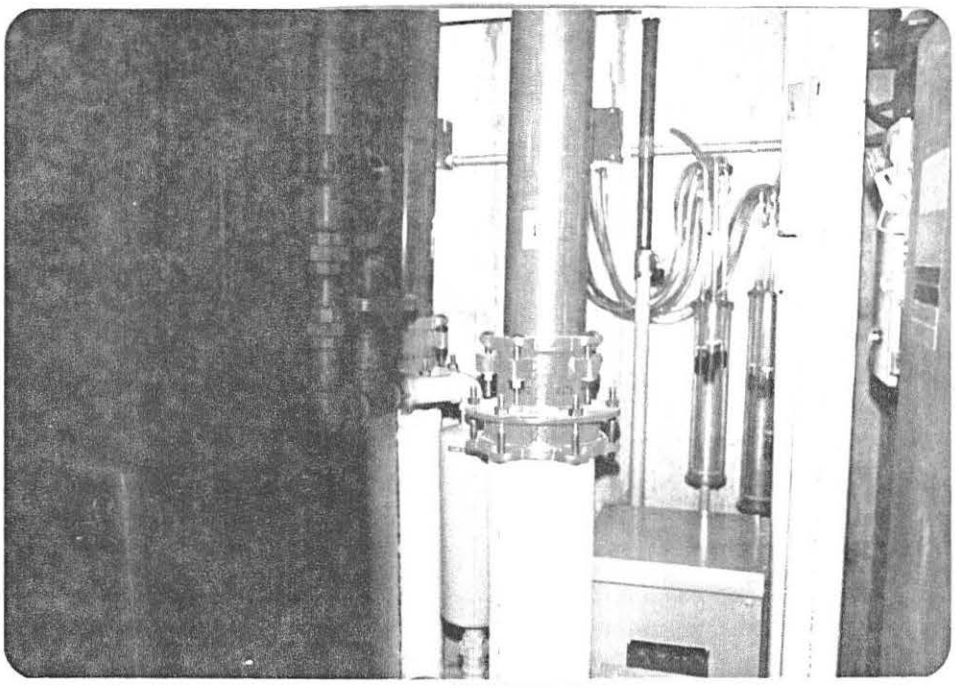

Photo No. 13 Interior of control house, showing valves which monitor Fabridam pressures and water levels.

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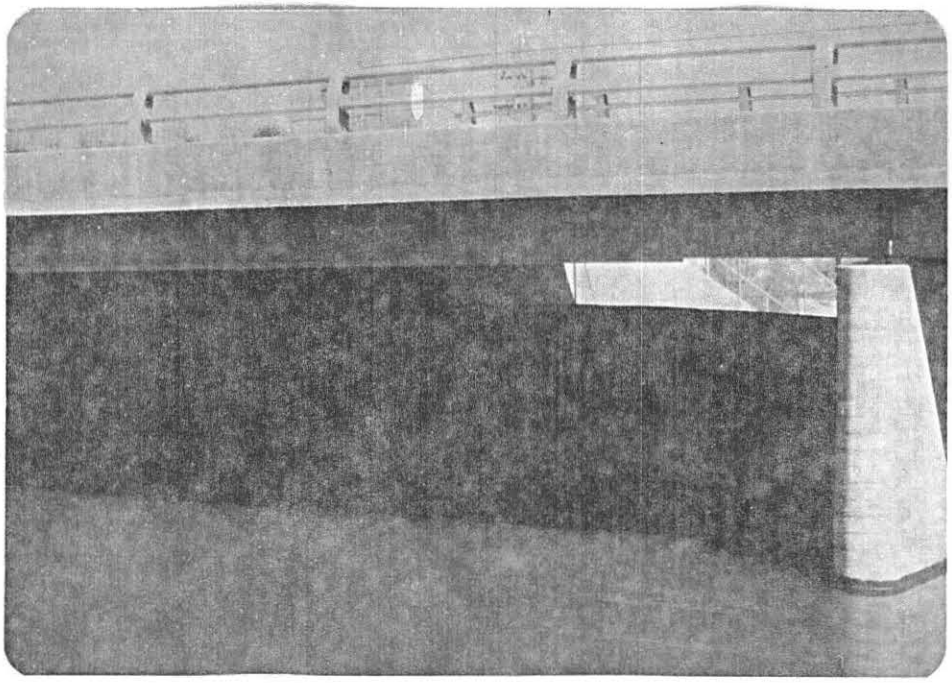

Photo No. 14 Upstream view of 10-ft. high Fabridam in west bay of spillway.

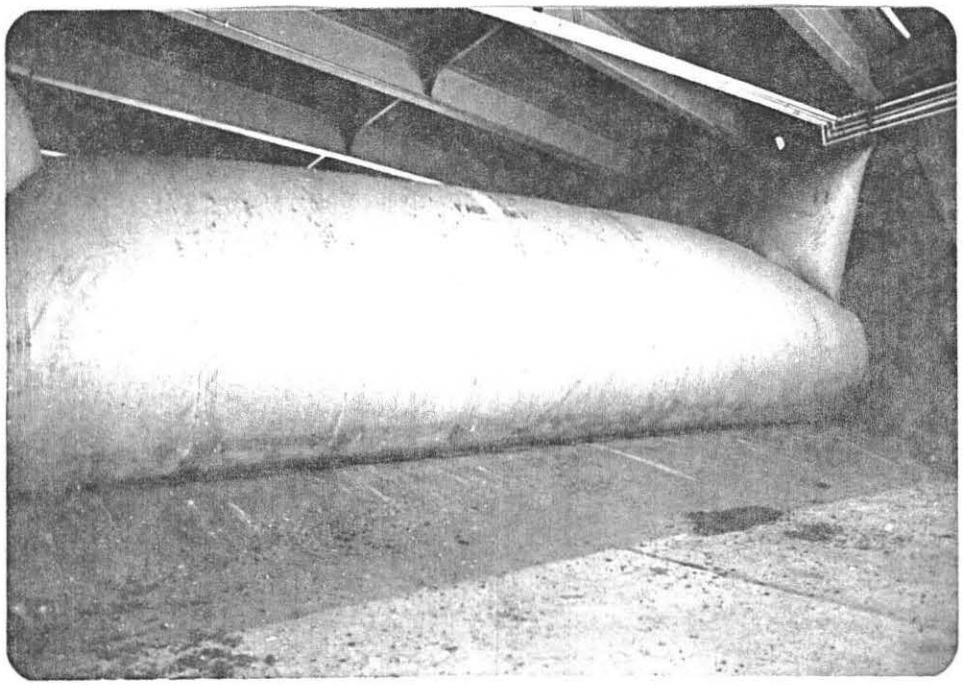

Photo No. 15 Downstream view of 10-ft. high Fabridam.

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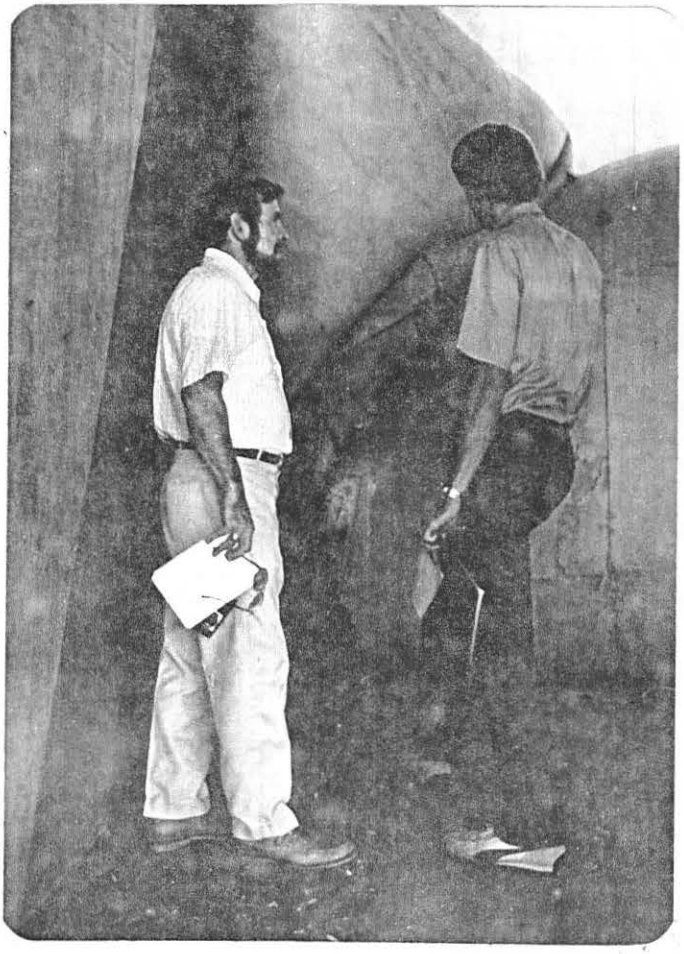
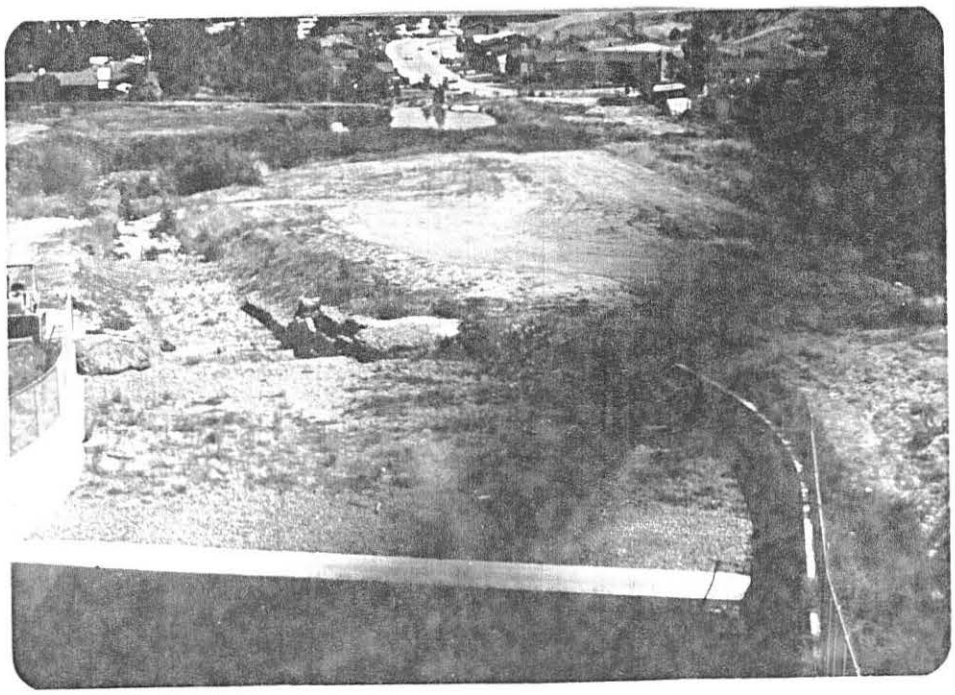


Photo No. 16 View of repaired area in fold of 6-ft. Fabridam.

Photo No. 17 Stilling basin, spillway channel and floodplain of Maple Grove Dam.



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APPENDIX C

PROJECT PLATES

Plate 1	1955 Construction - Plan and Capacity Table
Plate 2	1955 Construction - Profile and Typical Dam Section
Plate 3	1955 Construction - Outlet Facilities
Plate 4	1955 Construction - Spillway and Culvert Details
Plate 5	1960 Improvement - Relocated Spillway
Plate 6	1977 Improvement - Plan
Plate 7	1977 Improvement - Spillway Plan and Section
Plate 8	1977 Improvement - Spillway Wall Elevations
Plate 9	1977 Improvement - Spillway Sections and Details

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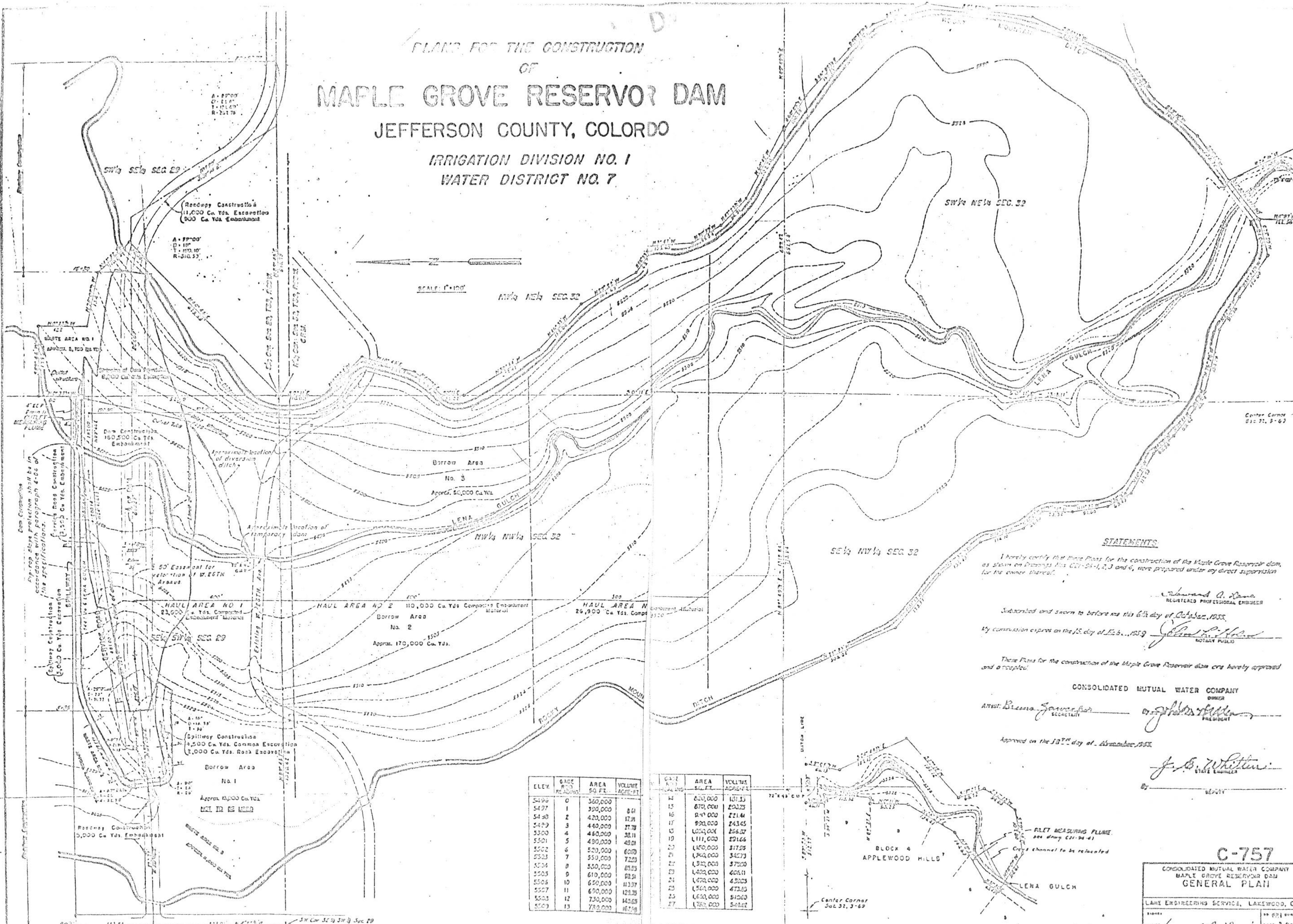
PLANS FOR THE CONSTRUCTION OF MAPLE GROVE RESERVOIR DAM

JEFFERSON COUNTY, COLORADO

IRRIGATION DIVISION NO. 1
WATER DISTRICT NO. 7



ELEV.	GAGE ROD READING	AREA SQ. FT.	VOLUME ACRE-FT.
5496	0	360,000	
5497	1	390,000	8.61
5498	2	420,000	17.91
5499	3	440,000	27.78
5500	4	460,000	38.11
5501	5	490,000	49.01
5502	6	520,000	60.90
5503	7	550,000	72.23
5504	8	580,000	85.55
5505	9	610,000	98.51
5506	10	650,000	113.37
5507	11	690,000	129.35
5508	12	730,000	143.63
5509	13	780,000	161.98

GAGE ROD READING	AREA SQ. FT.	VOLUME ACRE-FT.
14	820,000	181.35
15	870,000	200.25
16	930,000	221.41
17	990,000	243.45
18	1,050,000	266.07
19	1,111,000	291.66
20	1,180,000	317.25
21	1,260,000	345.73
22	1,330,000	375.00
23	1,400,000	406.11
24	1,470,000	439.03
25	1,560,000	473.83
26	1,650,000	510.63
27	1,750,000	549.62

STATEMENTS

I hereby certify that these Plans for the construction of the Maple Grove Reservoir dam, as shown on Drawings Nos. C21-94-1, 2, 3 and 4, were prepared under my direct supervision for the owner thereof.

Howard A. Lane
REGISTERED PROFESSIONAL ENGINEER

Subscribed and sworn to before me this 6th day of October, 1955.

My commission expires on the 15 day of Feb., 1959 ________
NOTARY PUBLIC

These Plans for the construction of the Maple Grove Reservoir dam are hereby approved and accepted.

CONSOLIDATED MUTUAL WATER COMPANY
OWNER

Attest: ________ SECRETARY   By ________ PRESIDENT

Approved on the 18th day of November, 1955.

J. E. Whitten
STATE ENGINEER

By ________
DEPUTY

C-757

CONSOLIDATED MUTUAL WATER COMPANY
MAPLE GROVE RESERVOIR DAM
GENERAL PLAN

LANE ENGINEERING SERVICE, LAKEWOOD, COLO.

SIGNED: Howard A. Lane, REGISTERED PROFESSIONAL ENGINEER

DWG. C21-94-1

PROFILE AT ℄ OF DAM AND ROAD
SCALES: HORIZ. 1"=100'
VERT. 1"=10'

PROFILE AT ℄ OF SPILLWAY
SCALES: HORIZ. 1"=100'
VERT. 1"=10'

PROFILE AT ℄ OF SERVICE ROAD
SCALES: HORIZ. 1"=100'
VERT. 1"=10'

TYPICAL GUARD POST DETAIL
SCALE: 1/2"=1'-0"

TYPICAL SERVICE ROAD SECTION IN CUT
SCALE: 1"=10'

TYPICAL SERVICE ROAD SECTION IN FILL
SCALE: 1"=10'

TYPICAL HEADWALL DETAIL
SCALE: 1"=1'-0"

TYPICAL ROAD SECTION OVER DAM
SCALE: 1"=10'

TYPICAL DAM SECTION
SCALE: 1"=20'

TYPICAL ROAD SECTION IN CUT
SCALE: 1"=10'

FILTER ZONE AND DRAIN
SCALE: 1"=5'

TYPICAL ROAD SECTION IN FILL
SCALE: 1"=10'

C-757

CONSOLIDATED MUTUAL WATER COMPANY
MAPLE GROVE RESERVOIR DAM
PROFILES AND TYPICAL SECTIONS

LAKE ENGINEERING SERVICE, LAKEWOOD, COLO.

Approved on the 18th day of November, 1953
J. C. Whitten
STATE ENGINEER
By _____ DEPUTY

Edward A. Stone
STATE OF COLORADO
REGISTERED ENGINEER

DRAWN: EAS
DATE: 3 DEC. 1953
SCALE: AS SHOWN

PLAN OF INLET STRUCTURE
NORMAL TO FACE OF DAM
SCALE: 1/4"=1'-0"

SECTION A-A THRU C. OF INLET STRUCTURE
SCALE: 1/4"=1'-0"

STEM GUIDE SUPPORT
SCALE: 1/8"=1'-0"

PEDESTAL LIFT STRUCTURE
SCALE: 1/4"=1'-0"

SECTION E-E
SCALE: 1/4"=1'-0"

SECTION F-F
SCALE: 1/4"=1'-0"

ELEVATION OF CUT-OFF WALLS
SCALE: 1/4"=1'-0"

GENERAL PLAN OF
OUTLET STRUCTURE
AND RECEIVING FLUME
SCALE: 1/4"=1'-0"

SECTION AT OUTLET TUBE
SCALE: 1"=5'

SECTION D-D
SCALE: 1"=10'

SECTION C-C
SCALE: 1/4"=1'-0"

SECTION B-B
SCALE: 1/4"=1'-0"

CASE ROD MARKING
SCALE: 1/2"=1'

ROOF PLAN
SCALE: 1/4"=1'-0"

PIPING PLAN AT OUTLET STRUCTURE
SCALE: 1/4"=1'-0"

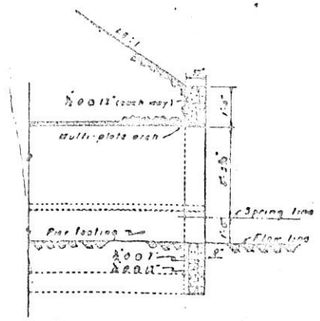
SECTION G-G
SCALE: 1/4"=1'-0"

CONSOLIDATED NUTUAL WATER COMPANY
MARKS GROVE RESERVOIR DAM
OUTLET FACILITIES

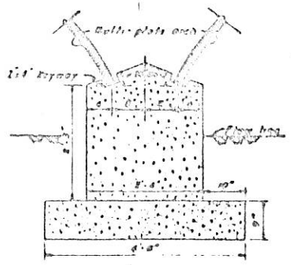
LAND ENGINEERING SERVICE, LAKEWOOD, COLO.

C-757

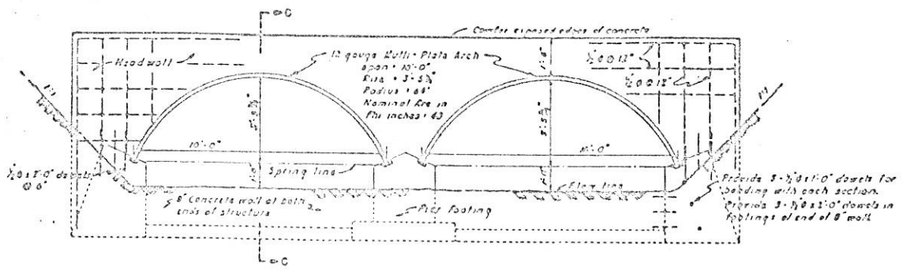
Appendix C - Plate 3



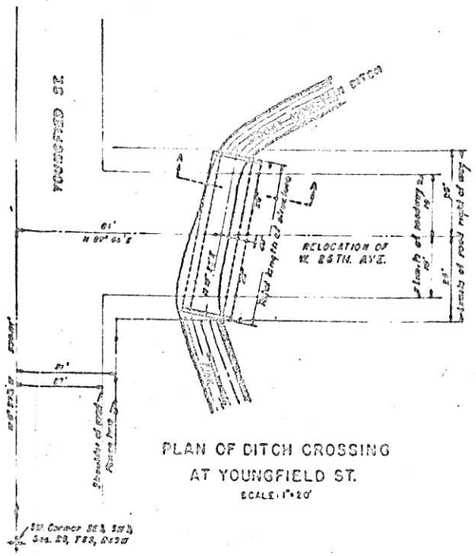
SECTION C-C
SCALE: 1/8"=1'-0"



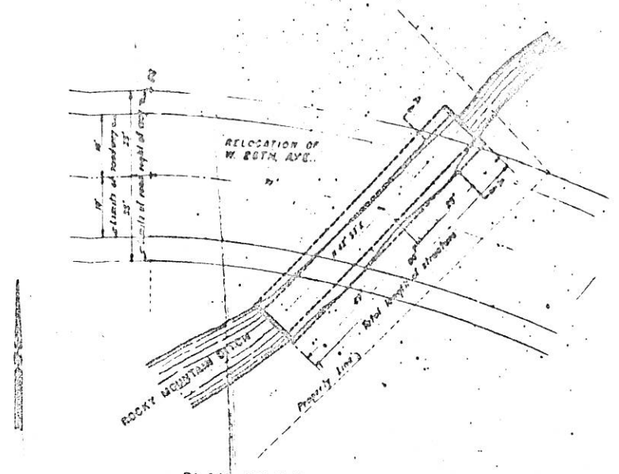
PIER FOOTING DETAIL
SCALE: 3/4"=1'-0"



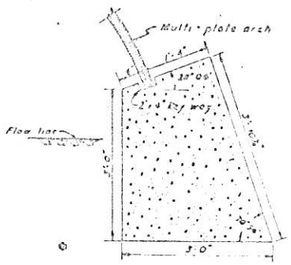
SECTION B-B
SCALE: 1/4"=1'-0"



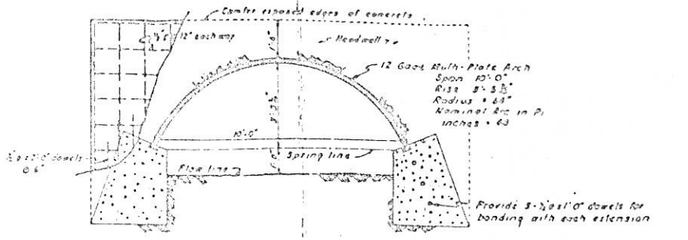
PLAN OF DITCH CROSSING AT YOUNGFIELD ST.
SCALE: 1"=20'



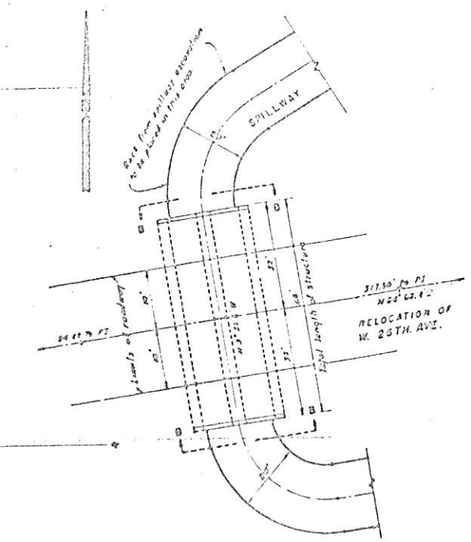
PLAN OF DITCH CROSSING AT EAST END OF DAM
SCALE: 1"=20'



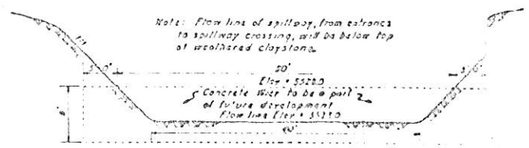
FOOTING DETAIL
SCALE: 3/4"=1'-0"



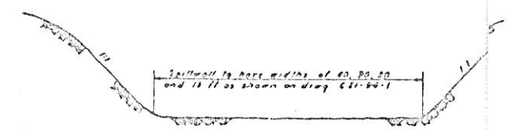
SECTION A-A
SCALE: 1/4"=1'-0"



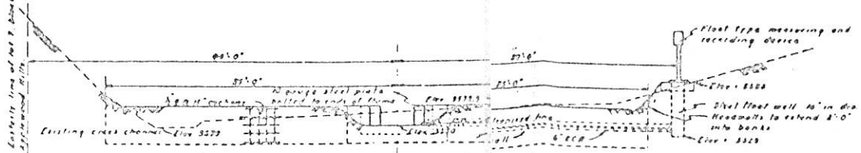
PLAN OF SPILLWAY CROSSING
SCALE: 1"=20'



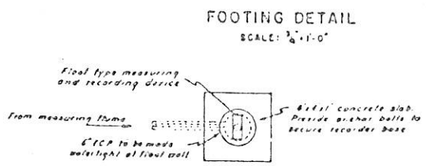
SECTION AT SPILLWAY ENTRANCE
SCALE: 1"=10'



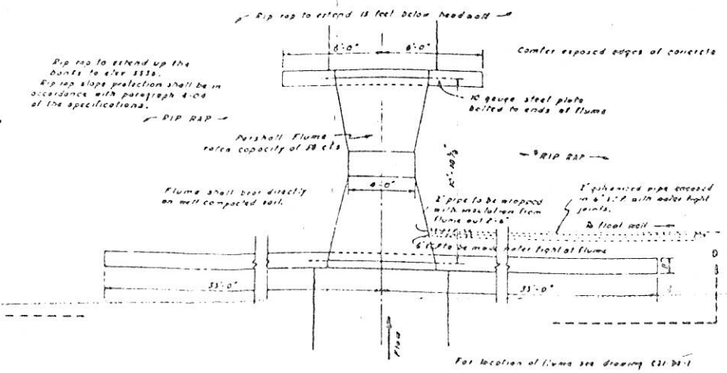
TYPICAL SECTION THRU SPILLWAY



SECTION D-D
SCALE: 1/4"=1'-0"



PLAN AT FLOAT WELL
SCALE: 1/4"=1'-0"



PLAN AT INLET MEASURING FLUME
SCALE: 1/4"=1'-0"

C-757

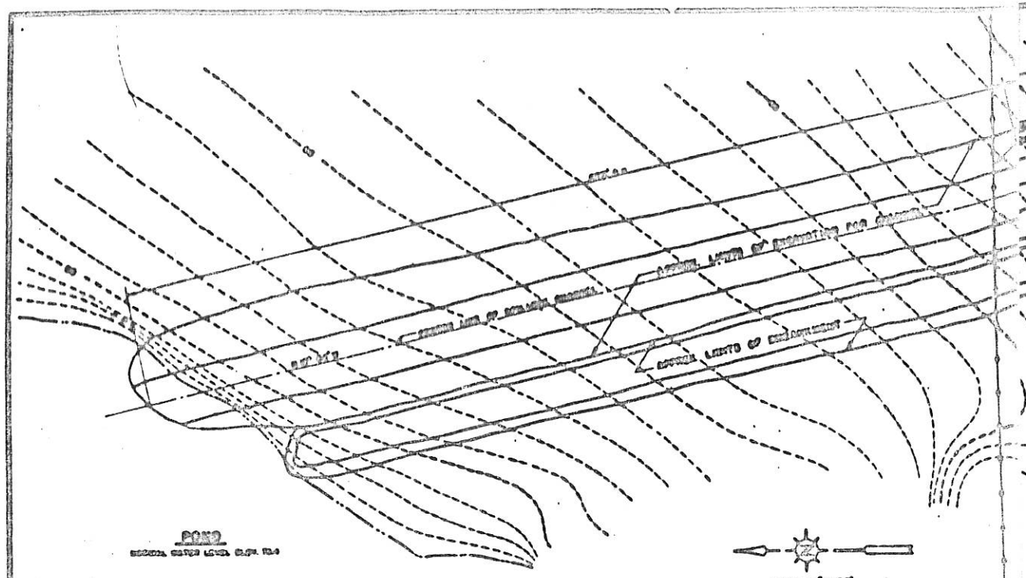
CONSOLIDATED MUTUAL WATER COMPANY
MAPLE GROVE RESERVOIR DAM

SPILLWAY AND CULVERT DETAILS

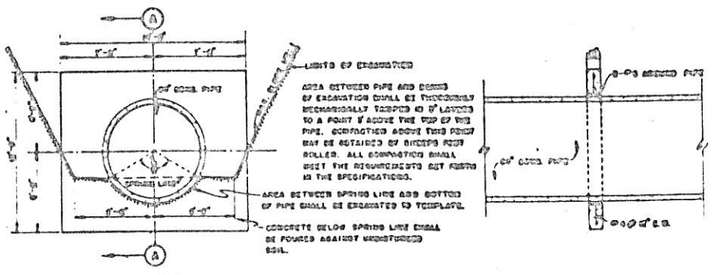
LANE ENGINEERING SERVICE, LAKEWOOD, COLO.

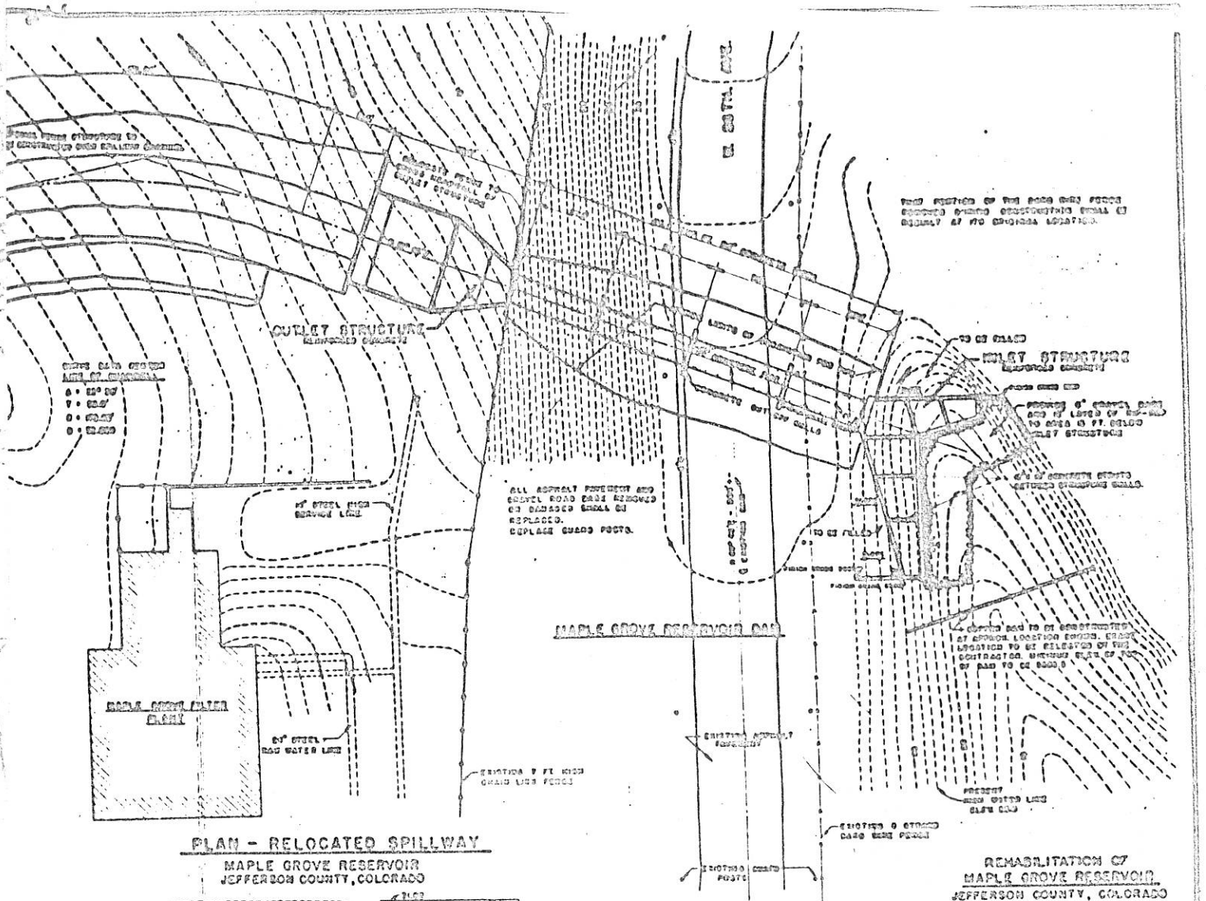
Approved on the 18th day of November, 1964
J. C. Whetter
STATE ENGINEER
By
DEPUTY

Designed
Drawn
Traced
Checked

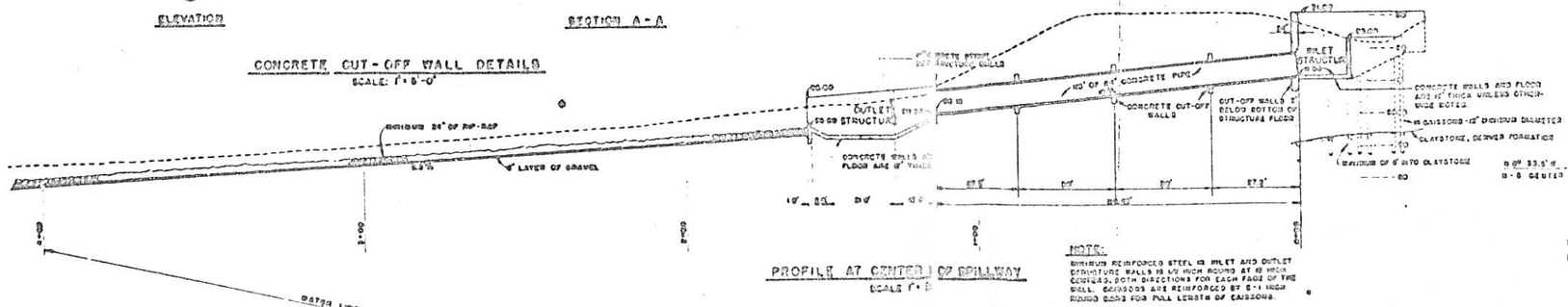


SCALE: 1" = 50'

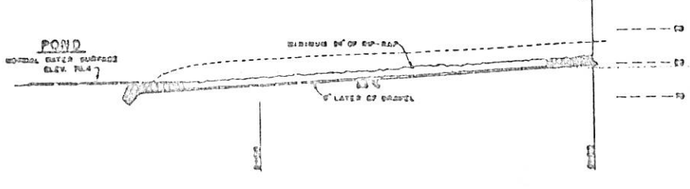


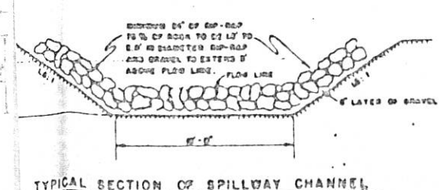


PLAN - RELOCATED SPILLWAY
MAPLE GROVE RESERVOIR
JEFFERSON COUNTY, COLORADO



NOTE:
MINIMUM REINFORCED STEEL IN INLET AND OUTLET STRUCTURE WALLS IS 1/2 INCH ROUND AT 12 INCH CENTERS, BOTH DIRECTIONS FOR EACH FACE OF THE WALL. CAISSONS ARE REINFORCED BY 8-1 INCH ROUND BARS FOR FULL LENGTH OF CAISSONS.





TYPICAL SECTION OF SPILLWAY CHANNEL
SCALE: 1" = 6'-0"

PREPARED BY
ANE ENGINEERING SERVICES
LAKEWOOD, COLORADO

REHABILITATION OF
MAPLE GROVE RESERVOIR
JEFFERSON COUNTY, COLORADO
IRRIGATION DIVISION NO. 1
WATER DISTRICT NO. 7
COURSES REFERRED TO TRUE MERIDIAN
SCALE: AS NOTED

STATEMENTS

I hereby certify that this plan for the construction of the relocated spillway at Maple Grove Reservoir Dam as shown on this drawing, was prepared under my direct supervision for the owner thereof.

Leonard A. Jones
REGISTERED PROFESSIONAL ENGINEER

Subscribed and sworn to before me this 5th day of April, 1960.

My commission expires on 7th day of March 1961. Lucile Hight
NOTARY PUBLIC

This plan for the construction of the relocated spillway at Maple Grove Reservoir Dam is hereby approved and accepted.

CONSOLIDATED MUTUAL WATER COMPANY

ATTEST: Lucile Hight
SECRETARY

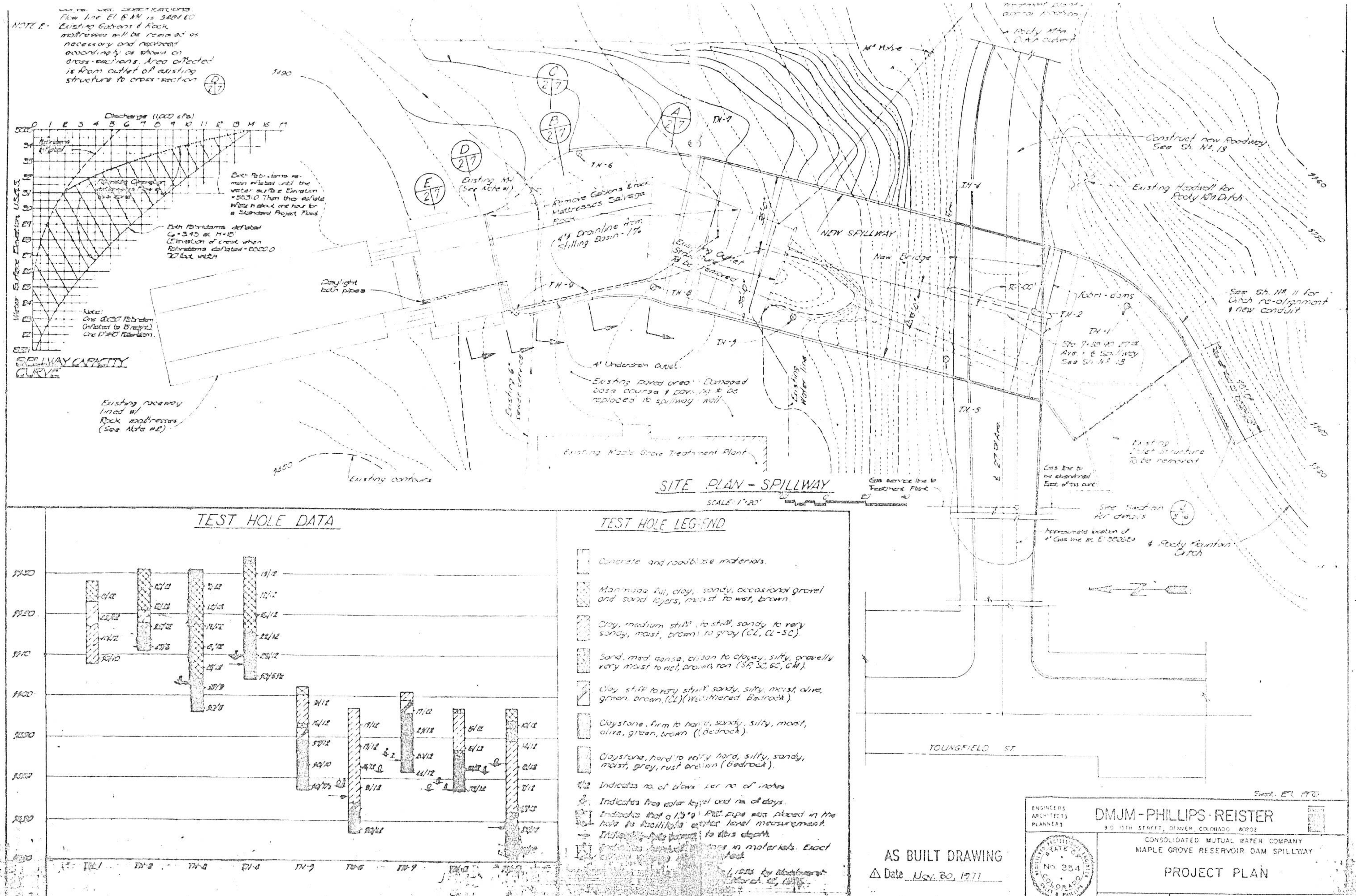
BY: John Wilson
PRESIDENT

Approved on the 17th day of MAY, 1960.

J.E. Whitten
STATE ENGINEER

BY: A. Rollie Evans
DEPUTY

C-757A



Appendix C - Plate 6

Sheet pile cutoff

Outside Bridge Stringer

Anchor Bolts for Fabricators shops for layout & bolts to be furnished by others for installation under this contract.

Outside bridge stringer

Remove hatched portion of existing 7'-0" R/conc. pipe as required.

Continues 40'± straight wall; See C

Remove existing Inlet structure

Curtain collars

Sheet pile cutoff

See supplemental dwg. S-2 for crest details and cut off wall

Cut off wall

Sheet pile cutoff 6" min except at existing 84" conc. pipe

AS BUILT DRAWING

Date Nov. 30, 1977

Scale 1"=10'

STATION	ELEVATION
0+00	5490.00
0+10	5491.00
0+18	5491.83
0+20	5492.00
0+24	5493.00
0+28	5494.00
0+32	5495.00
0+36	5496.00
0+40	5497.00
0+44	5498.00
0+48	5499.00
0+52	5500.00
0+56	5501.00
0+60	5502.00
0+64	5503.00
0+68	5504.00
0+72	5505.00
0+76	5506.00
0+80	5507.00
0+84	5508.00
0+88	5509.00
0+92	5510.00
0+96	5511.00
1+00	5512.00
1+04	5513.00
1+08	5514.00
1+12	5515.00
1+16	5516.00
1+20	5517.00
1+24	5518.00

ENGINEERS ARCHITECTS PLANNERS
DMJM-PHILLIPS·REISTER
910 15TH STREET, DENVER, COLORADO 80202

CONSOLIDATED MUTUAL WATER COMPANY
MAPLE GROVE RESERVOIR DAM SPILLWAY

SPILLWAY
PLAN & SECTION

REGISTERED STATE OF COLORADO No. 354

DATE NOVEMBER 1978 JOB NO. 8003-02

Appendix C - Plate 7

Cantilevers & cutoff collars

3' Recess in wall

Normal water surface

Fabridam (Not in this Contract)

Cut off

Anchor bolts for Fabridam furnished by others for installation under this Contract See Fabridam manufacturer's dwgs for A-bolt layout

Sheet pile cutoff, 6' Min.

Existing ground line

Conc Cutoff Wall

Toe of Riprap

Tie Rock mattress to cut off wall

Dam Detail

Section of Pip

Existing water line (Elev. unknown & exact position unknown) Relocation, if required will be done as a change order

See supplemental dwg. #3 for crest slab, footing and wall details

EAST WALL PROFILE

SCALE 1"=10'-0"

Existing 6" Sanitary sewer, Flow line El. 8402.65

Conc. Cutoff wall

Existing Outlet Structure

Existing ground line

Existing water line (Elev. unknown & exact position unknown)

Existing Outlet Structure to be removed

Cantilevers

Portion of exist. 7'-0" conc. pipe to be removed

Fabridam & Recess Beyond

Cut off

Control Bldg. drain 8" RNC, la. 8367.10

See supplemental dwg #3 for Crest, slab footing and wall details

Existing 7'-0" conc pipe to be filled w/ concrete

Sheet pile cutoff

East Inlet Structure to be removed

AS BUILT DRAWING

Date NOV. 30, 1977

Sept 8th, 1976

ENGINEERS ARCHITECTS PLANNERS

DMJM - PHILLIPS · REISTER

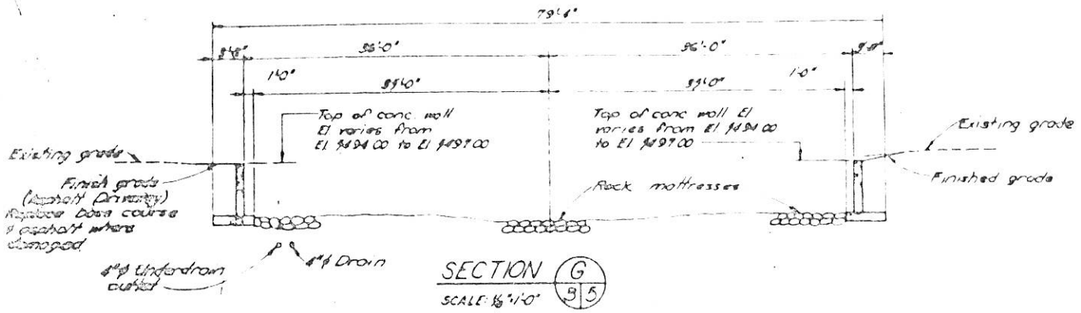
910 15TH STREET, DENVER, COLORADO 80202

CONSOLIDATED MUTUAL WATER COMPANY

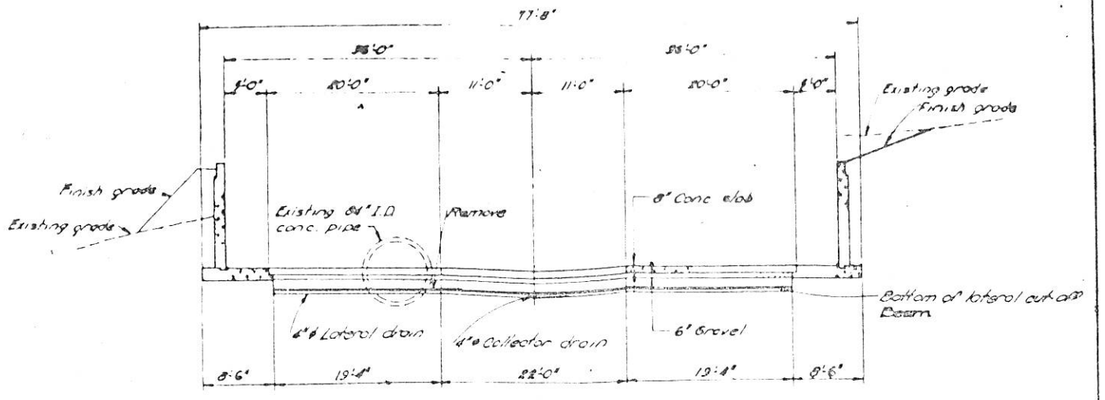
MAPLE GROVE RESERVOIR DAM SPILLWAY

SPILLWAY WALL ELEVATIONS

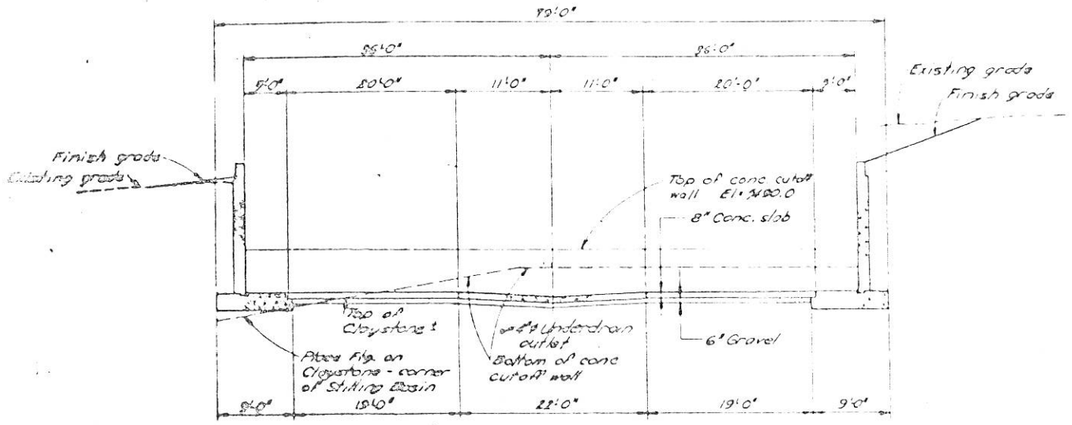
REGISTERED PROFESSIONAL ENGINEER STATE OF COLORADO No. 334



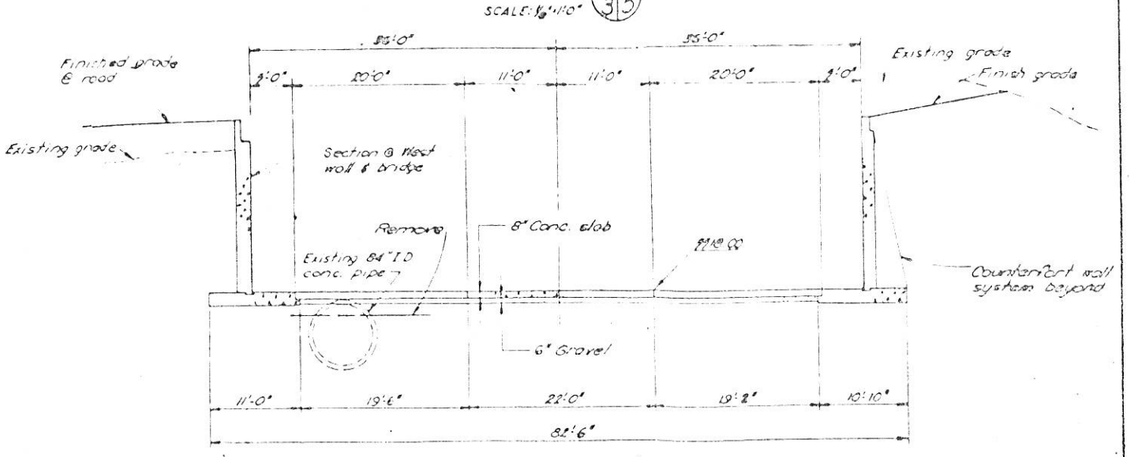
SECTION G
SCALE: 1/8"=1'-0" 3|5



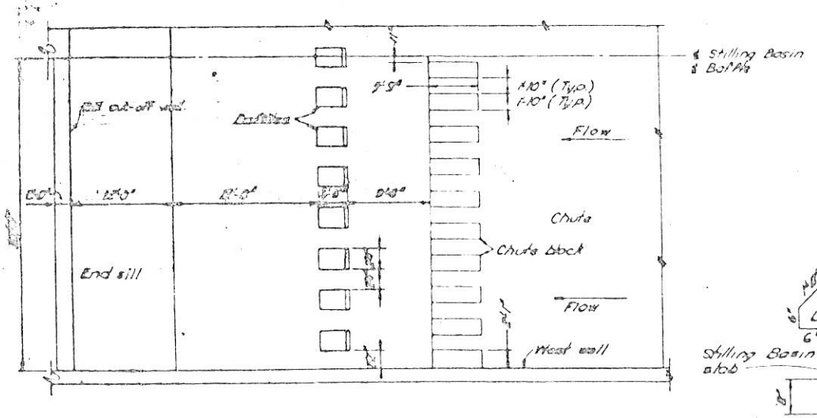
SECTION K
SCALE: 1/8"=1'-0" 3|5



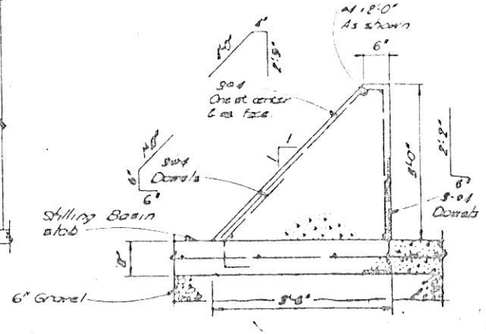
SECTION I
SCALE: 1/8"=1'-0" 3|5



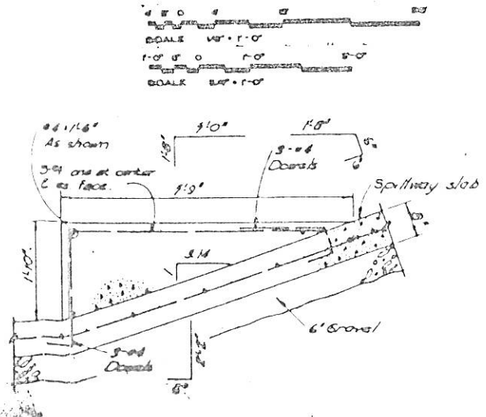
SECTION M
SCALE: 1/8"=1'-0" 3|5



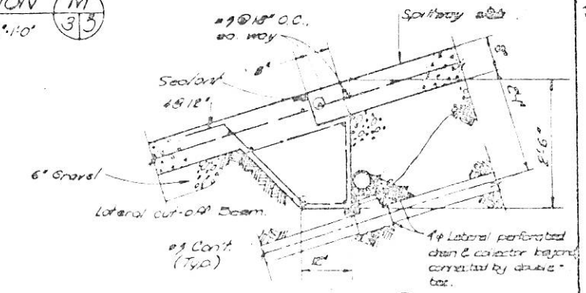
PLAN - STILLING BASIN
SCALE: 1/8"=1'-0"



BAFFLE PROFILE
SCALE: 1/4"=1'-0"



CHUTE BLOCK PROFILE
SCALE: 1/4"=1'-0"



SECTION O
SCALE: 3/4"=1'-0" 3|5

AS BUILT DRAWING
Date NOV. 30, 1977

Sept. 27, 1978

ENGINEERS ARCHITECTS PLANNERS
DMJM - PHILLIPS · REISTER
910 15TH STREET, DENVER, COLORADO 80202

REGISTERED PROFESSIONAL ENGINEER STATE OF COLORADO No. 354 DMJM PHILLIPS REISTER

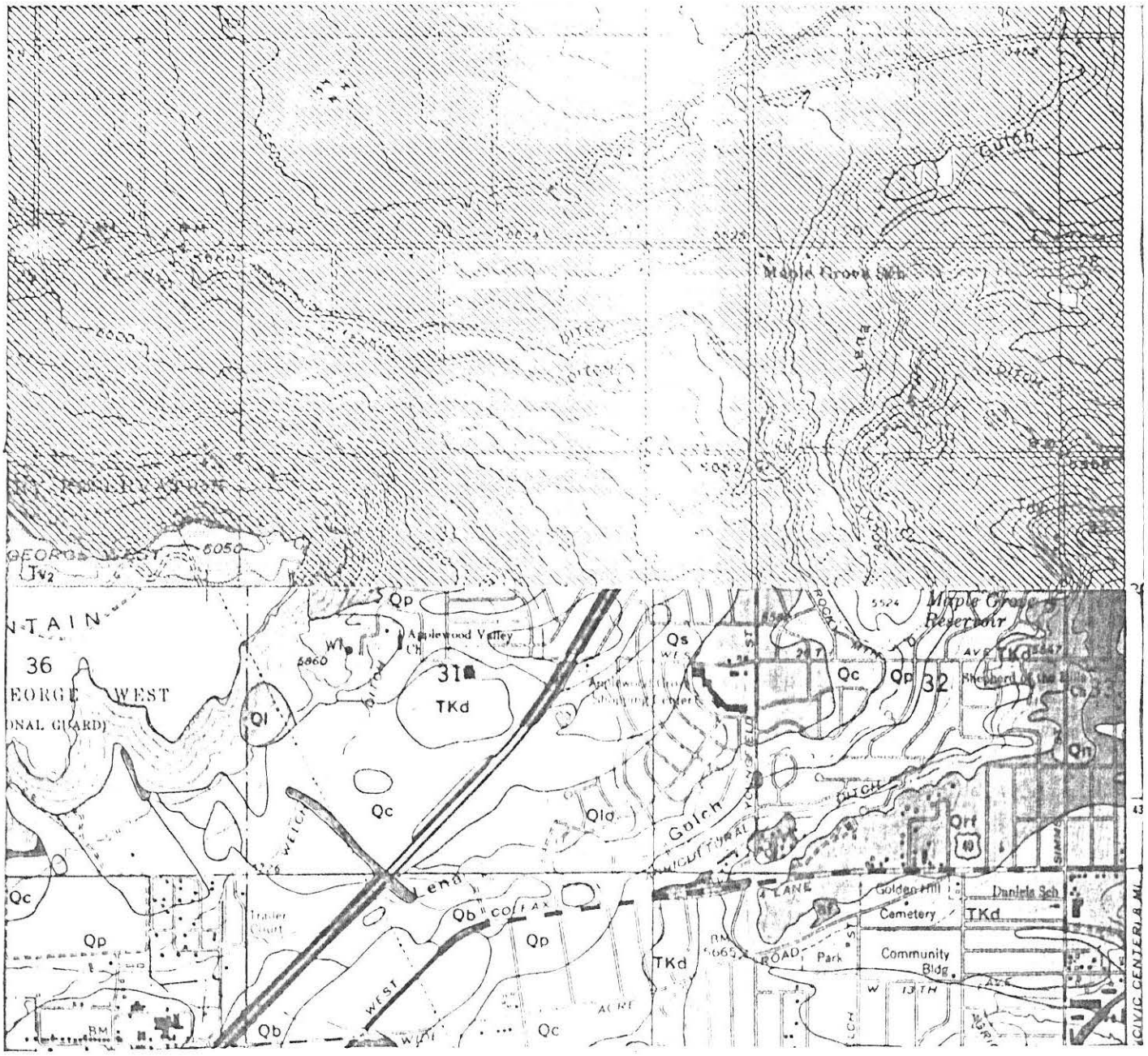
CONSOLIDATED MUTUAL WATER COMPANY
MAPLE GROVE RESERVOIR DAM "SPILLWAY
SPILLWAY
SECTIONS & DETAILS

DATE JUNE 1978 | JOB NO. 5003-02 | SHEET 9 OF 14

APPENDIX D

ENGINEERING DATA

Plate 1	Bedrock Geology Map
Plate 2	Seismic Events Map
Plate 3	Drainage Area Map
Plate 4	Hydrologic Data for DSD Procedures
Plate 5	DSD - PMP 6-Hour, Direct Runoff and Plotting Table
Plate 6	DSD - Probable Maximum Flood Graph, PMP 6-Hour
Plate 7	DSD - Flood Routing of PMP 6-Hour, Inflow Hydrograph
	A. Fabridams Operating Properly
	B. Fabridams Inflated
	C. Fabridams Deflated
Plate 8	DSD - PMP 1-Hour, Direct Runoff and Plotting Table
Plate 9	DSD - Probable Maximum Flood Graph, PMP 1-Hour
Plate 10	DSD - Flood Routing of PMP 1-Hour, Inflow Hydrograph
	A. Fabridams Operating Properly
	B. Fabridams Inflated
	C. Fabridams Deflated
Plate 11	C of E - Computed Snyders 0.25 Hour Unit Hydrograph
Plate 12	C of E - Computed Probable Maximum Flood Hydrograph
Plate 13	C of E - Lake Elevations, Storages and Discharge Rating Tables with Fabridams Working Properly
Plate 14	C of E - Summary Table
	A. Fabridams Operating Properly
	B. Fabridams Inflated
	C. Fabridams Deflated



Maple Grove Reservoir in relation to adjacent bedrock and soils.

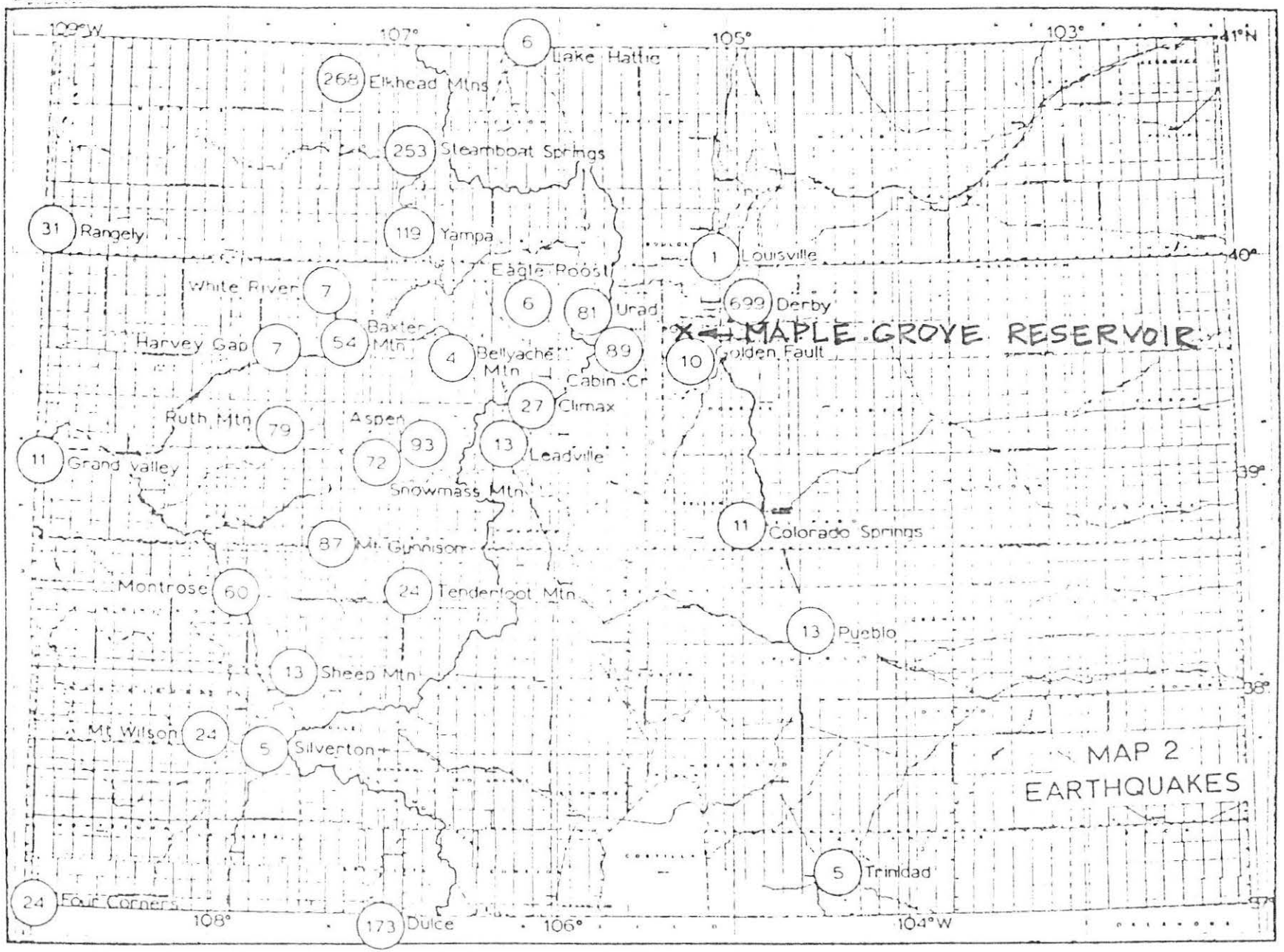
Tdv = Tertiary Denver formation-light gray to brown, lenticular, loosely cemented, tuffaceous sandstone, silty claystone, and andesitic conglomerate.

Source: U.S. Geological Survey, 1957

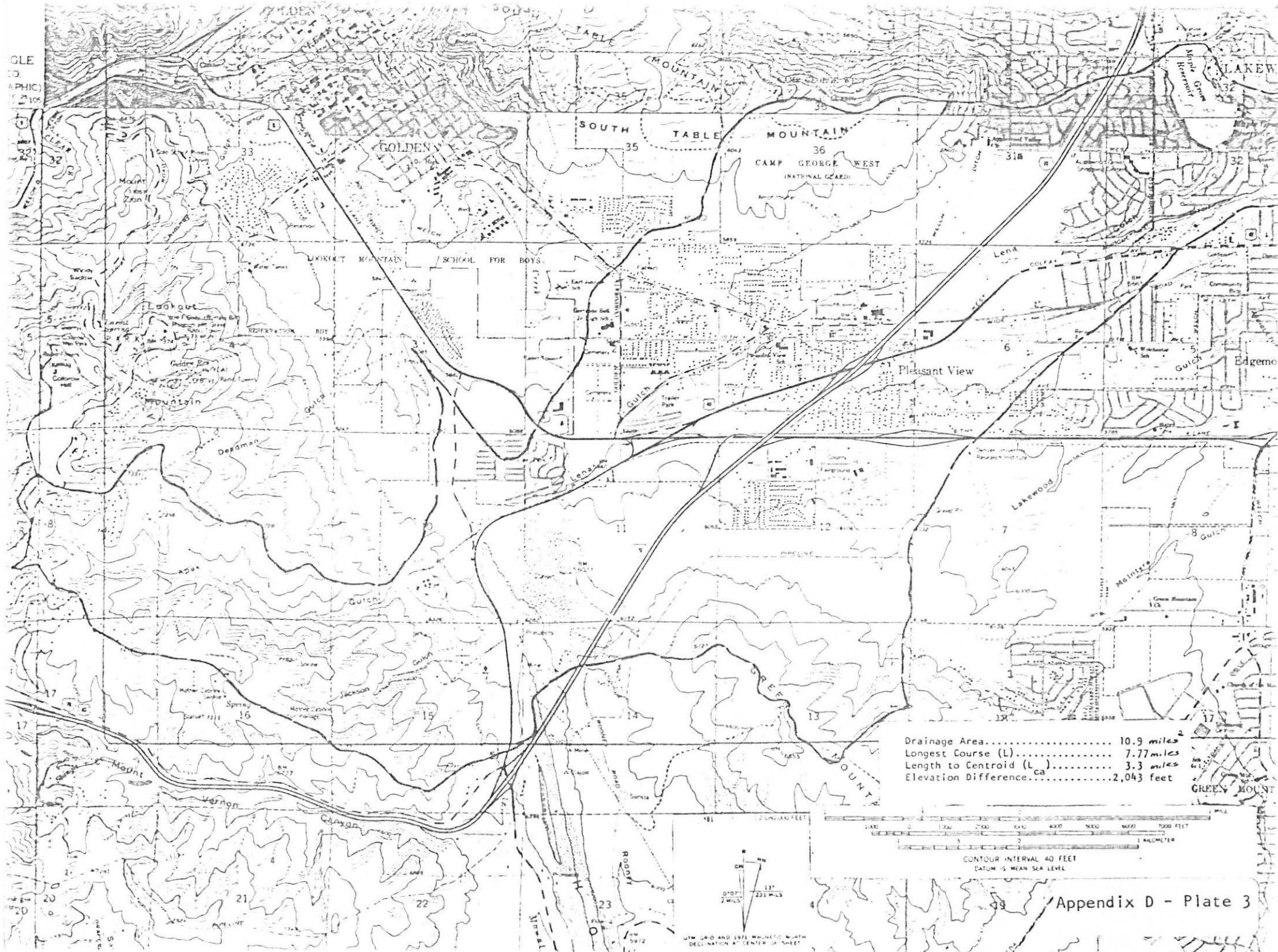
Qc = Colluvium - Dark-gray to reddish-brown bouldery to sandy silt and clay on slopes in mountains and plains where it was deposited by gravity and sheet wash.

Qp = Piney Creek Alluvium - Dark-gray to reddish brown humic clayey silt and sand containing layers of pebbles, generally in lower part.

Source: U.S. Geological Survey, 1978



Appendix D - Plate 2



Appendix D - Plate 3

5. Time to peak, Tp (use 1-hour unitgragh; i.e., D=1 hour)

$$Tp = \frac{D}{2} + 0.6\ Tc = \frac{1}{2} + (0.6)(1.86) = 1.62 \text{ hr.}$$

6. Base time, Tb

$$Tb = 2.67\ Tp = 4.33 \text{ hr.}$$

7. Peak Discharge, Qp

$$Qp = \frac{484AQ}{Tp} = \frac{484(10.9)(1)}{1.62} = 3260 \text{ cfs}$$

8. For second 6-hour period use D=6 hours.

$$Tp = \frac{6}{2} + 0.6(1.86) = 4.12 \text{ hr.}$$

$$Tb = 2.67\ Tp = 11.0 \text{ hr.}$$

$$Qp = \frac{484(10.9)(1)}{4.12} = 1280 \text{ cfs}$$

9. For PMP, 1-hour (thunderstorm) use 15-minute unitgraph

$$Tp = \frac{.25}{2} + 0.6\ Tc = .125 + 1.12 = 1.25 \text{ hr.}$$

$$Tb = 2.67\ Tp = 3.34 \text{ hr.}$$

$$Qp = \frac{484(10.9)(1)}{1.25} = 4220 \text{ cfs}$$

MAPLE GROVE RESERVOIR DAM

HIGH HAZARD FLOOD HYDROGRAPH ANALYSIS
HYDROLOGIC DATA FOR DSD PROCEDURES

A. Design Precipitation

1. Watershed Location: Jefferson County, Colorado. This is west of 105° Meridian, east of Continental Divide, below 8000' contour.

2. Probable Maximum 6-Hour Precipitation for 10 sq. mi. (USWB TP No. 40): 22 inches

3. Probable Maximum 1-Hour Point Rainfall (DSD, Fig. 20): 13 inches

B. Runoff Indexes

1. PMP, 6-Hour

a. Representative Hydrologic Soil Group: C

b. Soil-Cover-Complex Number

	CN	% of Area	Weighted CN
Pasture or range (poor)	86	50	43.0
Meadow	71	20	14.2
Urban Area (Medium density)	85	30	25.5
			82.7 -- use 83

2. PMP, 1-Hour

a. Zone III, Brush, Sage, grass, less than 50% (DSD, Table A-9, p. 544): 75

C. Unit Hydrograph Calculations

1. Drainage Area: 10.9 sq. mi.

2. Longest Course: 7.77 mi.

3. Elevation Difference between divide and spillway: 2043 feet

4. Time of Concentration, $Tc = Tc_1 + Tc_2$

Tc_1 L = 2.39 mi. ΔH = 1287 ft.

Tc_2 L = 5.38 mi. ΔH = 756 ft.

$$Tc_1 = \left(\frac{11.9L^3}{\Delta H}\right)^{0.385} = \left(\frac{11.9 \times 2.39^3}{1287}\right)^{0.385} = 0.45 \text{ hr.}$$

$$Tc_2 = \left(\frac{11.9 \times 5.38^3}{756}\right)^{0.385} = 1.41 \text{ hr.}$$

$Tc = Tc_1 + Tc_2 = 1.86$ hrs.

5. Time to peak, Tp (use 1-hour unitgragh; i.e., D=1 hour)

$$Tp = \frac{D}{2} + 0.6\ Tc = \frac{1}{2} + (0.6)(1.86) = 1.62 \text{ hr.}$$

6. Base time, Tb

$$Tb = 2.67\ Tp = 4.33 \text{ hr.}$$

7. Peak Discharge, Qp

$$Qp = \frac{484AQ}{Tp} = \frac{484(10.9)(1)}{1.62} = 3260 \text{ cfs}$$

8. For second 6-hour period use D=6 hours.

$$Tp = \frac{6}{2} + 0.6(1.86) = 4.12 \text{ hr.}$$

$$Tb = 2.67\ Tp = 11.0 \text{ hr.}$$

$$Qp = \frac{484(10.9)(1)}{4.12} = 1280 \text{ cfs}$$

9. For PMP, 1-hour (thunderstorm) use 15-minute unitgraph

$$Tp = \frac{.25}{2} + 0.6\ Tc = .125 + 1.12 = 1.25 \text{ hr.}$$

$$Tb = 2.67\ Tp = 3.34 \text{ hr.}$$

$$Qp = \frac{484(10.9)(1)}{1.25} = 4220 \text{ cfs}$$

DIRECT RUNOFF AND PLOTTING TABLE

MAPLE GROVE RESERVOIR DAM
PMP 6-HOUR

Location: Jefferson County, CO, Sec. 29, T3S, R69W
PMP, 6-hour, 10 sq. mi.: 22 in., USWB TP No. 40
Depth-area-duration zone 4, Design of Small Dams 2nd Ed. Fig. 15, p. 48
Drainage Area: 10.9 sq. mi.

PMP Extension (DSD, Fig. 16, p. 49)

Time, hours	6	12	24	48
% of 6-hr-10 sq. mi. precip. (DSD, Fig. 16, p. 49)	100	111	118	126
Total PMP	22.0	24.4	26.0	27.7
Adjustment for imperfect storm fit: 0.8 (DSD, p. 48)	17.6	19.5	20.8	22.2

Time Hours	% of 6-hr. Precip[1/]	PMP Accum. P, inch	PMP Increm. P, inch	Arranged PMP[2/] Increm. P, inch	Arranged PMP[2/] Accum. P, inch	Direct Runoff[3/] Accum. inch	Direct Runoff[3/] Increm. inch	Increm. Loss inch	Increm. Runoff inch	Unitgraph Peak cfs	Increm. Runoff Peak cfs	Plotting Table Begin Hour	Plotting Table Peak Hour	Plotting Table End Hour
1.0	49	8.6	8.6	1.4	1.4	0.3	0.3	1.1	0.3	3260	978	0	1.62	4.33
2.0	64	11.3	2.7	1.6	3.0	1.4	1.1	0.5	1.1	3260	3590	1	2.62	5.33
3.0	75	13.2	1.9	1.9	4.9	3.1	1.7	0.2	1.7	3260	5540	2	3.62	6.33
4.0	84	14.8	1.6	8.6	13.5	11.3	8.2	0.4	8.2	3260	26700	3	4.62	7.33
5.0	92	16.2	1.4	2.7	16.2	14.0	2.7	0.1[4/]	2.6	3260	8480	4	5.62	8.33
6.0	100	17.6	1.4	1.4	17.6	15.4	1.4	0.1[4/]	1.3	3260	4240	5	6.62	9.33
12.0		19.5	1.9	1.9	19.5	17.2	1.8	0.6[4/]	1.3	1280	1540	6	10.12	17.0

$16.5 \text{ in.} \times 10.9 \text{ sq. mi.} \times \frac{640 \text{ ac.}}{\text{sq. mi.}} \times \frac{1 \text{ ft.}}{12 \text{ in.}} = 9590 \text{ ac. ft.}$

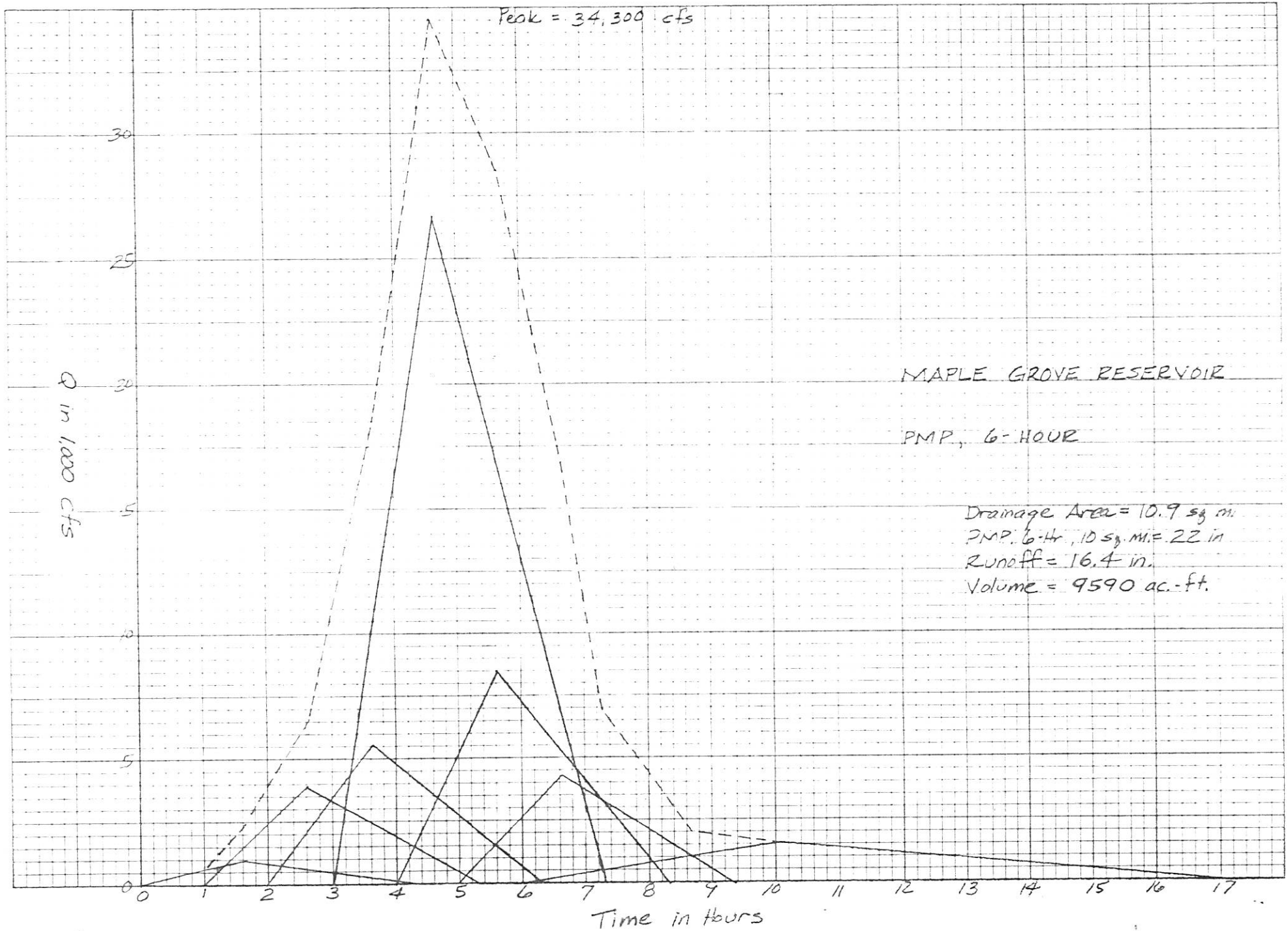
1/ Curve Zone C DSD, Fig. 18, p. 51

2/ DSD, p. 76, Ex. 1, 3(c): (6,4,3,1,2,5)

3/ CN 82, $Q = \frac{(p-0.2S)^2}{p+0.8S}$, $S = \frac{1000}{CN} - 10$

4/ Minimum retention rate applies: 0.1 in/hr, DSD, p. 64, sec. 51c

Appendix D Plate 5


Peak = 34,300 cfs
MAPLE GROVE RESERVOIR
PMP, 6-HOUR
Drainage Area = 10.9 sq. mi.
PMP. 6-Hr, 10 sq. MI. = 22 in
Runoff = 16.4 in.
Volume = 9590 ac.-ft.
Q in 1000 cfs
Time in Hours
0
5
10
15
20
25
30
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

DSD - Flood Routing of PMP 6-hour, Inflow Hydrograph

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DAM INSPECTION HYDROLOGIC ANALYSIS - SUMMARY TABLE

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HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM
FABRIDAMS OPERATING PROPERLY
ROCKY MOUNTAIN CONSULTANTS INC. LONGMONT COLORADO
AUGUST 1979

INPUT LAKE INFLOW HYDROGRAPH ORDINATES IN CFS AT .250 HOUR INTERVALS BEGINNING AT ZERO TIME

0.0	151.0	302.0	453.0	604.0	1309.0	2014.0	2593.0	3057.0	4376.0	5694.0	6553.0
6986.0	11540.0	16094.0	19938.0	23126.0	27622.0	32180.0	33343.0	31347.0	30004.0	28887.0	26789.0
23687.0	20678.0	18017.0	14975.0	11432.0	7889.0	6021.0	4941.0	3861.0	2781.0	2233.0	1935.0
1638.0	1340.0	1308.0	1402.0	1495.0	1511.0	1455.0	1399.0	1343.0	1287.0	1231.0	1175.0
1119.0	1063.0	1007.0	951.0	895.0	839.0	783.0	727.0	672.0	616.0	560.0	504.0
448.0	392.0	336.0	280.0	224.0	168.0	112.0	56.0	0.0			

LAKE AND DAM INFORMATION

BEGINNING POOL ELEV FT,MSL	OUTLET INVERT FT,MSL	BOTTOM OF LAKE FT,MSL	SPILLWAY CREST FT,MSL	SPILLWAY CREST WIDTH FEET	TOP OF DAM ELEVATION FT,MSL	TOP OF DAM LENGTH FEET	HEIGHT OF DAM FEET	DOWNSTREAM SLOPE OF DAM	N-VALVE ON DS SLOPE	COEF OF FLOW OVER DAM
5525.00	5496.00	5496.00	5525.00	70.0	5534.44	1424.0	38.4	1V ON 1.75H	.030	3.60

SUMMARY OF FLOOD ROUTINGS OF INFLOW HYDROGRAPH THROUGH THE LAKE

ROUTING NUMBER	PERCENT OF LAKE INFLOW HYDROGRAPH	TOTAL INFLOW VOLUME AC-FT	MAXIMUM LAKE ELEVATION FT,MSL	DEPTH OF LAKE OVER TOP OF DAM FEET	ESTIMATED VELOCITIES CREST FPS	ESTIMATED VELOCITIES TOE FPS	INITIAL TIME TO OVER TOP HOUR	TOTAL TIME OVER DAM HOURS	VOLUME SPILLED OVER DAM AC-FT	MAXIMUM DISCHARGE FROM DAM CFS
1	100.0	9540.	5536.83	2.39	7.17	23.75	3.60	3.72	4019.9	33229.7
2	90.0	8586.	5536.55	2.11	6.74	22.03	3.67	3.56	3279.4	29906.8
3	80.0	7632.	5536.27	1.83	6.27	20.22	3.76	3.36	2558.4	26583.8
4	70.0	6678.	5535.98	1.54	5.75	18.24	3.88	3.07	1859.5	23221.0
5	60.0	5724.	5535.61	1.17	5.02	15.47	4.06	2.66	1202.5	19903.7
6	50.0	4770.	5535.24	.80	4.15	12.32	4.33	2.05	616.4	16586.3
7	40.0	3816.	5534.76	.32	2.62	7.10	4.66	1.15	152.4	13200.3
8	30.0	2862.	5534.11	-.33	0.00	0.00	0.00	0.00	0.0	9868.5

DAM INSPECTION HYDROLOGIC ANALYSIS - SUMMARY TABLE

HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM-SMALL DAMS 6 HOUR
FABRIDAMS DEFLATED
ROCKY MOUNTAIN CONSULTANTS INC. LONGMONT COLORADO
AUGUST 1979

INPUT LAKE INFLOW HYDROGRAPH ORDINATES IN CFS AT .250 HOUR INTERVALS BEGINNING AT ZERO TIME

0.0	151.0	362.	453.0	604.0	1209.0	2014.0	2593.0	3057.0	4376.0	5694.0	6553.0
6886.	11547.0	16084.	19938.0	23126.0	27622.0	32180.0	33343.0	31347.0	30004.0	28887.0	26789.0
27647.	20678.0	18017.0	14975.0	11432.0	7889.0	6021.0	4941.0	3861.0	2781.0	2233.0	1935.0
1638.	134.	1298.	1462.0	1465.	1511.0	1455.0	1399.0	1343.0	1287.0	1231.0	1175.0
1119.	1063.0	1007.0	951.0	895.0	839.0	783.0	727.0	672.0	616.0	560.0	504.0
448.	392.	336.	280.0	224.0	168.0	112.0	56.0	0.0			

LAKE AND DAM INFORMATION

BEGINNING POOL ELEV FT,MSL	OUTLET INVERT FT,MSL	BOTTOM OF LAKE FT,MSL	SPILLWAY CREST FT,MSL	SPILLWAY CREST WIDTH FEET	TOP OF DAM ELEVATION FT,MSL	TOP OF DAM LENGTH FEET	HEIGHT OF DAM FEET	DOWNSTREAM SLOPE OF DAM	N-VALVE ON DS SLOPE	COEF OF FLOW OVER DAM
5526.0	5496.0	5496.0	5520.0	70.0	5534.44	1424.0	38.4	1V ON 1.75H	.030	3.60

SUMMARY OF FLOOD ROUTINGS OF INFLOW HYDROGRAPH THROUGH THE LAKE

ROUTING NUMBER	PERCENT OF LAKE INFLOW HYDROGRAPH	TOTAL INFLOW VOLUME AC-FT	MAXIMUM LAKE ELEVATION FT,MSL	DEPTH OF LAKE OVER TOP OF DAM FEET	ESTIMATED VELOCITIES CREST FPS	ESTIMATED VELOCITIES TOE FPS	INITIAL TIME TO OVER TOP HOUR	TOTAL TIME OVER DAM HOURS	VOLUME SPILLED OVER DAM AC-FT	MAXIMUM DISCHARGE FROM DAM CFS
1	100.0	9540.	5536.83	2.39	7.17	23.74	3.50	3.37	3476.6	33229.6
2	89.0	8586.	5536.55	2.11	6.73	22.02	3.99	3.17	2759.0	29906.7
3	80.0	7632.	5536.27	1.93	6.27	20.21	4.12	2.91	2065.4	26583.7
4	70.0	6678.	5535.98	1.54	5.75	18.22	4.28	2.56	1412.2	23221.6
5	60.0	5724.	5535.61	1.17	5.01	15.45	4.48	2.08	816.6	19904.1
6	50.0	4770.	5535.24	.80	4.14	12.27	4.74	1.46	311.1	16549.9
7	40.0	3816.	5534.09	-.35	0.00	0.00	0.00	0.00	0.0	12242.3

DSD - Flood Routing of PMP 6-hour, Inflow Hydrograph

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DAM INSPECTION HYDROLOGIC ANALYSIS - SUMMARY TABLE

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HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM
FABRIDAMS INFLATED
ROCKY MOUNTAIN CONSULTANTS INC. LONGMONT COLORADO
AUGUST 1979

INPUT LAKE INFLOW HYDROGRAPH ORDINATES IN CFS AT .250 HOUR INTERVALS BEGINNING AT ZERO TIME

0.0	151.0	302.0	453.0	604.0	1309.0	2014.0	2593.0	3057.0	4376.0	5694.0	6553.0
6986.0	11540.0	16094.0	19938.0	23126.0	27622.0	32180.0	33343.0	31347.0	30004.0	28887.0	26789.0
23687.0	20678.0	18017.0	14975.0	11432.0	7889.0	6021.0	4941.0	3861.0	2781.0	2233.0	1935.0
1638.0	1340.0	1308.0	1402.0	1495.0	1511.0	1455.0	1399.0	1343.0	1287.0	1231.0	1175.0
1119.0	1063.0	1007.0	951.0	895.0	839.0	783.0	727.0	672.0	616.0	560.0	504.0
448.0	392.0	336.0	280.0	224.0	168.0	112.0	56.0	0.0			

LAKE AND DAM INFORMATION

BEGINNING POOL ELEV FT,MSL	OUTLET INVERT FT,MSL	BOTTOM OF LAKE FT,MSL	SPILLWAY CREST FT,MSL	SPILLWAY CREST WIDTH FEET	TOP OF DAM ELEVATION FT,MSL	TOP OF DAM LENGTH FEET	HEIGHT OF DAM FEET	DOWNSTREAM SLOPE OF DAM	N-VALVE ON DS SLOPE	COEF OF FLOW OVER DAM
5525.00	5496.00	5496.00	5525.00	70.0	5534.44	1424.0	38.4	1V ON 1.75H	.030	3.60

SUMMARY OF FLOOD ROUTINGS OF INFLOW HYDROGRAPH THROUGH THE LAKE

ROUTING NUMBER	PERCENT OF LAKE INFLOW HYDROGRAPH	TOTAL INFLOW VOLUME AC-FT	MAXIMUM LAKE ELEVATION FT,MSL	DEPTH OF LAKE OVER TOP OF DAM FEET	ESTIMATED VELOCITIES CREST FPS	ESTIMATED VELOCITIES TOE FPS	INITIAL TIME TO OVER TOP HOUR	TOTAL TIME OVER DAM HOURS	VOLUME SPILLED OVER DAM AC-FT	MAXIMUM DISCHARGE FROM DAM CFS
1	100.0	9540.	5537.38	2.94	7.94	26.86	3.19	4.85	6180.6	33259.7
2	90.0	8586.	5537.15	2.71	7.62	25.56	3.33	4.59	5352.3	29933.7
3	80.0	7632.	5536.89	2.45	7.26	24.10	3.44	4.36	4535.5	26584.2
4	70.0	6678.	5536.61	2.17	6.83	22.41	3.54	4.14	3728.5	23261.2
5	60.0	5724.	5536.33	1.89	6.37	20.63	3.66	3.90	2938.3	19938.1
6	50.0	4770.	5536.05	1.61	5.88	18.73	3.81	3.63	2161.7	16614.9
7	40.0	3816.	5535.70	1.26	5.20	16.16	4.00	3.24	1411.7	13270.8
8	30.0	2862.	5535.34	.90	4.39	13.17	4.32	2.57	706.3	9953.1
9	20.0	1908.	5534.79	.35	2.73	7.45	4.87	1.21	124.3	6355.7
10	10.0	954.	5532.01	-2.43	0.00	0.00	0.00	0.00	0.0	2803.3

DIRECT RUNOFF AND PLOTTING TABLE

MAPLE GROVE RESERVOIR DAM
PMP 1-HOUR

Location: Jefferson County, CO, Sec. 29, T3S, R69W
PMP, 1-hour point rainfall: 13 in., DSD, Fig. 20, p. 53
Drainage Area: 10.9 sq. mi.
Area Adjustment Zone III, DSD, Fig. 21, p. 54: 0.89
PMP, 1-hour, 1 sq. mi.: 11.6 in.

Time Hours	% of 1-hr. Precip 1/	PMTS		Arranged PMTS 2/		Direct Runoff 3/		Increm. Loss inch	Increm. Peak 5/ cfs	Plotting Table		
		Accum. P, inch	Increm. P, inch	Increm. P, inch	Accum. P, inch	Accum. inch	Increm. inch			Begin Hour	Peak Hour	End Hour
0.25	48	5.6	5.6	1.4	1.4	0.1	0.1	1.3	422	0	1.25	3.34
0.50	71	8.2	2.6	2.0	3.4	1.2	1.1	0.9	4640	.25	1.50	3.59
0.75	88	10.2	2.0	2.6	6.0	3.3	2.1	0.5	8860	.50	1.75	3.84
1.00	100	11.6	1.4	5.6	11.6	3.4	5.1	0.5	21500	.75	2.00	4.09
1.25	110	12.8	1.2	1.2	12.8	9.5	1.1	0.1	4640	1.00	2.25	4.34
1.50	117	13.6	0.8	0.8	13.6	10.3	0.77	0.03 4/	3250	1.25	2.50	4.59
1.75	122	14.2	0.6	0.6	14.2	10.8	0.5	0.1	2110	1.50	2.75	4.84
2.00	126	14.6	0.4	0.4	14.6	11.2	0.37	0.03 4/	1560	1.75	3.00	5.09
2.25	129	15.0	0.4	0.4	15.0	11.6	0.37	0.03 4/	1560	2.00	3.25	5.34
2.50	131.5	15.3	0.3	0.3	15.3	11.9	0.27	0.03 4/	1140	2.25	3.50	5.59
2.75	133	15.4	0.1	0.1	15.4	12.0	0.07	0.03 4/	295	2.50	3.75	5.84
3.00	134	15.5	0.1	0.1	15.5	12.1	0.07	0.03 4/	295	2.75	4.00	6.04

11.9 in. x 10.9 sq. mi. $\times \frac{640 \text{ ac.}}{\text{sq. mi.}} \times \frac{1 \text{ ft.}}{12 \text{in.}} = 6920$ ac. ft.

1/ DSD, Table 2, p. 52, Zone III

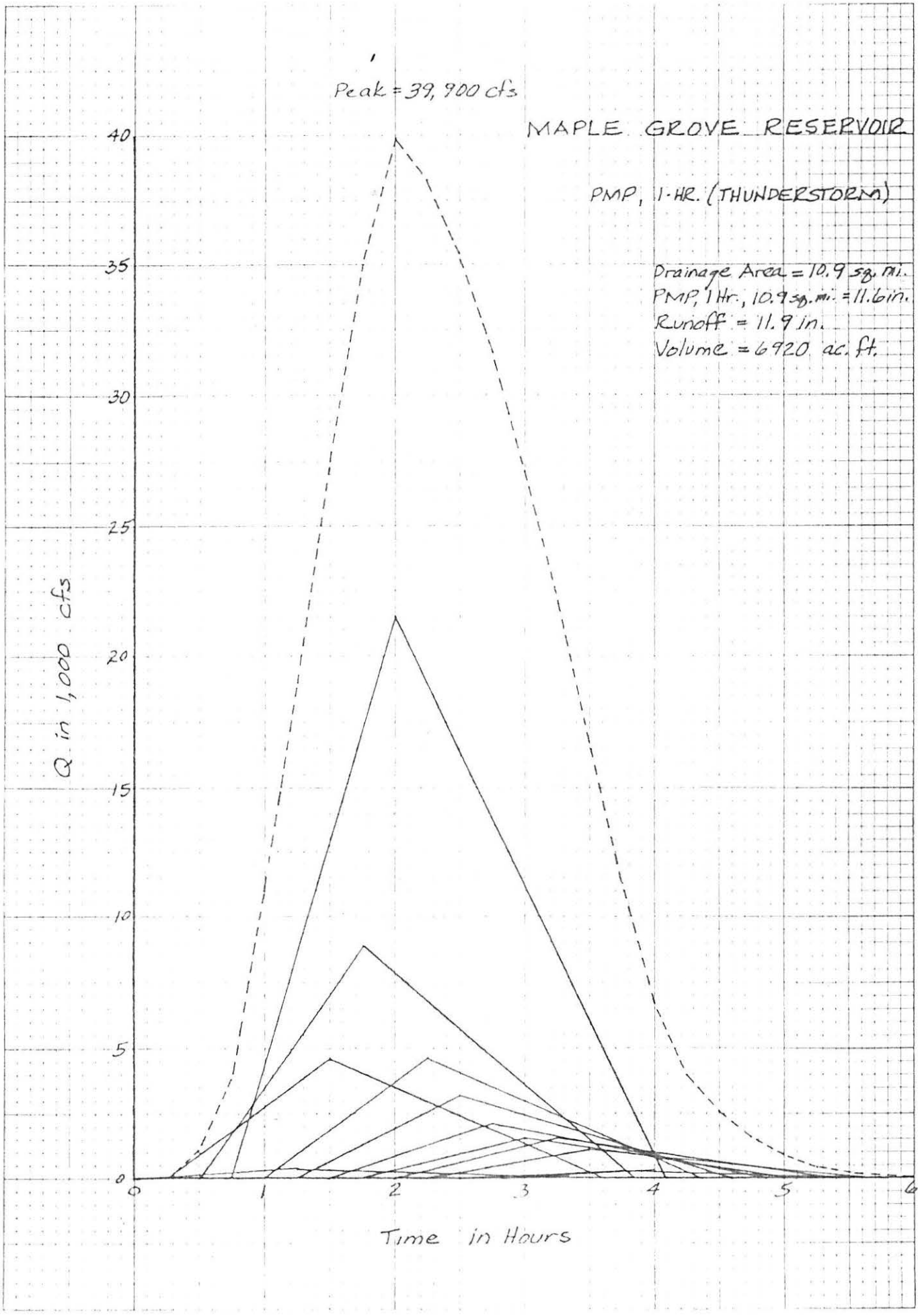
2/ DSD, Table A-8, p. 543 (4,3,2,1,5,6,7,8,9,10,11,12)

3/ DSD, Table A-9, p. 544 (CN75)

4/ DSD, minimum retention rate applies: .03 in/.25 hr., DSD, p. 64, sec. 51c

5/ 0.25 hr. unitgraph peak of 4220 cfs times incremental runoff amount

Appendix D Plate 8


Peak = 39,900 cfs
MAPLE GROVE RESERVOIR
PMP, 1-HR. (THUNDERSTORM)
Drainage Area = 10.9 sq. mi.
PMP, 1 Hr., 10.9 sq. mi. = 11.6 in.
Runoff = 11.9 in.
Volume = 6920 ac. ft.
Q in 1,000 cfs
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
Time in Hours

DSD - Flood Routing of PMP 1-hour, Inflow Hydrograph

DAM INSPECTION HYDROLOGIC ANALYSIS - SUMMARY TABLE

HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM-SMALL DAMS 1 HOUR
FABRIDAMS OPERATING PROPERLY
ROCKY MOUNTAIN CONSULTANTS INC. LONGMONT COLORADO
AUGUST 1979

INPUT LAKE INFLOW HYDROGRAPH ORDINATES IN CFS AT .25 HOUR INTERVALS BEGINNING AT ZERO TIME

0.	84.	1197.	3881.0	10966.	18978.	27506.	34972.	39918.	38326.	35438.	31590.
27126.	22165.	16736.	11318.0	6682.	395.	2559.	1546.	915.	484.	180.	61.
13.	0.										

LAKE AND DAM INFORMATION

BEGINNING POOL ELEV FT,MSL	OUTLET INVERT FT,MSL	BOTTOM OF LAKE FT,MSL	SPILLWAY CREST FT,MSL	SPILLWAY CREST WIDTH FEET	TOP OF DAM ELEVATION FT,MSL	TOP OF DAM LENGTH FEET	HEIGHT OF DAM FEET	DOWNSTREAM SLOPE OF DAM	N-VALVE ON OS SLOPE	COEF OF FLOW OVER DAM
5525.00	5496.	5496.	5525.00	70.	5534.44	1404.	38.4	1V ON 1.75H	.030	3.60

SUMMARY OF FLOOD ROUTINGS OF INFLOW HYDROGRAPH THROUGH THE LAKE

ROUTING NUMBER	PERCENT OF LAKE INFLOW HYDROGRAPH	TOTAL INFLOW VOLUME AC-FT	MAXIMUM LAKE ELEVATION FT,MSL	DEPTH OF LAKE OVER TOP OF DAM FEET	ESTIMATED VELOCITIES CREST FPS	TOE FPS	INITIAL TIME TO OVER TOP HOUR	TOTAL TIME OVER DAM HOURS	VOLUME SPILLED OVER DAM AC-FT	MAXIMUM DISCHARGE FROM DAM CFS
1	16.	5953.	5537.32	2.88	7.86	26.51	1.46	2.61	775.	39575.
2	9.	5254.	5537.	2.	7.	24.	1.	2.	31[illegible]	[illegible]
3	8.	5562.	5536.70	2.25	8.37	25.[illegible]	1.[illegible]	2.33	[illegible]	[illegible]
4	7.	4857.	5536.37	1.93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	6.	4172.	5536.03	1.59	8.84	28.58	1.68	2.04	1355.	23713.
6	5.	3475.	5535.68	1.15	4.98	15.54	1.78	2.77	[illegible]	19746.
7	4.	2781.	5535.15	.71	3.31	11.47	1.94	1.29	347.	15795.
8	3.	2 96.	5534.47	.[illegible]	.77	1.[illegible]	[illegible]	.23	14.	11714.
9	2.	1391.	5533.41	-1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7597.

DAM INSPECTION HYDROLOGIC ANALYSIS - SUMMARY TABLE

HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM - 1 HR DSD
FABRIDAMS INFLATED
ROCKY MOUNTAIN CONSULTANTS INC. LONGMONT COLORADO
AUGUST 1979

INPUT LAKE INFLOW HYDROGRAPH ORDINATES IN CFS AT .250 HOUR INTERVALS BEGINNING AT ZERO TIME

0.0	84.0	1097.0	3881.0	10966.0	18978.0	27506.0	34972.0	39919.0	38306.0	35438.0	31590.0
27126.0	22165.0	16736.0	11318.0	6682.0	3980.0	2559.0	1586.0	915.0	454.0	180.0	61.0
13.0	0.0										

LAKE AND DAM INFORMATION

BEGINNING POOL ELEV FT,MSL	OUTLET INVERT FT,MSL	BOTTOM OF LAKE FT,MSL	SPILLWAY CREST FT,MSL	SPILLWAY CREST WIDTH FEET	TOP OF DAM ELEVATION FT,MSL	TOP OF DAM LENGTH FEET	HEIGHT OF DAM FEET	DOWNSTREAM SLOPE OF DAM	N-VALVE ON DS SLOPE	COEF OF FLOW OVER DAM
5525.00	5496.00	5496.00	5525.00	70.0	5534.44	1424.0	38.4	1V ON 1.75H	.030	3.60

SUMMARY OF FLOOD ROUTINGS OF INFLOW HYDROGRAPH THROUGH THE LAKE

ROUTING NUMBER	PERCENT OF LAKE INFLOW HYDROGRAPH	TOTAL INFLOW VOLUME AC-FT	MAXIMUM LAKE ELEVATION FT,MSL	DEPTH OF LAKE OVER TOP OF DAM FEET	ESTIMATED VELOCITIES CREST FPS	ESTIMATED VELOCITIES TOE FPS	INITIAL TIME TO OVER TOP HOUR	TOTAL TIME OVER DAM HOURS	VOLUME SPILLED OVER DAM AC-FT	MAXIMUM DISCHARGE FROM DAM CFS
1	100.0	6953.	5537.83	3.39	8.53	29.25	1.42	3.08	5165.9	39677.3
2	90.0	6258.	5537.55	3.11	8.17	27.79	1.45	3.00	4502.3	35709.5
3	80.0	5562.	5537.27	2.83	7.80	26.27	1.49	2.90	3841.6	31741.8
4	70.0	4867.	5536.99	2.55	7.40	24.67	1.54	2.78	3186.9	27721.1
5	60.0	4172.	5536.66	2.22	6.90	22.67	1.60	2.65	2539.4	23761.3
6	50.0	3476.	5536.32	1.88	6.35	20.55	1.68	2.48	1903.7	19801.8
7	40.0	2781.	5535.98	1.54	5.75	18.22	1.79	2.24	1281.3	15842.8
8	30.0	2086.	5535.54	1.10	4.87	14.93	1.96	1.87	692.5	11845.1
9	20.0	1391.	5535.07	.63	3.68	10.68	2.28	1.11	174.8	7544.6
10	10.0	695.	5532.24	-2.20	0.00	0.00	0.00	0.00	0.0	2988.4

DSD - Flood Routing of PMP 1-hour, Inflow Hydrograph

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DAM INSPECTION HYDROLOGIC ANALYSIS - SUMMARY TABLE

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HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM -1 HR DSD
FABRIDAMS DEFLATED
ROCKY MOUNTAIN CONSULTANTS INC. LONGMONT COLORADO
AUGUST 1979

INPUT LAKE INFLOW HYDROGRAPH ORDINATES IN CFS AT .250 HOUR INTERVALS BEGINNING AT ZERO TIME

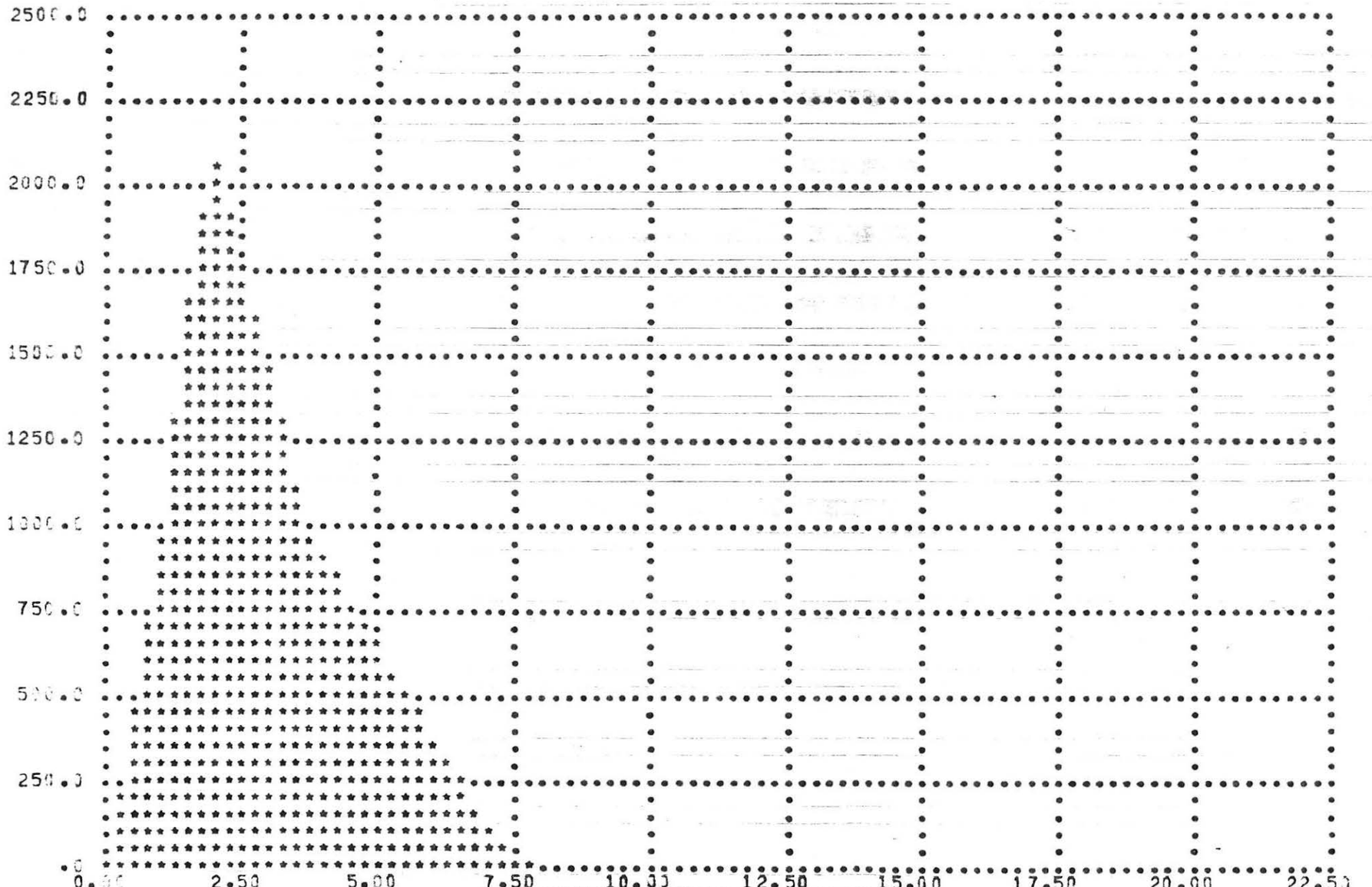
0.0	84.0	1097.0	3881.0	10966.0	18978.0	27506.0	34972.0	39919.0	38306.0	35438.0	31590.0
27126.0	22165.0	16736.0	11318.0	6682.0	3980.0	2559.0	1586.0	915.0	454.0	180.0	61.0
13.0	0.0										

LAKE AND DAM INFORMATION

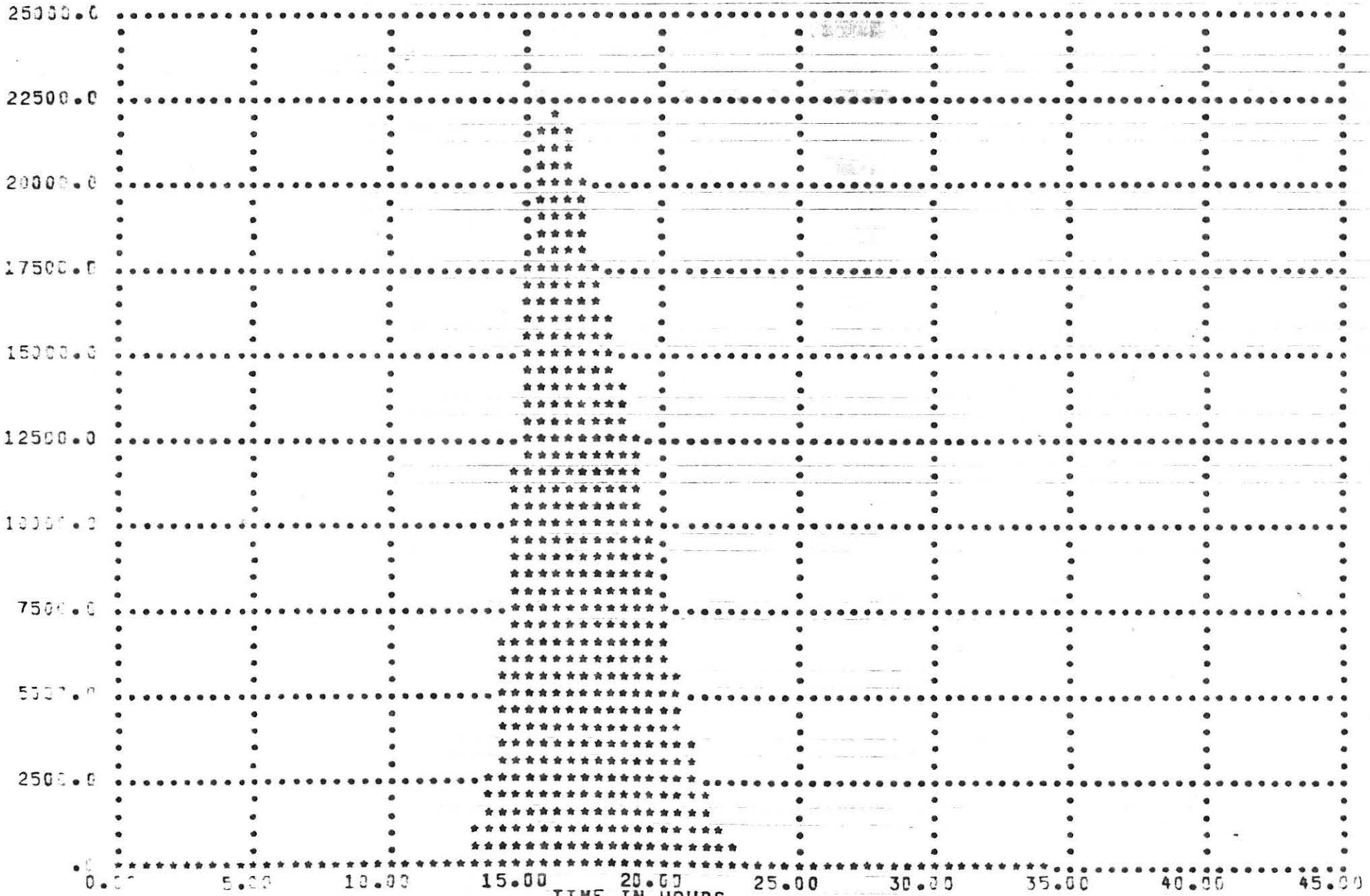
BEGINNING POOL ELEV FT,MSL	OUTLET INVERT FT,MSL	BOTTOM OF LAKE FT,MSL	SPILLWAY CREST FT,MSL	SPILLWAY CREST WIDTH FEET	TOP OF DAM ELEVATION FT,MSL	TOP OF DAM LENGTH FEET	HEIGHT OF DAM FEET	DOWNSTREAM SLOPE OF DAM	N-VALVE ON DS SLOPE	COEF OF FLOW OVER DAM
5520.00	5496.00	5496.00	5520.00	70.0	5534.44	1424.0	38.4	1V ON 1.75H	.030	3.60

SUMMARY OF FLOOD ROUTINGS OF INFLOW HYDROGRAPH THROUGH THE LAKE

ROUTING NUMBER	PERCENT OF LAKE INFLOW HYDROGRAPH	TOTAL INFLOW VOLUME AC-FT	MAXIMUM LAKE ELEVATION FT,MSL	DEPTH OF LAKE OVER TOP OF DAM FEET	ESTIMATED VELOCITIES CREST FPS	ESTIMATED VELOCITIES TOE FPS	INITIAL TIME TO OVER TOP HOUR	TOTAL TIME OVER DAM HOURS	VOLUME SPILLED OVER DAM AC-FT	MAXIMUM DISCHARGE FROM DAM CFS
1	100.0	6953.	5537.31	2.87	7.85	26.50	1.65	2.38	3294.0	39675.6
2	90.0	6258.	5537.03	2.59	7.46	24.91	1.70	2.27	2690.1	35678.7
3	80.0	5562.	5536.70	2.26	6.97	22.95	1.77	2.13	2099.3	31679.9
4	70.0	4867.	5536.37	1.93	6.43	20.84	1.84	1.94	1530.6	27719.7
5	60.0	4172.	5536.03	1.59	5.84	18.56	1.95	1.70	992.1	23727.4
6	50.0	3476.	5535.58	1.14	4.96	15.25	2.09	1.35	504.1	19569.9
7	40.0	2781.	5535.06	.62	3.65	10.56	2.35	.73	108.6	14969.3
8	30.0	2086.	5532.45	-1.99	0.00	0.00	0.00	0.00	0.0	10623.1



DAM INSPECTION HYDROLOGIC ANALYSIS - COMPUTED SNYDERS .250 HOUR UNIT HYDROGRAPH
HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM



DAM INSPECTION HYDROLOGIC ANALYSIS - COMPUTED PROBABLE MAXIMUM FLOOD HYDROGRAPH (LAKE INFLOW HYDROGRAPH)
HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM

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DAM INSPECTION HYDROLOGIC ANALYSIS - LAKE ELEVATIONS, STORAGES AND DISCHARGE RATING TABLES
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HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM-FABRIDAMS OPERATING PROPERLY

LAKE ELEVATION FT,MSL	LAKE STORAGE AC-FT	STORAGE PLUS HALF DISCHARGE AC-FT	OUTLET DISCHARGE C.F.S.	SPILLWAY DISCHARGE C.F.S.	OVER TOP OF DAM C.F.S.	TOTAL DISCHARGE C.F.S.
5540.000	1158.100	2023.971	108.017	16600.000	67107.061	83815.078
5539.000	1122.200	1800.961	106.860	15790.376	49805.894	65703.130
5538.000	1086.300	1596.771	105.703	15000.992	34306.194	49412.889
5537.000	1050.400	1413.856	104.546	14231.849	20845.603	35181.997
5536.000	1014.500	1255.977	103.389	13482.946	9788.257	23374.592
5535.000	978.600	1127.599	102.232	12713.000	1607.650	14422.882
5534.000	942.700	1039.128	101.075	9233.037	0.000	9334.111
5533.000	906.800	973.002	99.863	6308.401	0.000	6408.264
5532.000	870.900	910.652	97.934	3750.000	0.000	3847.934
5531.000	834.900	856.553	96.006	2000.000	0.000	2096.006
5530.000	799.000	814.435	94.078	1400.000	0.000	1494.078
5529.000	763.100	773.350	92.149	900.000	0.000	992.149
5528.000	727.200	733.814	90.221	550.000	0.000	640.221
5527.000	691.300	695.311	88.292	300.000	0.000	388.292
5526.000	655.400	657.325	86.364	100.000	0.000	186.364
5525.000	619.500	620.372	84.436	.000	0.000	84.436
5524.000	583.600	584.452	82.507	0.000	0.000	82.507
5523.000	549.820	550.652	80.579	0.000	0.000	80.579
5522.000	510.680	511.493	78.650	0.000	0.000	78.650
5521.000	473.830	474.623	76.722	0.000	0.000	76.722
5520.000	439.050	439.823	74.794	0.000	0.000	74.794
5519.000	406.110	406.863	72.865	0.000	0.000	72.865
5518.000	375.000	375.733	70.937	0.000	0.000	70.937
5517.000	345.730	346.443	69.008	0.000	0.000	69.008
5516.000	317.960	318.653	67.080	0.000	0.000	67.080
5515.000	291.660	292.333	65.152	0.000	0.000	65.152
5514.000	266.870	267.523	63.223	0.000	0.000	63.223
5513.000	243.450	244.083	61.295	0.000	0.000	61.295
5512.000	221.410	222.023	59.367	0.000	0.000	59.367
5511.000	200.750	201.343	57.438	0.000	0.000	57.438
5510.000	181.350	181.923	55.510	0.000	0.000	55.510
5509.000	162.980	163.534	53.581	0.000	0.000	53.581
5508.000	145.650	146.184	51.653	0.000	0.000	51.653
5507.000	129.350	129.863	49.630	0.000	0.000	49.630
5506.000	113.970	114.456	47.042	0.000	0.000	47.042
5505.000	99.510	99.969	44.454	0.000	0.000	44.454
5504.000	85.850	86.283	41.866	0.000	0.000	41.866
5503.000	72.890	73.296	39.278	0.000	0.000	39.278
5502.000	60.600	60.979	36.690	0.000	0.000	36.690
5501.000	49.010	49.362	34.102	0.000	0.000	34.102
5500.000	38.110	38.436	31.514	0.000	0.000	31.514
5499.000	27.780	27.991	20.469	0.000	0.000	20.469
5498.000	17.910	18.025	11.142	0.000	0.000	11.142
5497.000	8.610	8.651	3.939	0.000	0.000	3.939
5496.000	0.000	0.000	0.000	0.000	0.000	0.000

C of E - Summary Table

DAM INSPECTION HYDROLOGIC ANALYSIS - SUMMARY TABLE

HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM
FABRIDAMS OPERATING PROPERLY
ROCKY MOUNTAIN CONSULTANTS INC. LONGMONT COLORADO
AUGUST 1979

SYNDERS .250 HOUR UNIT HYDROGRAPH DATA AND PARAMETERS

DURATION HOURS	DA SQ-MI	L MILES	LCA MILES	CP	CT	QP C.F.S	TP HOURS	W50 HOURS	W75 HOURS	UNIT VOL AC-FT
.250	10.90	7.77	3.30	.580	.720	2150.6	1.91	2.60	1.50	581.33

PROBABLE MAXIMUM STORM PRECIPITATION AND RUNOFF CHARACTERISTICS

PMP INDEX	RAIN FACTOR	DISTRIBUTION IN PERCENT OF PMP 6-HR	12-HR	18-HR	24-HR	INT-LOS INCHES	INF-RATE INCH/HR	VOLUME IN INCHES RAIN	LOSS	EXCESS
22.00	.891	99.00	110.00	114.04	117.00	.30	.30	20.62	4.83	15.79

LAKE INFLOW HYDROGRAPH ORDINATES

PROBABLE MAXIMUM FLOOD HYDROGRAPH ORDINATES IN CFS AT .250 HOUR INTERVALS BEGINNING AT ZERO TIME

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.5	4.5	9.0	15.0	23.0	32.9	44.4	56.5	67.9	78.5	88.3
97.2	105.1	111.9	118.0	123.6	128.9	133.8	138.3	142.4	146.2	149.6	152.5
155.1	249.3	367.4	577.1	855.7	1281.2	1799.9	2541.1	3390.5	5009.4	7349.8	9829.1
12364.2	15145.8	18241.5	20551.6	22370.6	22981.3	22791.0	22323.5	21595.8	20577.9	19397.8	18291.3
17450.0	16676.6	15842.8	14959.2	14031.0	13017.1	11915.6	10760.5	9585.2	8445.1	7347.9	6293.0
5260.3	4346.8	3481.3	2716.5	2168.4	1788.9	1465.3	1188.9	958.2	764.7	595.1	449.6
328.1	229.1	148.3	85.8	41.4	13.8	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				

LAKE AND DAM INFORMATION

BEGINNING POOL ELEV FT,MSL	OUTLET INVERT FT,MSL	BOTTOM OF LAKE FT,MSL	SPILLWAY CREST FT,MSL	SPILLWAY CREST WIDTH FEET	TOP OF DAM ELEVATION FT,MSL	TOP OF DAM LENGTH FEET	HEIGHT OF DAM FEET	DOWNSTREAM SLOPE OF DAM	N-VALVE ON DS SLOPE	COEF OF FLOW OVER DAM
5525.00	5496.00	5496.00	5525.00	70.0	5534.44	1424.0	38.4	1V ON 1.75H	.030	3.60

SUMMARY OF FLOOD ROUTINGS OF INFLOW HYDROGRAPH THROUGH THE LAKE

ROUTING NUMBER	PERCENT PMF INFLOW HYDROGRAPH	TOTAL INFLOW VOLUME AC-FT	MAXIMUM LAKE ELEVATION FT,MSL	DEPTH OF LAKE OVER TOP OF DAM FEET	ESTIMATED VELOCITIES CREST FPS	TOE FPS	INITIAL TIME TO OVER TOP HOUR	TOTAL TIME OVER DAM HOURS	VOLUME SPILLED OVER DAM AC-FT	MAXIMUM DISCHARGE FROM DAM CFS
1	100.0	9178.	5535.95	1.51	5.69	18.01	15.27	4.64	2745.0	22930.1
2	90.0	8260.	5535.69	1.25	5.19	16.11	15.39	4.23	2048.9	20637.1
3	80.0	7342.	5535.44	1.00	4.63	14.05	15.53	3.69	1396.1	18344.1
4	70.0	6424.	5535.18	.74	3.99	11.76	15.71	2.92	807.3	16051.0
5	60.0	5507.	5534.86	.42	3.02	8.40	15.96	1.90	328.9	13730.3
6	50.0	4589.	5534.41	-.03	0.00	0.00	0.00	0.00	0.0	11441.8

C of E - Summary Table

DAM INSPECTION HYDROLOGIC ANALYSIS - SUMMARY TABLE

HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM
FABRIDAMS INFLATED
ROCKY MOUNTAIN CONSULTANTS INC. LONGMONT COLORADO
AUGUST 1979

SYNDERS .250 HOUR UNIT HYDROGRAPH DATA AND PARAMETERS

DURATION HOURS	DA SQ-MI	L MILES	LCA MILES	CP	CT	QP C.F.S	TP HOURS	W50 HOURS	W75 HOURS	UNIT VOL AC-FT
.250	10.90	7.77	3.30	.580	.720	2150.6	1.91	2.60	1.50	581.33

PROBABLE MAXIMUM STORM PRECIPITATION AND RUNOFF CHARACTERISTICS

PMP INDEX	RAIN FACTOR	DISTRIBUTION IN PERCENT OF PMP 6-HR	12-HR	18-HR	24-HR	INT-LOS INCHES	INF-RATE INCH/HR	VOLUME IN INCHES RAIN	LOSS	EXCESS
22.00	.801	99.00	110.00	114.04	117.00	.30	.30	20.62	4.83	15.79

LAKE INFLOW HYDROGRAPH ORDINATES

PROBABLE MAXIMUM FLOOD HYDROGRAPH ORDINATES IN CFS AT .250 HOUR INTERVALS BEGINNING AT ZERO TIME

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.5	4.5	9.0	15.0	23.0	32.9	44.4	56.5	67.9	78.5	88.3
97.2	105.1	111.9	118.0	123.6	128.9	133.8	138.3	142.4	146.2	149.6	152.5
155.1	249.3	367.4	577.1	855.7	1281.2	1799.9	2541.1	3390.5	5009.4	7349.8	9829.1
12364.2	15145.8	18041.5	20551.6	22370.6	22981.3	22791.0	22323.5	21595.8	20577.9	19397.8	18291.3
17450.0	16676.6	15842.8	14959.2	14031.0	13017.1	11915.6	10760.5	9585.2	8445.1	7347.9	6293.0
5290.3	4346.8	3481.3	2716.5	2168.4	1788.9	1465.3	1188.9	958.2	764.7	595.1	449.6
328.1	229.1	148.3	85.8	41.4	13.8	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				

LAKE AND DAM INFORMATION

BEGINNING POOL ELEV FT,MSL	OUTLET INVERT FT,MSL	BOTTOM OF LAKE FT,MSL	SPILLWAY CREST FT,MSL	SPILLWAY CREST WIDTH FEET	TOP OF DAM ELEVATION FT,MSL	TOP OF DAM LENGTH FEET	HEIGHT OF DAM FEET	DOWNSTREAM SLOPE OF DAM	N-VALVE ON DS SLOPE	COEF OF FLOW OVER DAM
5525.00	5496.00	5496.00	5525.00	70.0	5534.44	1424.0	38.4	1V ON 1.75H	.03%	3.60

SUMMARY OF FLOOD ROUTINGS OF INFLOW HYDROGRAPH THROUGH THE LAKE

ROUTING NUMBER	PERCENT PMF INFLOW HYDROGRAPH	TOTAL INFLOW VOLUME AC-FT	MAXIMUM LAKE ELEVATION FT,MSL	DEPTH OF LAKE OVER TOP OF DAM FEET	ESTIMATED VELOCITIES CREST FPS	TOE FPS	INITIAL TIME TO OVER TOP HOUR	TOTAL TIME OVER DAM HOURS	VOLUME SPILLED OVER DAM AC-FT	MAXIMUM DISCHARGE FROM DAM CFS
1	100.0	9178.	5536.59	2.15	6.79	22.24	14.95	6.42	5615.7	22942.9
2	90.0	8260.	5536.39	1.95	6.47	21.02	15.03	6.18	4775.6	20648.5
3	80.0	7342.	5536.20	1.76	6.15	19.74	15.13	5.90	3944.4	18354.3
4	70.0	6424.	5536.01	1.57	5.80	18.40	15.25	5.56	3128.7	16056.9
5	60.0	5507.	5535.75	1.31	5.31	16.57	15.39	5.12	2334.7	13758.7
6	50.0	4589.	5535.50	1.06	4.78	14.59	15.58	4.54	1571.7	11465.6
7	40.0	3671.	5535.25	.81	4.17	12.40	15.83	3.66	859.1	9172.5
8	30.0	2753.	5534.96	.52	3.35	9.52	16.24	1.95	248.7	6791.2
9	20.0	1836.	5533.77	-.67	0.00	0.00	0.00	0.00	0.0	4208.8

DAM INSPECTION HYDROLOGIC ANALYSIS - SUMMARY TABLE

HYDROLOGIC ANALYSIS OF MAPLE GROVE RESERVOIR DAM
FABRIDAMS DEFLATED
ROCKY MOUNTAIN CONSULTANTS INC. LONGMONT COLORADO
AUGUST 1979

SYNDERS .250 HOUR UNIT HYDROGRAPH DATA AND PARAMETERS

DURATION HOURS	DA SQ-MI	L MILES	LCA MILES	CP	CT	QP C.F.S	TP HOURS	W50 HOURS	W75 HOURS	UNIT VOL AC-FT
.250	10.90	7.77	3.30	.580	.720	2150.6	1.91	2.60	1.50	581.33

PROBABLE MAXIMUM STORM PRECIPITATION AND RUNOFF CHARACTERISTICS

PMP INDEX	RAIN FACTOR	DISTRIBUTION IN PERCENT OF PMP 6-HR	12-HR	18-HR	24-HR	INT-LOS INCHES	INF-RATE INCH/HR	VOLUME IN INCHES RAIN	LOSS	EXCESS
22.00	.801	99.00	110.00	114.04	117.00	.30	.30	20.62	4.83	15.79

LAKE INFLOW HYDROGRAPH ORDINATES

PROBABLE MAXIMUM FLOOD HYDROGRAPH ORDINATES IN CFS AT .250 HOUR INTERVALS BEGINNING AT ZERO TIME

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.5	4.5	9.0	15.0	23.0	32.9	44.4	56.5	67.9	78.5	88.3
97.2	105.1	111.9	118.0	123.6	128.9	133.8	138.3	142.4	146.2	149.6	152.5
155.1	249.3	367.4	577.1	855.7	1281.2	1799.9	2541.1	3390.5	5009.4	7349.8	9829.1
12364.2	15145.8	18041.5	20551.6	22370.6	22981.3	22791.0	22323.5	21595.8	20577.9	19397.8	18291.3
17450.0	16676.6	15842.8	14959.2	14031.0	13017.1	11915.6	10760.5	9585.2	8445.1	7347.9	6293.0
5290.3	4346.8	3481.3	2716.5	2168.4	1788.9	1465.3	1188.9	958.2	764.7	595.1	449.6
328.1	229.1	148.3	85.8	41.4	13.8	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				

LAKE AND DAM INFORMATION

BEGINNING POOL ELEV FT,MSL	OUTLET INVERT FT,MSL	BOTTOM OF LAKE FT,MSL	SPILLWAY CREST FT,MSL	SPILLWAY CREST WIDTH FEET	TOP OF DAM ELEVATION FT,MSL	TOP OF DAM LENGTH FEET	HEIGHT OF DAM FEET	DOWNSTREAM SLOPE OF DAM	N-VALVE ON DS SLOPE	COEF OF FLOW OVER DAM
5520.00	5496.00	5496.00	5520.00	70.0	5534.44	1424.0	38.4	1V ON 1.75H	.030	3.60

SUMMARY OF FLOOD ROUTINGS OF INFLOW HYDROGRAPH THROUGH THE LAKE

ROUTING NUMBER	PERCENT PMF INFLOW HYDROGRAPH	TOTAL INFLOW VOLUME AC-FT	MAXIMUM LAKE ELEVATION FT,MSL	DEPTH OF LAKE OVER TOP OF DAM FEET	ESTIMATED VELOCITIES CREST FPS	TOE FPS	INITIAL TIME TO OVER TOP HOUR	TOTAL TIME OVER DAM HOURS	VOLUME SPILLED OVER DAM AC-FT	MAXIMUM DISCHARGE FROM DAM CFS
1	100.0	9178.	5535.95	1.51	5.69	17.99	15.65	4.00	2106.7	22930.3
2	90.0	8260.	5535.69	1.25	5.18	16.09	15.78	3.50	1465.0	20637.3
3	80.0	7342.	5535.44	1.00	4.62	14.03	15.95	2.82	884.8	18344.2
4	70.0	6424.	5535.18	.74	3.99	11.74	16.18	1.91	401.5	16045.6
5	60.0	5507.	5534.62	.18	1.94	4.94	16.62	.71	57.5	13500.3
6	50.0	4589.	5532.86	-1.58	0.00	0.00	0.00	0.00	0.0	11094.3

APPENDIX E

ATTACHMENTS

Attachment 1	Chronology of Events at Maple Grove Reservoir
Attachment 1A	State Engineer's Letter Requiring Spillway Modification - 1974
Attachment 2	Hydraulic Design Report of Spillway - 1976
Attachment 3	Description of 1977 Improvement Project
Attachment 4	Letter Describing Safety Procedures Following Spillway Failure in 1979
Attachment 5	Fabridam Sequence During and After a Flood - 1979

CHRONOLOGY
MAPLE GROVE RESERVOIR
OFFICE OF THE STATE ENGINEER

DATE	ITEM
21 Oct 55	Letter from Lane Engineering transmitting "Analysis of Design for Maple Grove Reservoir Dam" to DWR.
11 Feb 57	Letter from Lane Engineering to DWR discussing location of measuring flumes.
11 Mar 57	Letter from DWR to Lane Engineering approving flume location.
17 June 63	Letter from DWR to Consolidated Mutual pointing out hazard of the failure of the small dam below Maple Grove. Storage in this small reservoir was banned until repairs were made and an adequate spillway constructed to pass Maple Grove outflows.
26 Jan 71	DWR Inspection Report showing Maple Grove Dam to be in excellent repair.
8 Nov 71	DWR Inspection Report on settling pond below Maple Grove Dam. Recommends removal of flashboards and construction of by-pass channel to carry Maple Grove flows.
30 Oct 72	Letter from Wheatridge to DWR expressing concern over proposed development below Maple Grove.
8 May 74	Letter from Seracuse-Lawler transmitting drainage report and spillway data to DWR.
13 May 74	Letter from DWR to Consolidated Mutual requesting upgrading of Maple Grove Spillway to pass Standard Project Flood. Unless construction completed by spring of 1975, storage would be restricted.
10 Jun 74	Letter from DWR to Seracuse-Lawler pointing out Maple Grove Dam is adequate but spillway is not.
14 Jun 74	Letter from Consolidated Mutual to DWR acknowledging restriction letter of 13 May 1974 stating that consultants were being interviewed and requesting extension of 15 June 74 deadline for submission of schedule.

CHRONOLOGICAL SYNOPSIS

MAPLE GROVE RESERVOIR & SPILLWAY

DATE	ITEM
11/18/55	State Engineer approved plans for first phase of construction - 600 A/F storage. (Designed for ultimate storage of 1,000 A/F. Spillway capacity approximately 570 C.F.S.)
6/29/56	Construction completed.
5/17/60	State Engineer approved plans for relocated spillway. (capacity approximately 1,100 C.F.S.)
8/6/60	Construction completed.
12/11/70	621 A/F storage decree adjudicated (Priority date 12/9/53) 409 A/F conditional decree (Priority date 11/22/54)
5/6/73	Major flood in Lena Gulch Drainage Basin (Spillway discharge approximately 850 C.F.S)
7/2/73	Intergovernmental Agreement on Lena Gulch Drainage Project executed by Urban Drainage & Flood Control District, Golden, Lakewood, Wheat Ridge, and Jefferson County.
5/13/74	State Engineer notification to enlarge spillway to pass "Standard Project Flood".
6/21/74	DMJM-Phillips-Reister authorized to design facilities to meet State Engineer's requirements.
10/8/74	Minimal inflow for Standard Project Flood defined.
10/18/74	Preliminary design concept completed (flood erosion protection for entire dam-not accepted)
2/7/75	Cost sharing agreement between Consolidated and Wright McLaughlin Engineers to expand Lena Gulch Master Drainage Plan to include cost/benefit analysis of the Maple Grove Reservoir as a water supply and flood control facility.
2/10/75	State Engineer authorized additional time to include Lena Gulch channel improvements in final spillway design considerations.
8/12/75	LENA GULCH MASTER DRAINAGE PLAN published (Alternate #3 recommended: Lena Gulch Improvements With Master Plan Channel With Maple Grove Reservoir Maintained as a Water Supply; Annual flood reduction costs of $419,500 with most economic Lena Gulch channel design costs.)

DATE	ITEM
10/9/75	Public meeting called by Jefferson County Commissioners to review status of Lena Gulch Drainage Project and Spillway improvements (Preliminary variable crest spillway design presented).
11/19/75	State Engineer tentatively approved variable crest design.
12/8/75	State Engineer approved Inflatable "FABRIDAM" concept.
1/22/76	Second public meeting called by Jefferson County Commisioners to review progress of spillway design (Fabridam concept presented in detail - concept approved by all present, subject to formal action by the respective Boards and Councils).
2/19/76	Final hydraulic design of spillway improvements completed (including two Fabridams).
4/29/76	Third public meeting called by Jefferson County Commissioners to review progress of spillway design and various approvals (Final design presented and concurred in).
4/30/76	Formal application to Jefferson County to issue Industrial Development Revenue Bonds, primarily to finance spillway improvements.
7/14/76	Intergovernmental Cost Sharing Agreement on spillway improvements executed by Urban Drainage & Flood Control District, Wheat Ridge, Lakewood, and Jefferson County.
7/15/76	Industrial Development Revenue Bond Financing Agreement executed by Jefferson County and Consolidated.
8/27/76	Cost Sharing Agreement on street improvements across the Maple Grove Dam executed by Lakewood and Consolidated.
10/14/76	State Engineer approved final spillway design, including dual Fabridam concept.
12/21/76	Industrial Development Revenue Bond Issue completed.
1/25/77	State Engineer approved final plans for Fabridams and control systems.
2/18/77	Special meeting to review more economical alternatives to spillway improvements (Attended by representatives of Urban Drainage & Flood Control District, the State Engineer's Office, N. M. Imbertson & Associates, DMJM Phillips-Reister, and Consolidated. All alternatives rejected - final design of spillway, Fabridams, and control systems reconfirmed.
8/10/77	Construction completed.

ohn D. Vanderhoof
Governor

C. J. KUIPER
State Engineer

DIVISION OF WATER RESOURCES

Department of Natural Resources
300 Columbine Building
1845 Sherman Street
Denver, Colorado 80203

May 13, 1974

Consolidated Mutual Water Co.
10075 West Colfax Avenue
Denver, CO

Re: Maple Grove Reservoir C-C757-A
W. Div. 1 W. Dist. 7

Gentlemen:

Recent reviews of the Maple Grove Reservoir Dam and the flood plain below the dam have shown the need for greater spillway capacity at this site.

In view of the population downstream and probable loss of life with the occurrence of a major storm event, a spillway capable of passing the standard project flood must be designed and constructed at this dam. In order to facilitate the work and assure public safety, we are requiring that you submit to this office by June 15, 1974, a schedule for the engineering and construction work.

If you wish to continue to use the full storage capacity of this reservoir, the new spillway must be constructed prior to the 1975 runoff season.

Members of this office will be available to discuss these requirements with you or your representatives. If you have any questions, kindly contact the Dams and Reservoir Section of this office.

Very truly yours,

C. J. Kuiper
State Engineer

CJK:JTS:cat

cc: W. G. Wilkinson
Arlyn C. Davison

Appendix E - Attachment 1A

DMJM

ORLEY O. PHILLIPS
FLOYD M. REISTER

DMJM-PHILLIPS·REISTER

June 7, 1976

Mr. Glen E. Whitten
Vice President
Consolidated Mutual Water Company
10075 West Colfax Avenue
Lakewood, Colorado 80215

Dear Mr. Whitten:

This letter report will present an updating of the February 19, 1976 letter for the design of the new spillway for Maple Grove Dam and Reservoir, which will pass the Corps of Engineers Standard Project Flood for Lena Gulch above the Reservoir.

I. INTRODUCTION

Described herein are specifics relating to the hydraulic design of the spillway for Maple Grove Reservoir to pass the Corps of Engineers Standard Project Flood and also provide a maximum benefit for storage and flood peak reduction for floods in the 0-100 year frequency range. The resulting flood control benefit of the dam and reservoir for the areas below the dam has been determined to be optimal considering the imposed requirements for the structure: (1) to pass the Standard Flood Project; (2) the physical constraints and limitations on spillway size; and (3) cost. The present design provides for a maximum flood control benefit within the restrictions imposed on the spillway design.

II. GENERAL DESCRIPTION

The design of the ogee type spillway is shown on the accompanying Figures 1 and 2. The spillway is a chute type concrete spillway with a modified ogee type crest with suppressed overflow having a clear opening of 70 feet in width and a minimum of 12.75 feet from the crest elevation of 5520.0 to the bottom of the bridge passing over the spillway. Installed on the crest and illustrated on Figure 2, are two inflatable (fabridam) dams as follows:

DENVER DIVISION · DANIEL, MANN, JOHNSON, & MENDENHALL
SUITE 700 · 910 FIFTEENTH STREET · DENVER, COLORADO 80202 · TELEPHONE (303) 892-1300 · CABLE DMJM DENVER

1. A 6'x30' Fabridam. When fully inflated results in a crest elevation of 5526.0. (Normal inflation will be 5 feet giving a crest elevation of 5525.0).

2. A 10'x40' Fabridam. When fully inflated results in a crest elevation of 5530.0.

A bridge pier 30' from the east wall will serve to provide end support for the fabridams and also support the bridge over the spillway.

It is intended that the fabridams will remain inflated during the occurrence of a flood of a frequency of 1% or greater (0 to 100 year frequency floods.) When the water level in the reservoir rises to an elevation of 5531.0 and continues to rise, the dams would begin to deflate at a rate such that they would completely collapse in about one hour. The time base of the SPF inflow design flood is such that a one hour deflation time is adequate for extreme flood conditions. However, the exact final operational procedure has not been established at the present time.

The minimum elevation of the underside of the new 27th Avenue bridge, which will pass over the spillway, will be 5532.75 (maximum of 5533.50). This will give a minimum of 12.75 feet of clearance over the crest of the spillway (elevation = 5520.0) when the fabridams are completely deflated which provides sufficient area to pass the Standard Project Flood without causing any overtopping of the dam embankment (taking into consideration the drawdown from the reservoir to the spillway crest). The maximum water surface elevation in the reservoir during the occurrence of a Standard Project Flood in Lena Gulch will be 5534.9. The dam embankment will be raised to a minimum 5535.0, thus providing a little freeboard during the occurrence of the SPF inflow design flood.

The dam and surrounding area on the inlet side of the spillway will be modified to provide for a smooth transition from the reservoir to the spillway for proper hydraulic flow characteristics. A portion of the Rocky Mountain Ditch near the spillway will be replaced with a buried concrete pipe, which is necessary to facilitate the spillway inlet modifications and to maintain an access road around the reservoir.

The hydraulic design of the spillway crest profile, chute, and stilling basin is shown on Figures 1 and 2.

III. HYDRAULIC AND HYDROLOGIC DESIGN DETAILS

A. Spillway Hydraulic Characteristics

Enclosed are four figures relating to the passage of flood waters through the reservoir and spillway for various conditions. Figure 3 presents the area-capacity curve for Maple Grove Reservoir. Figure 4 presents the water surface elevation vs. discharge curve for the spillway. Shown as the solid line is the discharge curve with the fabridams deflated. The dashed line is the discharge curve when the fabridams remain inflated. The zone between these two curves represents the water surface elevation vs. discharge relationships that are possible depending on the specified type of inflatable dam operation.

To achieve optimal flood storage benefits for floods in the 0-100 year frequency range, the fabridams would remain inflated until the water surface in the reservoir reached 5531.0 during the occurrence of a flood. When the water surface reaches this elevation then the fabridams would begin deflating and continue until completely deflated as long as the water surface elevation continued

rising. If the water surface elevation in the reservoir began dropping after the dams had deflated to some level, then the fabridams would cease deflating and begin inflating, continuing until completely inflated as long as the water surface elevation continued to drop. The dotted line in Figure 4 represents the assumed stage-discharge relation when the fabridams are deflating for the occurrence of a Standard Project Flood. This information was used in the routing of the Standard Project Flood through the Reservoir.

The stage-discharge curve for flow over the fabridams in the fully inflated mode was determined using variable-with-head discharge coefficients obtained from model studies. The stage-discharge curve for flow over the spillway crest with the fabridams deflated was determined using discharge coefficients obtained from model and prototype spillway tests performed by the Bureau of Reclamation. The spillway crest profile shown in Figure 2 is very similar to the Bartlett Dam spillway tested by the Bureau of Reclamation. The discharge coefficients vary between 3.02 at a head of 1.0 feet (W.S. elevation in reservoir = 5521.0) to 3.45 for the spillway design head of 15 feet. (W.S. elevation = 5535.0.)

Figures 5 and 6 illustrate the 100-year and Standard Project inflow design flood hydrographs for Maple Grove Reservoir. The figures also illustrate the routed outflow through the spillway.

The peak flow data into and out of the reservoir are tabulated below:

Flood	Maximum Inflow	Maximum Outflow	Maximum Water Surface
100-Year	3820 cfs	1725 cfs	5530.70
SPF	13950 cfs	13780 cfs	5534.90

Figure 5 illustrates the flood control benefit of Maple Grove Reservoir as a flood control facility for the 100-year flood, with the spillway and fabridam configuration as had been described. The 100-year inflow flood peak of 3820 cfs is reduced to an outflow of 1715 cfs in passing through the reservoir. This outflow compares very favorably with the 1500 cfs peak flow which was used in the Lena Gulch Study performed for Urban Drainage District.

The freeboard for normal reservoir operation will be 10.0 feet. During the passage of a 100-year flood the freeboard will be about 4.3 feet and this will drop to about 0.1 foot during the passage of a Standard Project Flood. This amount of freeboard for the various conditions results in acceptable factors of safety from the standpoint of dam overtopping.

B. Spillway Chute and Stilling Basin

The chute is designed to carry the Standard Project Flood without any overtopping of the concrete walls. The depth of flow in the chute varies from 10.6 feet near the top of the chute to a minimum of about 3.7 feet before entering the stilling basin for a flow of 13,780 cfs.

The design of the stilling basin shown on the figures was based on the Bureau of Reclamation's criteria for the design of Type III Hydraulic jump basins and was sized for a flow of 80 cfs/ft. of stilling basin width. This gives a total flow of 5600 cfs through the basin. It was determined that the design of a hydraulic jump stilling basin for a flow of 13,780 cfs (SPF) would require excessively high walls and the stilling action would not accomplish

much as the natural slope of the channel immediately downstream of the stilling basin is greater than the critical slope and supercritical velocities will occur in this area no matter what is done in the stilling basin. In discussing this with personnel in the State Engineer's office, they indicated that this design concept would be acceptable as long as the base of the dam was not affected and/or it was satisfactorily protected from the undermining with flood waters for the SPF.

The stilling basin is so sized that an hydraulic jump will occur in the basin for any flow of 5600 cfs or lower. For larger flows, the jump will not occur until reaching the wash water waste pond downstream. This is completely free of the structure, but to protect the spillway, chute, and stilling basin from erosion taking place underneath and near the structure, sheet piling will be installed at the end of the stilling basin. Also, riprap will be used to line the channel below the stilling basin to protect it from erosion caused by a 100-year flood or less.

IV. CONCLUSION AND SUMMARY

The final hydraulic design incorporates the following:

1. Removal of existing spillway.
2. Construction of 72 foot wide (spillway crest widths of 30 feet and 40 feet under the bridge) concrete spillway with varying wall heights for the crest, chute and stilling basin.

DMJM

DMJM-PHILLIPS·REISTER

3. Installation of two fabridams to control the normal storage level and to control the downstream flow during flooding periods. A 6'x30' fabridam and a 10'x40' fabridam separated by the 2 foot wide bridge pier.

4. Raising of the top of the dam to elevation of at least 5535.0 except over the spillway which will be raised higher due to the bridge.

5. Installation of a bridge over the spillway with the bottom of the bridge at a minimum elevation of 5532.75.

6. Reconstruction of 27th Avenue over the Dam.

7. Converting a portion of the Rocky Mountain Ditch to closed conduit flow.

8. Miscellaneous recontouring of the inlet to the spillway and the outlet of the stilling basin and the placement of required riprap.

This letter report has summarized the final hydraulic design of the spillway for Maple Grove Reservoir and Dam. This is for your information and files. We are presently proceeding with the final structural and related designs and fabridam design and operational procedures at the present time.

Very truly yours,

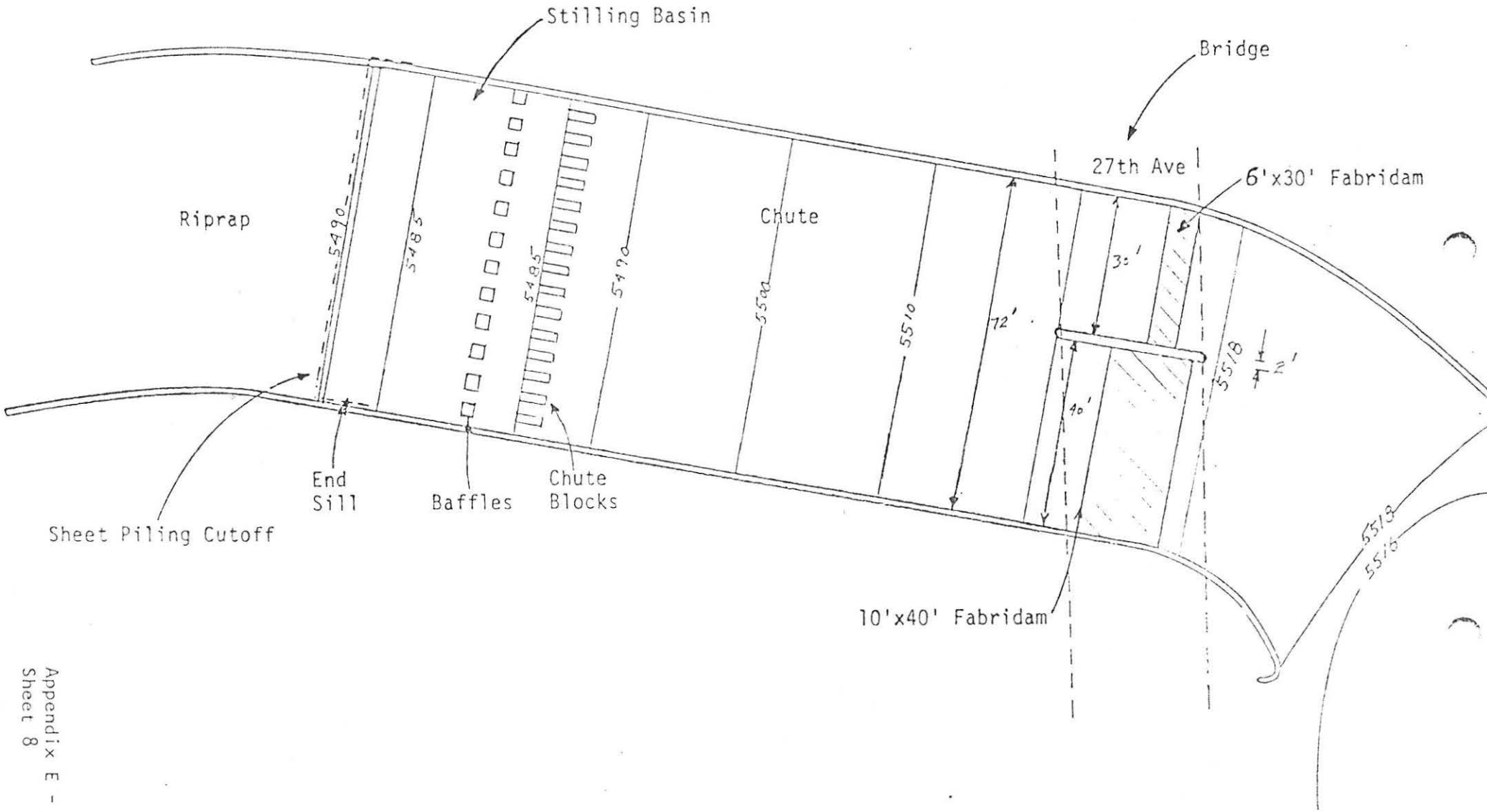
DMJM - PHILLIPS·REISTER, INC.

Kenneth A. Mangelson

Kenneth A. Mangelson, P.E.

KAM:vw

cc: C. J. Kuiper, State Engineer
Scott Tucker - UDFCD



Scale 1" = 30'

Figure 1. Plan View of Spillway for Maple Grove Dam and Reservoir

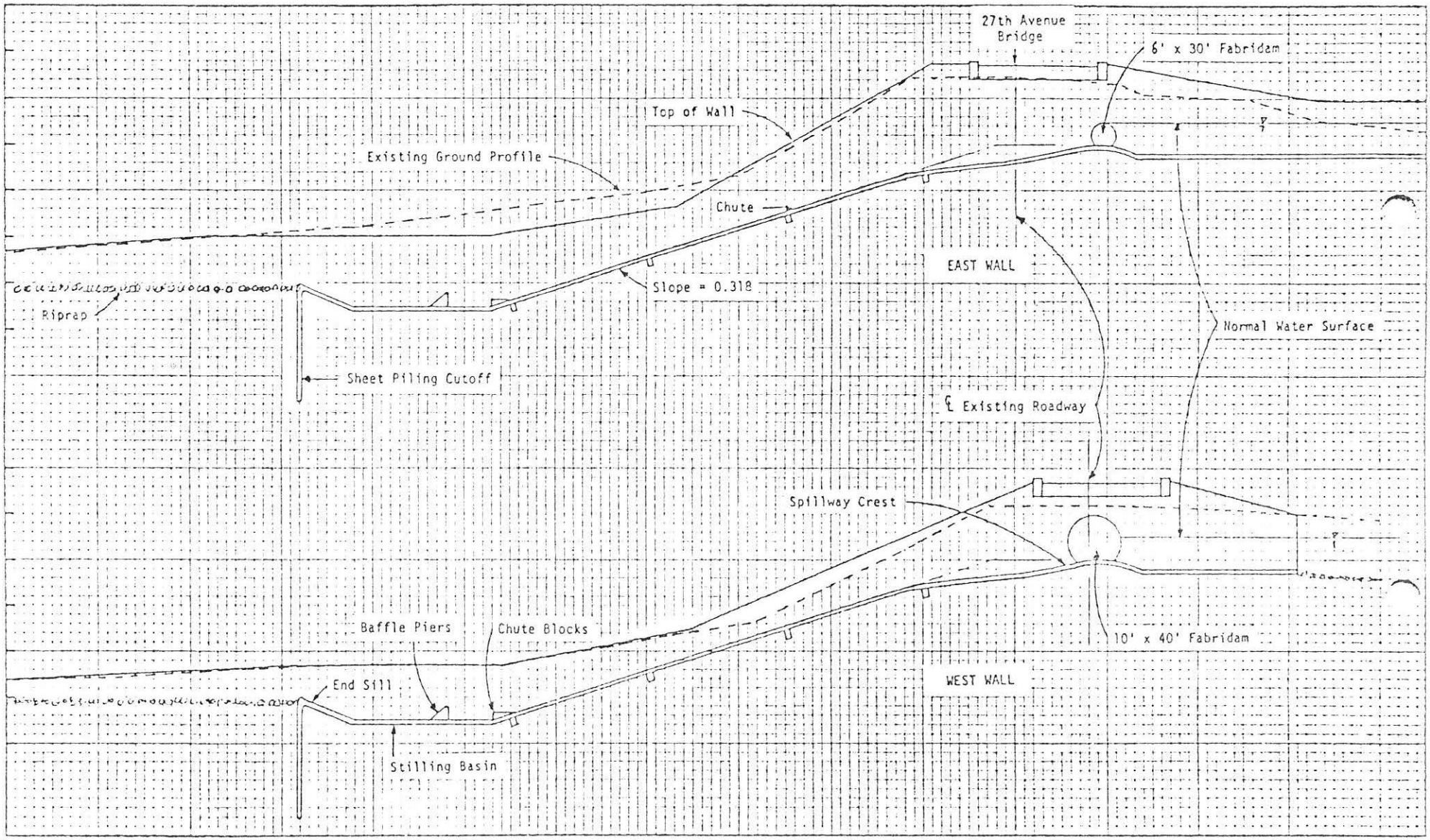


Figure 2 - Longitudinal Profiles of Spillway at East and West Walls for Maple Grove Dam and Reservoir.

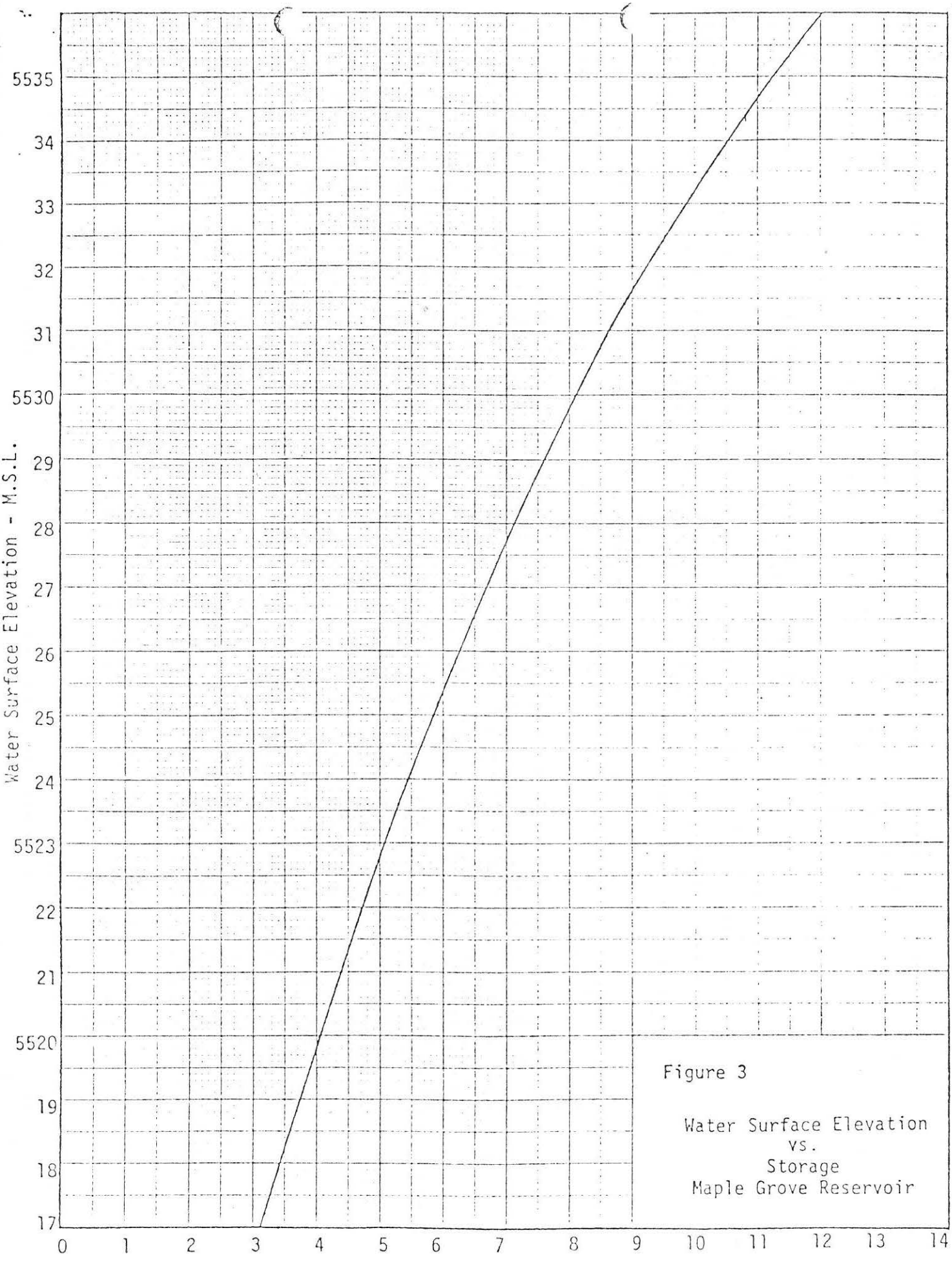


Figure 3

Water Surface Elevation
vs.
Storage
Maple Grove Reservoir

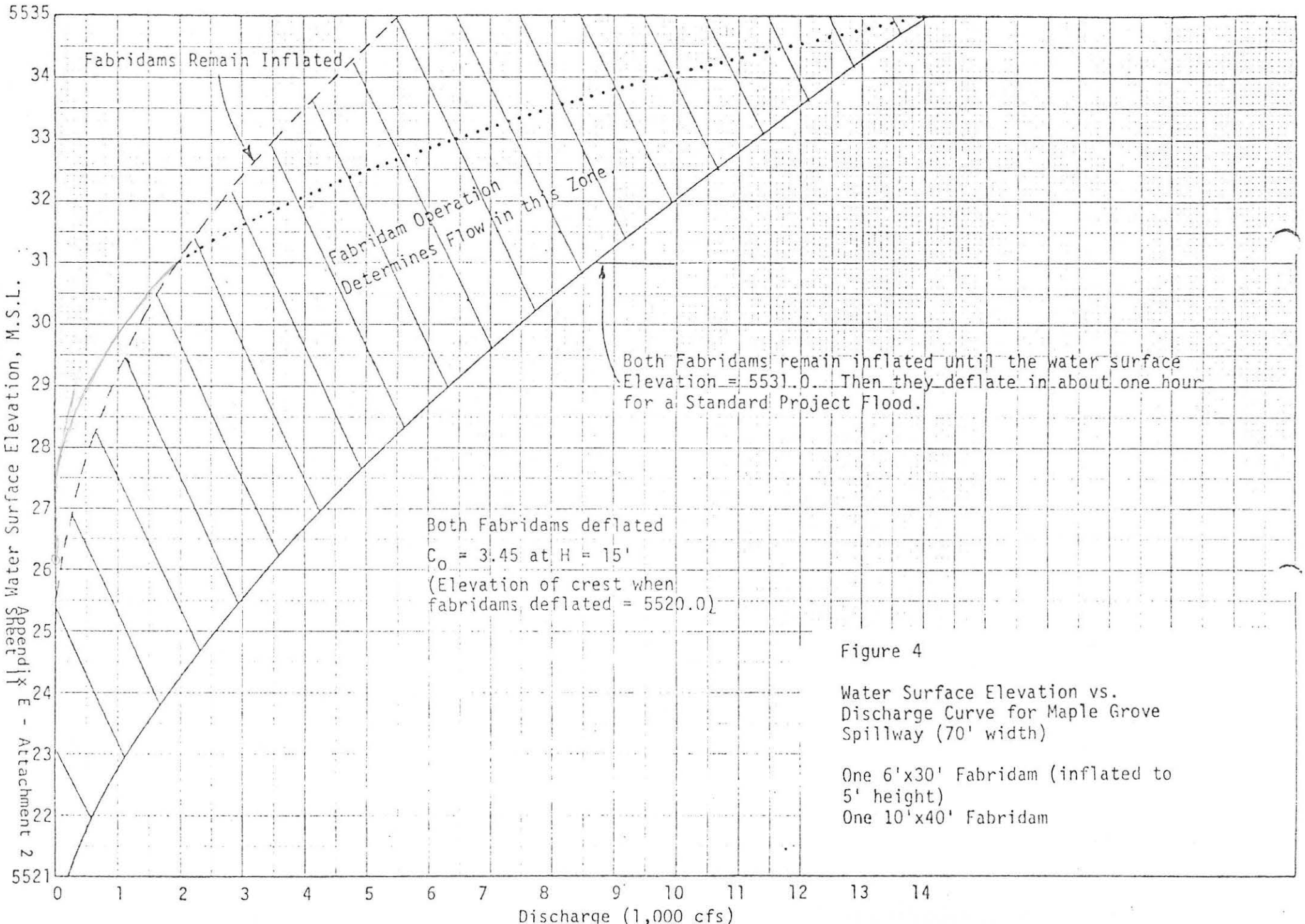
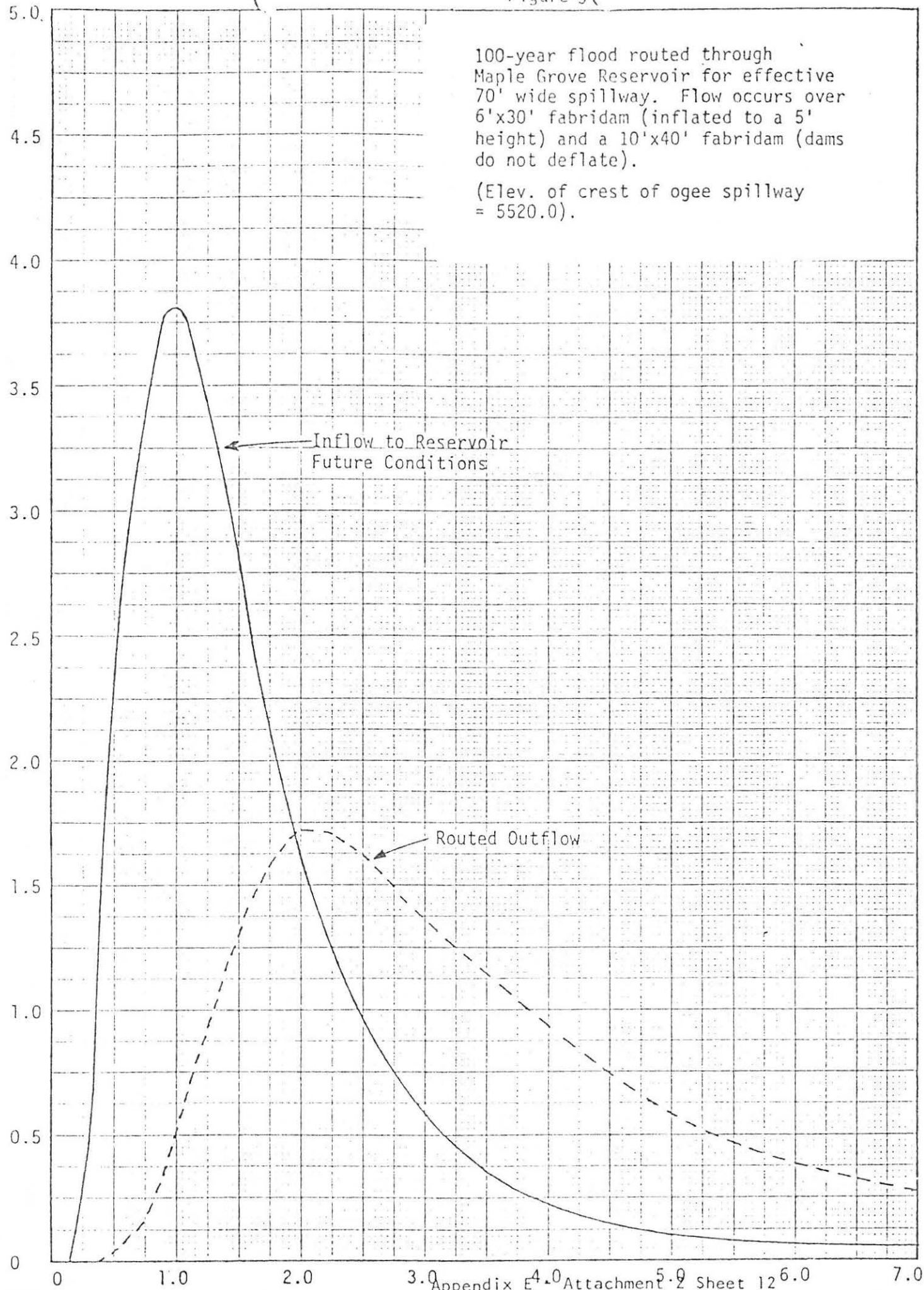


Figure 4

Water Surface Elevation vs. Discharge Curve for Maple Grove Spillway (70' width)

One 6'x30' Fabridam (inflated to 5' height)
One 10'x40' Fabridam

Figure 5


100-year flood routed through Maple Grove Reservoir for effective 70' wide spillway. Flow occurs over 6'x30' fabridam (inflated to a 5' height) and a 10'x40' fabridam (dams do not deflate).
(Elev. of crest of ogee spillway = 5520.0).
Inflow to Reservoir Future Conditions
Routed Outflow
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0

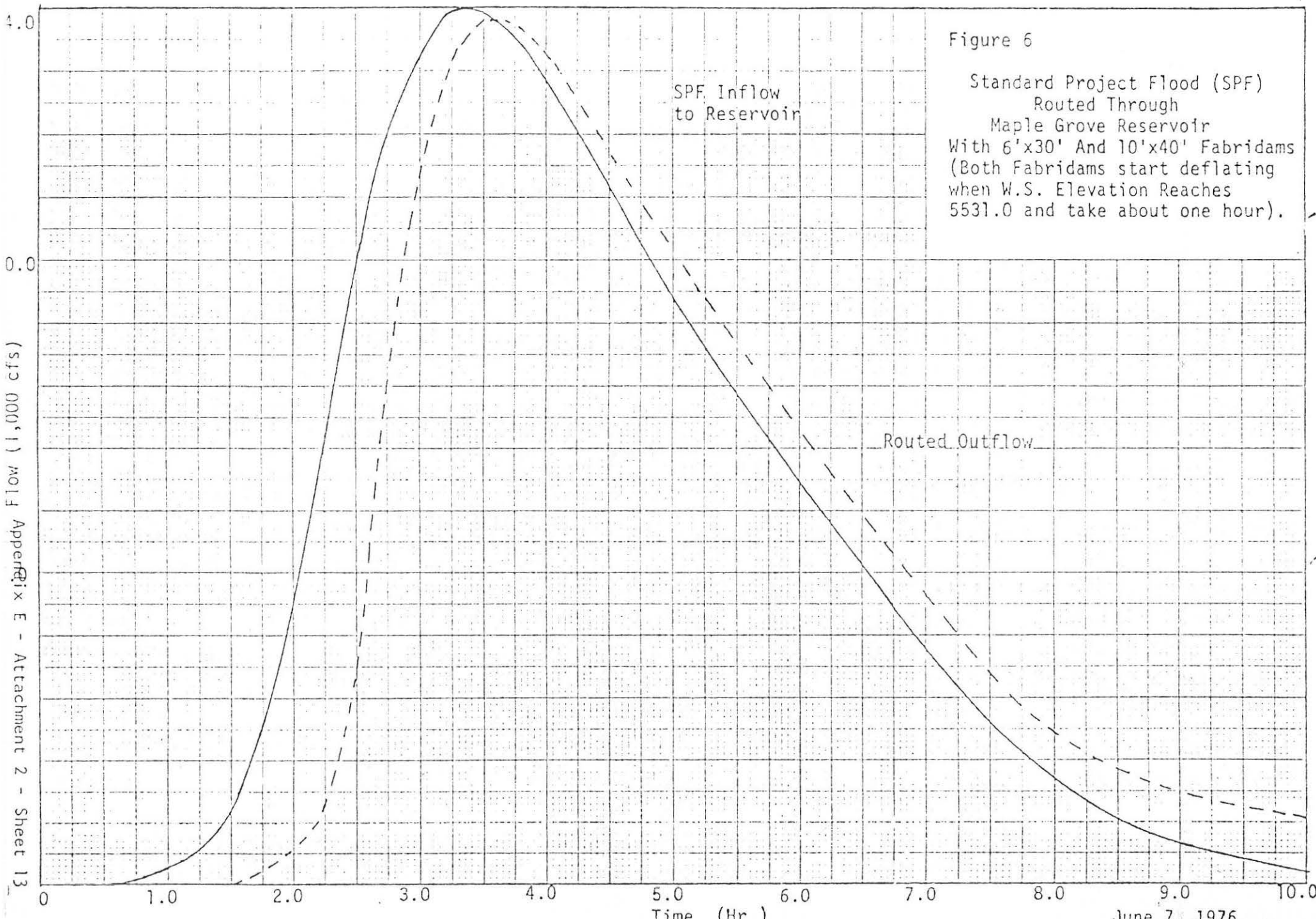


Figure 6
Standard Project Flood (SPF)
Routed Through
Maple Grove Reservoir
With 6'x30' And 10'x40' Fabridams
(Both Fabridams start deflating
when W.S. Elevation Reaches
5531.0 and take about one hour).
SPF Inflow
to Reservoir
Routed Outflow
4.0
0.0
(1,000 cfs) Flow
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Time (Hr.)
June 7, 1976

FOR IMMEDIATE RELEASE

JUNE 28, 1977

MAPLE GROVE/LENA GULCH/W. 27th AVE. IMPROVEMENT PROJECT

The opening of W. 27th Ave., from Youngfield Street across the Maple Grove Dam, on July 1, 1977, signals the near completion of a major improvement project being accomplished through the cooperative efforts of several Local Government Entities and The Consolidated Mutual Water Company, a private company.

The Maple Grove Reservoir, constructed in the late 1950's, is a major component of the Company's water storage and treatment facilities currently providing domestic water service to a populous of 15,000 in portions of Northwest Lakewood, Applewood, Wide Acres, Pleasant View, and Sixth Avenue West.

The principal features of the project include a new spillway on the east end of the dam, a 5' raise in the dam embankment, a new bridge and major street improvements across the dam, and inflatable "Fabridams" designed to automatically control the flow of water under varying flood conditions.

The new spillway, in conjunction with the increased flood routing capacity of the reservoir resulting from the higher dam, is designed to carry approximately 14,000 cubic feet of water per second. This rate of flow was established by the Colorado State Engineer as necessary to protect the safety of the dam under maximum anticipated flood conditions for the Lena Gulch drainage basin.

A unique feature of the project is two inflatable "Fabridams' (one 6' high by 30' long, and one 10' high by 40' long) and a sophisticated control

more -

feature was specifically incorporated in the project in cooperation with the Urban Drainage and Flood Control District, and is designed to accommodate the District's Master Plan for downstream channel improvements to the Lena Gulch Drainage System.

The new spillway design and the raising of the dam required the installation of a bridge and the rebuilding of W. 27th Ave. across the dam. In cooperation with the City of Lakewood, extensive street improvements were incorporated in the project, including curb and gutter, drainage, guard rails, chain link fencing, street lighting, and a 7' sidewalk.

The total cost of the project upon completion is estimated at nearly $800,000. As a result of a series of cooperative agreements, The Urban Drainage and Flood Control District, the Cities of Lakewood and Wheat Ridge, and Jefferson County, are jointly financing the added cost of special flood control features, and The City of Lakewood is financing a major portion of the street improvements.

The estimated net cost of the project to the Company is $640,000, which together with other needed improvements to the Company's water system, required additional long-term financing. Through the cooperative efforts of the Jefferson County Commissioners, favorable financing was accomplished. In December 1976, the County issued $1,300,000 of tax exempt Industrial Development Revenue Bonds under the provisions of the Colorado County and Municipality Economic Development Revenue Bond Act. The entire bond issue was sold to Boettcher & Company, Investment Bankers, at exceptionally favorable interest rates of 6½% and 6-5/8%. Jefferson Bank and Trust of Lakewood was appointed as Bond Trustee for the issue.

It now appears that it may be necessary to temporarily close W. 27th

more --

Ave. again during the week of July 18th, to accommodate the final phases of the project. Every effort will be made to keep the inconvenience to the public at a minimum during this temporary closing.

For further information, call Virgil L. Hill - 238-0451.

DRAFT - Suggested response for Governor Lamm

Prepared by Bill Mattern - Deputy State Engineer

James L. Gilbert
Attorney and Counselor at Law
7903 Ralston Road
Arvada, CO. 80002

Dear Mr. Gilbert:

In response to your letter of May 18, 1979 regarding Lena Gulch and Maple Grove Reservoir, I will supply the following information as to the procedures that have taken place in an effort to alleviate future problems.

I believe you are aware that the incident that occurred March 17, was an apparent act of vandalism and the following steps have been taken to alleviate the reoccurrence of such an act taking place in the future.

After repair work was made to the Fabri-Dam in the spillway of Maple Grove Reservoir a changeover was made from using air in the Fabri-Dam, to using water. This was accomplished on April 2. In addition, on-site surveillance by the personnel of Consolidated Mutual Water Company is accomplished at half hour intervals, 24 hours a day, seven days a week. This is not done on a routine fixed schedule whereby these on-site surveillance inspections would not establish a pattern which anyone could follow. Another phase is the security lighting. This lighting system has been installed and in operation since March 27. In addition, a low pressure monitor and alarm system has been put into operation which activates a visual and audio alert in the treatment plant anytime the pressure make-up system in the Fabri-Dam operates for longer than two minutes. This system was installed and has been in operation since June 4.

Additional security means which is taking place is the installation of additional security fences which are currently being installed. A variance has been applied for with the City of Lakewood to allow for a barbed wire overhang above the fenced enclosure. Alternatives for supplying of emergency power are also being worked on at this time and at this date have not been finalized. Future precautionary measures are being worked on at this time as proposed by the company's engineers and a fuse plug type structure would be utilized in lieu of the bulkhead gates. The purpose of this is to assure that any unintentional deflation of the Fabri-Dam would release only that water stored between the fuse plugs and the Fabri-Dam. This would be a quantity of less than 1/10 of an acre foot. These plans are tentatively approved and the construction details, including material specifications, will be submitted to the Office of the State Engineer for review and final approval.

I also wish to point out at this time that for many years prior to the present time, recommendations have been made through the State Engineer's Division of Water Resources for the county to prohibit construction and encroachment along Lena Gulch, due to the fact that this is what always has been a natural water course. Needless to say, the county commissioners, or those in the position to control this situation, have not taken many steps to prohibit such encroachment and it appears that the progress now being made through the Urban Flood Control District will undoubtedly prove to be expensive, but this is the only alternative approach that it appears can be taken at this time.

I hope this serves as an answer to those concerns that you and the people you represent will have in the future. If I can be of future assistance please contact my office.

Very truly yours,

Richard D. Lamm
Governor

MAPLE GROVE RESERVOIR SPILLWAY

FABRIDAM DEFLATION SEQUENCE DURING A FLOOD

JUL 9 1979

When water level in the reservoir rises to elevation:

5525	Normal maximum water storage elevation.
5525+	Slight spillage takes place thru folds of 6' Fabridam at abutments.
5526	Nominal crest elevation of 6' Fabridam. Above this elevation water will be spilling over the full width of the 6' Fabridam.
5527.09	Control system automatically increases the internal pressure in both 6' & 10' Fabridams to compensate for deformation of the Fabridams due to the increased upstream water pressure. Increased internal pressure will be maintained until either (a) the Fabridam deflates to pass a flood in excess of the 100 year flood, or (b) the lake level recedes below 5526.67.
5530.65	Water is beginning to spill over the 10' Fabridam. Discharge thru spillway = 1700 cfs. The 1" water release valve from the 6' Fabridam opens and the 6' Fabridam slowly begins to deflate. (On "winter" setting this step does not occur). Air and water supply valves to both Fabridams are de-activated.
5530.70	2" water release valve (summer) or 1/2" air release valve (winter) from 6' Fabridam opens; 6' Fabridam is now deflating faster.
5530.75	4" water release valve (summer) or 1" air release valve (winter) from 6' Fabridam opens; 6' Fabridam is now deflating much faster. Also, 1/2" air release valve from 10' Fabridam opens; 10' Fabridam begins to deflate slowly.
5530.80	1" air release valve from 10' Fabridam opens; 10' Fabridam deflates faster. (On "winter" setting, the next three steps do not occur).
5530.85	1" water release valve from 10' Fabridam opens (summer). 10' Fabridam is deflating faster.
5530.90	2" water release valve from 10' Fabridam opens (summer); 10' Fabridam is deflating faster.
5530.95	6" water release valve from 10' Fabridam opens (summer); 10' Fabridam is now deflating at maximum speed.

If the reservoir stops rising nothing will change until the water begins to recede . . . . if a Fabridam is in the process of deflating slowly it will continue to do so until the reservoir level begins to fall.

In "summer" operation the 6' Fabridam is filled with water; the 10' Fabridam approximately half water, half air. In "winter" operation both are filled only with air. Seasonal changeovers are made manually.

The Fabridams will not re-inflate until the reservoir level falls below elevation 5530.00 as follows.

FABRIDAM RE-INFLATION SEQUENCE

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As reservoir level drops below elevation:

5530.95	6" water release valve from 10' Fabridam closes (Summer); both Fabridams are still deflated. On "winter setting this and the next two steps do not occur.
5530.90	2" water release valve from 10' Fabridam closes (summer).
5530.85	1" water release valve from 10' Fabridam closes (summer); both Fabridams are still deflated.
5530.80	1" air release valve from 10' Fabridam closes.
5530.75	1/2" air release valve from 10' Fabridam closes; 10' Fabridam is ready for re-inflation, but will not automatically re-inflate.
	4" water release valve (summer) or 1" air release valve (winter) from 6' Fabridam closes; 6' Fabridam is still deflated.
5530.70	2" water release valve (summer) or 1/2" air release valve (winter) from 6' Fabridam closes.
5530.65	1" water release valve (summer) from 6' Fabridam closes; the 6' Fabridam is now ready for inflation. Air and water supply valves for both Fabridams are reactivated, ready for normal automatic operation.
5530.00	Both Fabridams begin to re-inflate. When fully inflated, water stops spilling over 10' Fabridam; water is still spilling over the re-inflated 6' Fabridam.
5526.67	The control system automatically decreases the internal pressure in both Fabridams back to normal.
5526±	Water stops spilling over crest of re-inflated 6' Fabridam.
5525+	Spillage thru folds at abutments of 6' Fabridam ceases.

As a safeguard, in case of a power failure or failure of the control system, the following would take place as the reservoir level rises:

Under summer operating mode, when the internal water pressure in the Fabridam exceeds the elevation of the siphonic pressure relief, the Fabridam will automatically deflate. If the siphon breaker valve (at the top of the inverted U siphon) is closed, the Fabridam will deflate completely without stopping. If the siphon breaker valve is open, the Fabridam will deflate at a slower rate and will cease to deflate if the lake level recedes before the Fabridam is completely deflated.

Under winter operating mode, if the internal air pressure exceeds the head due to the water depth in the blowoff tank, the Fabridam will automatically deflate.