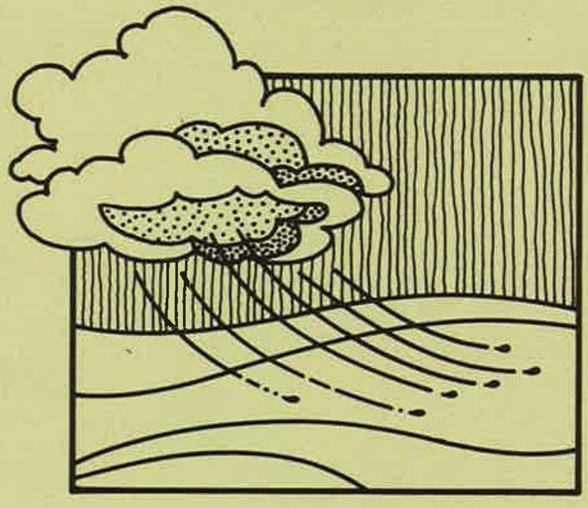
THE SUMMER STORM OF JUNE 24, 1985

MOUNT CARMEL DAM



SWC Project No. 1346
Cavalier County

N.D. STATE WATER COMMISSION
STATE OFFICE BUILDING
BISMARCK, NORTH DAKOTA 58505

January 9, 1986

Mr. August J. Dornbusch, Jr.
State Conservationist
Federal Building, Room 270
Rosser Avenue and Third Street
Box 1458
Bismarck, ND 58502-1458

RE: SWC Project #1346 - Mt. Carmel Dam

Dear Mr. Dornbusch:

During the summer of 1985, a violent wind and rainstorm hit the Mount Carmel Dam area. As a result of this storm, an estimated 28 tons of shale were deposited at or near the inlet structure. Much of this was washed into the service conduit and later became lodged in the downstream portion of the conduit and outlet structure.

Enclosed for your information, is a copy of the final report from that investigation.

If you have any comments or questions, please call or write me.

Sincerely yours,

David A. Sprynczynatyk, P.E.
Director, Engineering Division

DAS:ACG:dm
Encl.

THE SUMMER STORM
Of JUNE 24, 1985

Mount Carmel Dam

SWC Project No. 1346
Cavalier County

Technical Review and Final Report Preparation By

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Director, Engineering Division

I. INTRODUCTION

Mount Carmel Dam was reinspected on July 16 and 17, 1985, as a result of a phone call from Russell Schroeder on the afternoon of July 15, 1985. A severe windstorm with heavy rains on June 24, 1985, caused the reservoir water level to rapidly rise. An overflow depth of 10 inches at the inlet structure was reported within one to two days. Along with high flows, shale particles were observed flowing over the weir. Little attention was given to the above, until a subsequent inspection by Mr. Schroeder revealed that the stilling basin had been filled with shale particles and fragments to within 12 inches of the top of the principal spillway pipe.

The emergency inspection team consisted of Arland Grunseth, Edgar Schmidt, and Robert Bucholz of the State Water Commission; Russell Schroeder, of the Cavalier County Water Resource District; and Tom Beauchamp, Manager of the Mt. Carmel Recreation area. The observations, comments, and recommendations are listed as follows:

II. OBSERVATIONS

1) Shale was found in the stilling basin to within one-foot of the top of the principal conduit.

2) Mr. Schroeder became concerned when the low level drawdown pipe would not flow and it appeared that shale was building up in outlet of the conduit.

3) Shale was found approximately 15 feet into the conduit. The larger and more angular moderately hard shale fragments, ranged from three to four inches long and one to two inches in diameter. However, smaller soft shale fragments were also numerous (See Photo 1). Shale fragments as observed in photo No. 1 were tested for specific gravity and absorption. The apparent specific gravity was 2.45 and 2.51, with an absorption of 32.13 and 32.12.

4) Approximately 1/4 inch of water was flowing over the drop inlet on July 16, 1985.

5) The shale was deposited nearly level in the stilling basin, sloping to about 10 feet beyond the downstream end sill. The shale was so solidly packed, that its density easily supported people walking on its surface.

6) A backhoe arrived Tuesday morning, July 16th, and removed most of the shale from the stilling basin before Mr. Grunseth arrived at the site (See Photo 2).

7) The low level drawdown pipe would not flow until most of the shale had been removed from the corner of the outlet structure where the drawdown pipe exits.

8) The first 20 sections of conduit were inspected on July 16th, and determined to be in good condition.

9) While the low level drawdown was flowing, a build-up of shale near the end sill of the stilling basin was observed and a whirling mass or motion of shale particles was evident.

10) A range pole was used to try to determine if there was a hole in the floor of the stilling basin or where the shale was coming from.

11) At about the mid-point of the stilling basin, shale could be heard hitting the range pool. It was obviously being agitated by the current.

12) The low level drawdown was again closed on Wednesday morning, July 17th.

13) Another contractor from Langdon arrived on Wednesday morning, July 17th, with a 4-wheel drive front-end loader and installed a coffer dam about 100 feet downstream of the stilling basin. It was not possible to install the coffer dam any closer to the stilling basin because riprap would have allowed back flow through the voids in the riprap (See Photo 3).

14) Two pumps, one 3-inch and one 1 1/2-inch, were used to pump the water from within the stilling basin (estimated 400 gpm).

15) Two planks were placed on the drop inlet to reduce the flow over the spillway.

16) The pumps ran for about two hours before the water level was low enough to permit entrance into the stilling basin. The remaining shale was then removed manually from within the conduit and stilling basin. To assist the person working in the pipe, the planks were removed on the drop inlet. This helped to flush the shale out of the conduit (See Photos 4 through 6).

17) The last three downstream joints of the conduit were inspected about 12:30 p.m., Wednesday, July 17, and determined to be in good condition.

18) Upon completion of the pipe inspection, the backhoe removed the last of the shale from the stilling basin. The outlet structure was then inspected in its entirety and determined to be structurally sound, except for some surface abrasion to the concrete and the exposure of reinforcing steel (See Photos 7 and 8).

19) The end sill was worn down about 3 to 3 1/2 inches. Reinforcing steel was exposed by 1 1/2 to 2 inches on its upstream corner.

20) The side walls adjacent to the end sill were worn back approximately 1/2 inch deep. The surface abrasion areas ranged from 18 to 22 inches in diameter. The deepest abrasions were about 8 to 10 inches upstream of the end sill and 10 inches above the floor.

21) Seepage from the right (south) abutment drain was observed and appeared to be about the same as in previous years. The old v-notch weir for measuring flows from the above abutment drain was inoperative, allowing water to bypass it.

22) The upstream embankment slope was inspected and no serious erosion or scouring was observed. An abundance of shale particles were visible on the south side of the drop inlet. Shale particles to the north of the structure were observed, but seemed to be less conspicuous.

23) A good grass cover was found on both the upstream and downstream slopes of the embankment.

24) The south abutment area as well as the emergency spillway were inspected. Both areas showed little or no evidence of severe scarping or erosion.

25) No trees were observed on the embankment.

III. COMMENTS:

1) The reservoir elevation was approximately 1/2-inch above the drop inlet on Wednesday, July 17th. It rose overnight as the area had an inch of rain on Tuesday evening.

2) The drop inlet was tipped back toward the embankment and appeared to be about an inch higher on the lake side than on the embankment side.

3) The 66-inch RCP was reported to have been filled with shale to within one foot of the top. Since the invert of the pipe is

one foot above the floor of the outlet structure, the stilling basin would have then had 5 1/2 feet of shale deposited in it.

4) If the shale were an average of 5 feet deep there would have been about 20.7 CY in the stilling basin. The area below the stilling basin would have contained about 7.4 CY, while 2.7 CY were in the conduit. This would give a total of 30.8 CY. However, the spoil pile does not appear to be that large (See Photo 9). If the stilling basin averaged 4 feet deep, its volume would have contained 16.6 CY. If the area below the stilling basin was 1-foot deep, it would then contain about 3.7 CY, with 2.7 CY remaining in the conduit. The total volume would then equal 23.0 CY.

5) Where did the shale come from? No one really knows. As previously mentioned, a severe wind and rainstorm hit the area about 5:00 p.m., June 24, 1985. A tornado was reported to have blown down a barn about a mile from the dam site. However, it is not known what path the tornado followed while moving through the area, nor what wind velocities were reached. It can be assumed the storm moved in a southwesterly to northeasterly direction. This is the normal pattern for most storms in this region of the country.

6) Based on the above, we can assume the following:

   a. A tornado may have been directly responsible for depositing the shale into the reservoir.

   b. The source of the shale was believed to have come from a wave cut cliff, located approximately 600 feet in a southwesterly direction from the inlet structure (See Photos 10 and 11). The unstable cliff is adjacent too and directly north of the emergency spillway inlet. The face of the cliff is constantly exposed to westerly winds, causing the fractured shale to erode and fall into and along the reservoir shoreline. From here, it could be transported by wave action to the embankment shoreline. During the storm, the tornado probably removed a portion of the cliff. In time, the combination of high winds and wave action carried a large portion of the shale mass across the reservoir. Turbulence and violent agitation of the reservoir water continued long enough to deposit significant amounts of shale into the inlet box. A small shale dune is now exposed to the south of the inlet structure (See Photos 12 and 13). Other than that and scattered shale fragments along the shoreline, no physical evidence remains to support the aforementioned hypothesis.

IV. RECOMMENDATIONS

1) The stilling basin end sill should be gunited or a new end sill should be installed at some future time. The walls may require maintenance also.

2) The service road on the downstream slope of the embankment could use some graveling.

3) Monitoring of the seepage areas should be continued.

4) Install a new weir to monitor the flows from the south abutment drain.

Photo No. 1 - Close-up view of some of the larger, angular shale fragments.

Photo No. 2 - View of Stilling Basin after most of the shale had been removed the morning of July 16th.

Photo No. 3 - View of downstream area and Earthen Cofferdam.

Photo No. 4 - Partial view of Stilling Basin and Conduit. Note shale remaining in Conduit that had to be removed manually.

Photo No. 5 - View of Arland Grunseth inside of Conduit.
To get the shale out - we had to shovel it out.

Photo No. 6 - Ed Schmidt and Russ Schroeder take turns on the shovel outside of Conduit.

Photo No. 7 - The last of the shale after its removal from the Conduit.

Photo No. 8 - Shale Removal Complete. Note view of Drawdown Pipe adjacent to Conduit.

Photo No. 9 - View of downstream area showing leveled shale pile (Photo taken July 17, A.M.).

Photo No. 10 - View of Inlet Structure in relation to Wave Cut Cliff. Viewed from the Inlet Structure looking Southwesterly towards the cliff.

Photo No. 11 - Another view of Inlet Structure and Wave Cut Cliff. Photo taken with telephoto lens.

Photo No. 12 - View of Inlet Structure looking North. Note shale dune on South side of structure and along shore line. Another shale dune is exposed to the North of the structure.

Photo No. 13 - Close-up view of Inlet Structure showing shale deposition on South and East sides of structure.

MT. CARMEL DAM

Shale Calculations - July 16 and 17, 1985
SWC Project #1346

1) Shale was about 4.5 feet deep in the 5.5-foot pipe

2) Floor of stilling basin is 1-foot below the 66" RCP invert

3) Size of Stilling Basin (ID)

15 feet long, 8-foot wide, average depth of shale estimated at 4 feet

$V = 14 \times 8 \times 4 = 448\ ft^3 =$ 16.6 cu yd

4) Volume in 66-inch pipe

$A = \pi\ D^2/_4 = 23.76\ ft^2$ (full)

$A_o = d/D = 4.5/5.5 = .82 \quad \therefore a/A = .877$

$A_o = .877\ (23.76) = 20.83\ ft^2$

$A_1 = d/D = 1.5'/5.5 = .27 \quad \therefore a/A = .213$

$_{A1} = .213\ (23.76) = 5.06$ ft2

$A_2 = d/D = 0 \quad a/A = 0 \quad \therefore A_2 = 0$

$V = (L/6)\ (A_o + 4A_1 + A_2)$

$= (12/6)\ (20.83 + 4(5.06)+0) = 72.03\ ft^3 =$ 2.7 cu yd

5 Volume below stilling basin

a) shale extended about 10 feet beyond end of stilling basin
b) base of plunge pool was 3 feet above floor of stilling basin
c) estimated depth = 4-3 = 1-foot deep
d) estimated length = 10 feet
e) estimated width = 10 feet
f) volume = $10 \times 10 \times 1 = 100\ ft^3$ 3.7 cu yd

6) Grand Total 23.0 cu yd

There doesn't appear to be this large a volume of spoil around the area. Therefore, the average depth estimates provided by others may not have been the average all the way through the respective areas.

Mt. Carmel Dam

Inspection of Conduit Joints

Joint	6-6-1984		7-17-85	
No.	Bottom	Top	Bottom	Top
1	3/4"	Close	Close	1/2
2	Close	Close	3/8	Close
3	Close	Close(1)	Close	3/8(2)
4	Close	Close	Close	3/4
5	Close	Close	3/4	Close
6	Close	Close	1/2	Close
7	3/4	Close	Close	1/2
8	Close	3/4	3/4	Close
9	Close	Close	Close	Tight
10	Close	Close	1/2	Tight
11	Close	Close	1/2	Tight
12	Close	Close	3/8	Tight
13	Close	Close	Close	Close
14	Close	Close	Close	Close
15	Close	Close	Tight	Tight
16	Close	3/4	Tight	3/4(3)
17	Close	Close	Tight	1/2
18	Close	1	Tight	1
19	Close	Close	Tight	Tight
20	Close	3/4	Tight	1/2"
21	Tail Water		Tight	Close
22	Tail Water		1/2	Tight
23	Tail Water		1/2	Tight

Notes:

84-1) has chip out of bottom with v-notch 5/8" wide.
85-2) bottonm side of spigot end cracked.
85-3) a flaw or crack in RCP one-foot upstream from joint.

Mt. Carmel Dam

Runoff Calculations - July 16 and 17, 1985
SWC Project #1346

I. ASSUMPTIONS:

1. The maximum stage was 10 inches above the weir elevation.
2. The peak flow occurred 24 hours after the storm began.
3. The pool was at control elevation when the storm began.
4. Precipitation was uniformly distributed over the entire basin.

II. CALCULATIONS:

1. Lake storage at 1530.0 msl = 4975 ac-ft
2. Lake storage at 1527.5 msl = 4083 ac-ft
3. Difference = 892 ac-ft
4. Average volume per foot = 356.8 ac-ft
5. Lake volume for 10 inches = 297.3 ac-ft
6. 1 ac-ft/day = 0.504 ft^3/sec.
7. Weir: C=3.1, L=24, $Q=CLH^{1.5}$, $Q=74.4\ H^{1.5}$

8. Day	0	1	2	3	4	5	6	7	8	9	10	11
9. Reservoir rise (in)	0	10	9	8	7	6	5	4	3	2	1	0
10. Average outflow (in)		5	9.5	8.5	7.5	6.5	5.5	4.5	3.5	2.5	1.5	0.5
11. Average daily Q (cfs)		20	52	44	37	30	23	17	12	7	3	1

12. Total outflow = 246 cfs days
13. Total storm volume = 488 ac-ft
14. Drainage area = 63 sq. mi.
15. Runoff = 0.15 inch from 63 sq. mi.
16. CN value = 76 precipitation = 1.4 inches