APPENDIX A

STRUCTURAL INSPECTION
AND
DAM REPAIR COST

Ayres, Lewis, Norris & May, Inc.
Engineers · Architects · Planners
3983 Research Park Drive
Ann Arbor, Michigan 48104

April 22, 1981

MEMORANDUM

RE: Corunna Dam Repairs and Cost Estimate

The recommended repairs and estimated costs are as follows:

1. The seepage underneath the wingwall should be repaired. If the foundation in this area washes away, the powerhouse walls will settle.

2. The seepage around and through the right retaining wall should be repaired.

The estimated cost for the two foregoing important items is $16,000.

If the work crew is at the site, it might be advisable to repair the seepage 110 feet right of the left abutment. The repair of this item is not necessary for structural stability. Estimated cost: $4,000.

1 crew @ $1,400/day x 10 days	=	$14,000
mobilization		2,000
contingency		4,000
		$20,000

Robert L. Ryden

Robert L. Ryden, P. E.

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES

Corunna Dam
Corunna, Michigan 48817

DAM INSPECTION REPORT
(Act 146, P.A. 1961, As Amended)

42°59'53" North Latitude
84°07'03" West Longitude

NAME OF WATER	COUNTY	TOWN, RANGE, SECTION
Shiawassee River	Shiawassee	T7N, R3E, Sec. 21, Caledonia Twp.
DATE ELEVATION SET BY COURT	SUMMER ELEVATION	WINTER ELEVATION
N/A	N/A	N/A
DATE OF INSPECTION	LEVEL THIS DATE	HIGH WATER MARK ELEVATION
March 23, 1981	0.2 feet above crest	same

DESCRIPTION OF CONTROL STRUCTURE

TYPE	BY WHOM CONSTRUCTED	DATE
Soil and Rock filled Gravity Structure	Unknown	N/A
LENGTH OF DIKE	LENGTH OF SPILLWAY	HEAD
N/A	Uncontrolled Section 150 ft. long.	7.1 feet
VERTICAL PIPE SIZE	HORIZONTAL PIPE SIZE	FREEBOARD
N/A	N/A	2.5 feet

EARTH DIKE

CONDITION OF COVER	SETTLEMENT OF FILL (If any)
N/A	N/A
EROSION (SHEET)	WAVE ACTION (Beach or Bank)
N/A	N/A
EROSION (RIVULETS)	VEHICLE OR FOOT TRAFFIC
N/A	N/A
SEEPAGE AT TOE OF DAM	SEEPAGE ON SLOPE
N/A	N/A
SEEPAGE AT DISCHARGE PIPE OR CONTROL STRUCTURE	HOLES BY ANIMALS
N/A	N/A

CONTROL STRUCTURE

STOPLOG VALVES & GATES (Open and Close to Check Condition): Check Location of Top Stop-Log in relation to top of riserpipe intake box or fixed crest, for leakage, and condition of stop-logs, valves, & gates.

Stop logs appear to be in good condition.

OUTLET PIPE: Check for damage from ice, logs, vandalism; inside discharge pipe for settlement and/or joint separation; condition of pipe coating.

The outlet works for the gated section is the old powerhouse. The concrete walls are in fair condition, with no signs of major settlements. The south wall has a section missing.

CONCRETE STRUCTURE: Check for erosion; location of cracking or spalling, if old or new; settlement or tipping; need for crack repairs.

The forebay retaining walls indicate differential settlement, and there is seepage underneath the left forebay retaining wall. The old powerhouse concrete appears sound underwater, and in fair condition above water. Noted seepage through overflow spillway rock structure at top center section. Right retaining wall shows seepage around stop logs.

WALKWAY & RAILING: Check if in place or removed, and condition.

Handrail needs to be added along right (west) retaining wall.

OUTLET CHANNEL: Check for erosion, riprap; obstructions - beaver dams - brush - debris.

The downstream apron varies in depth and length, no serious undermining was found.

R-4526 (3/71)

DIKES & DITCHES

SETTLEMENT

N/A

EROSION

N/A

COVER ON SLOPES

N/A

WEED GROWTH IN DITCHES

N/A

TREE & BRUSH GROWTH IN DITCHES & ON DIKE

N/A

PUMPS (Running)

VIBRATION

N/A

EXCESSIVE NOISE

N/A

MOUNTINGS

N/A

ALIGNMENT OF BELTS & SHEAVES - EXCESSIVE WEAR

N/A

MOTOR OVERHEATING

N/A

GATES

N/A

PIPE LEAKAGE

N/A

EROSION AT DISCHARGE PIPE

N/A

RECOMMENDATIONS

List work needed, how to be done, by whom, estimated cost, source of funds, recommended completion date. If emergency, to what extent. ADDITIONAL COMMENTS.

1. Stop seepage underneath left forebay retaining wall.
2. Stop seepage through masonry structure at top center of overflow spillway.
3. Repair right (west) retaining wall around stop log area.
4. Add handrails to right retaining wall.
5. Add upstream warning signs.

Robert L. Ryden Michigan #20084
REG. ENGINEERS NAME & REG. NO.

Ayres, Lewis, Norris & May, Inc.
3983 Research Park Drive
ADDRESS

UNDERWATER INSPECTION REPORT OF CORUNNA DAM STRUCTURE
MARCH 23, 1981

Prepared by:

Great Lakes Diving Consultants
Traverse City, Michigan

March 31, 1981

UNDERWATER INSPECTION REPORT OF CORUNNA DAM STRUCTURE
MARCH 23, 1981

INTRODUCTION

Great Lakes Diving Consultants of Traverse City, Michigan conducted an underwater inspection of the Corunna Dam Structure located on the Shiawassee River at Corunna, Michigan for Ayres, Lewis, Norris and May, Inc. of Ann Arbor, Michigan on March 23, 1981.

Surface-supplied diving equipment rigged with a two-way voice communication system was used during this work. One section of stoplogs was removed by the Corunna Department of Public Works to facilitate inspection work along the stone filled weir section of the dam. The stoplogs were replaced for the inspection of the existing concrete spillbays on the west side of the river.

Personnel of Great Lakes Diving Consultants worked with Robert Ryden of Ayres, Lewis, Norris and May, Inc. and W.W. (Walt) Davis, Civil Engineer Consultant.

STONE FILLED WEIR SECTION OF DAM

The stone filled weir section of the dam extends from the east bank of the river across to the two concrete spillbays located on the west bank. The stone filled weir section of the dam is capped off with concrete.

UPSTREAM INSPECTION OF WEIR SECTION

A concrete apron extended several feet upstream from the leading edge of the weir. A 6 inch diameter vortex was observed at the edge of the concrete apron near the east side of the river. Subsequent release of dye into the vortex revealed seepage through the weir with several discharge points observed both above and below the tailrace near the east side of the river. This was the only area found on the upstream side of the weir

section where seepage is occurring under the apron. The location and depth at the base of the slope were plotted at stations along the upstream side of the weir.

DOWNSTREAM INSPECTION OF WEIR SECTION

An inspection along the downstream side of the weir revealed no large scale breaks or deterioration in the sloping concrete surface. A rectangular opening is located in the sloping face of the weir at the west end where it intersects a concrete retaining wall. The rectangular opening was plugged with logs and other debris. The tailrace along the base of the weir was quite irregular and broken up in several areas. No significant evidence of undermining was found along the downstream side of the weir.

CONCRETE SPILLBAYS AND SUBSTRUCTURE - WEST SIDE OF RIVER

Downstream Inspection

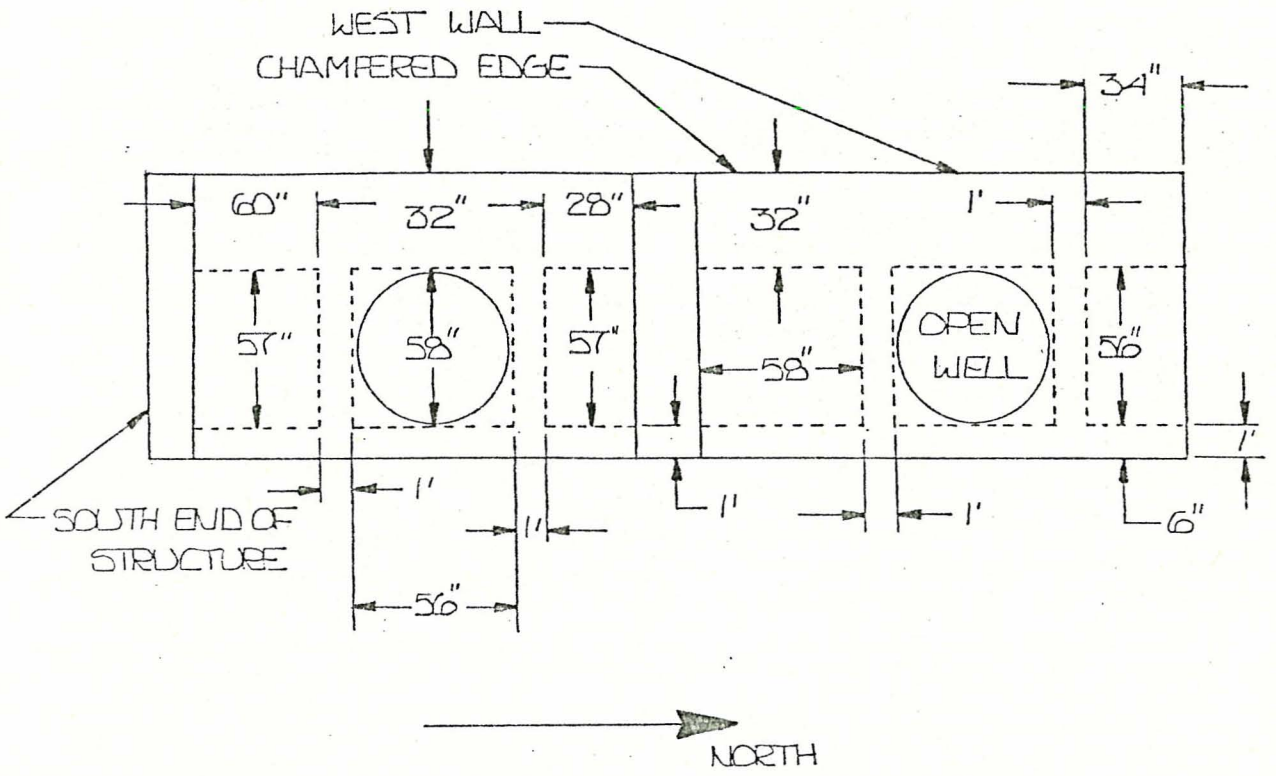
Inspection work in this area consisted of determining the make-up and condition of the substructure of the spillbay floor in which two circular openings were located. The substructure was divided into two chambers (north and south) by a center support wall that separated the two circular openings. Sketches of the various features observed in each of the chambers is present in Figure 1. A recessed opening was found in the overhead on each side of the circular openings. Wooden boards used as forms in the original construction were still in place in these recessed areas. The perimeter along the overhead of each chamber where it meets the vertical walls (north, west and south side) contained a chamfered edge. The chamfered edge extended up into the recessed areas of the overhead along the north and vertical walls of each chamber. The overall depth of the concrete spillbay floor in which the two circular open wells are located is about 20 inches and constructed of two separate 10 inch concrete slabs. A square recessed concrete slab was found under each open well. The depth of the recessed areas in the overhead on each side of the open wells varied between 10 and 11 inches. Accumulations of gravel and stone were found on the floor of the north chamber. The south chamber is relatively clear of stone and gravel. The overall condition of the concrete masonry in the two chambers is good. No cracks or soft concrete were observed in either chamber. The most common type of deterioration found in the

chambers consists of moderate to heavyscaling (gradual and continuing loss of surface mortar and aggregate) varying from $\frac{1}{4}$ to 1 inch in depth. Water depth out in front of the two chambers was 5 feet. Stone, broken concrete and debris from the original structure are scattered along the bottom out in front of the two chambers. Concrete deterioration was observed at the south end of the east retaining wall where it intersects the floor of the concrete spillbays. Seepage was noted through an oblong hole in this area. A strong flow of water was found discharging from the stone riprap foundation located several feet east of the retaining wall below the pile of wood debris that has accumulated on the upstream side of the dam.

Upstream Inspection

A sketch of the two spillbays and retaining walls on the upstream side of the existing structure is shown in Figure 2. A concrete retaining wall is located along the west bank of the river. Water depth alongside the retaining wall is 5 feet. Vertical and horizontal cracking is present in the west retaining wall. A horizontal crack 1 foot below the surface of the water extends from the stoplogs in the first spillbay about 7 feet upstream where it ends at a vertical construction joint. The width of the crack is $\frac{1}{4}$ inch and it varies between 2 and 3 inches in depth. No undermining was observed along the base of the retaining wall in the vicinity of the first spillbay. Bags of dry mix concrete were found under the base of the retaining wall directly out from a house located adjacent to the wall. Slabs of broken concrete and boulders were placed along the base of the retaining wall for scour protection near the upstream end. A 1 inch opening was found under the stoplogs in the first spillbay. The width of the concrete apron in the two spillbays varies between 21 and 24 inches. The depth of the apron is aout 10 inches and no undermining has occurred along the upstream margin. The east retaining wall is submerged upstream from the second spillbay. The average width of an apron connected to the east retaining wall is 18 inches. Evidence of seepage was found under the apron about 52 inches upstream from the stoplogs in the second spillbay. A wing wall that extends 7 feet to the east is connected to the east retaining wall. Several areas of seepage were located along the base of the wing wall. The most turbulent seepage areas were located directly upstream from the pile of logs and wood debris. Dye released into the seepage areas on the upstream side showed them to be interconnected with discharge occuring at two downstream locations.

TOP VIEW OF FLOOR IN CONCRETE SPILLBAY



FRONT VIEW OF SPILLBAY SUBSTRUCTURE

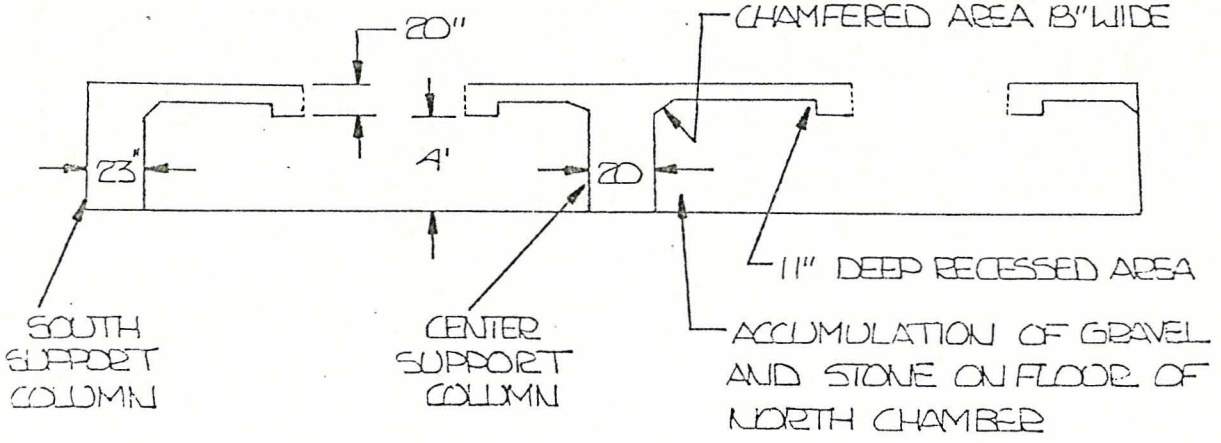


FIG. 1 SKETCH OF CONCRETE SPILLBAY FLOOR AND SUBSTRUCTURE. NOT TO SCALE

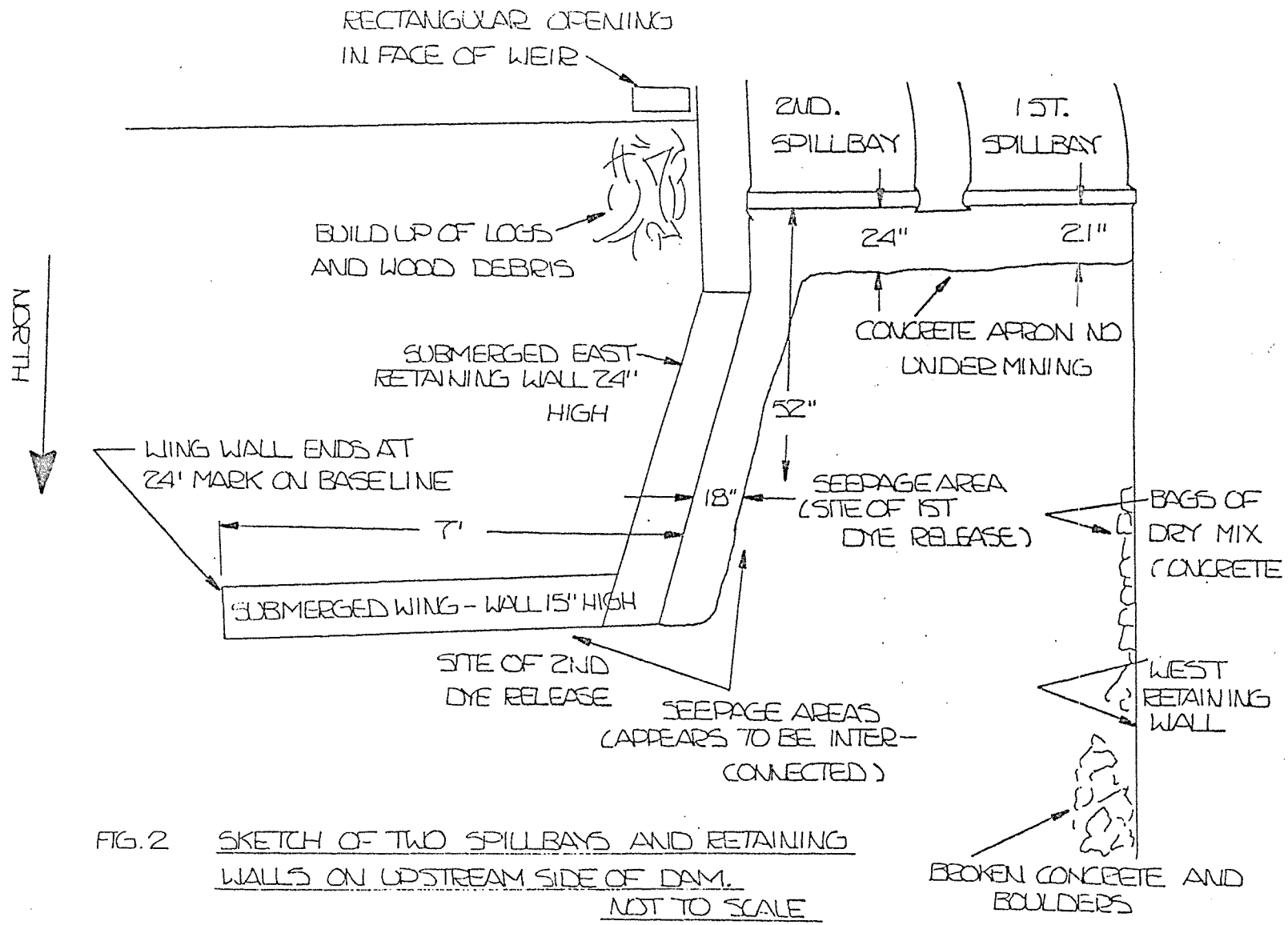


FIG. 2 SKETCH OF TWO SPILLBAYS AND RETAINING WALLS ON UPSTREAM SIDE OF DAM. NOT TO SCALE

INSPECTIONS AND EVALUATION OF CORUNNA DAM

Prepared by:

W.W. Davis, P.E., P.C.
Michigan Register 12645

INSPECTION AND EVALUATION OF CORUNNA DAM

INTRODUCTION

The Ayres, Lewis, Norris & May, Inc., Consulting Engineers of Ann Arbor, Michigan were authorized by the City of Corunna, Michigan to perform an inspection and evaluation of the Corunna Dam to establish the feasibility of repair and renovation to provide a structurally sound facility for adding hydroelectric power generation under a participation grant from the Department of Energy.

SCOPE OF WORK

The work consisted of a thorough visual inspection of the dam spillway, forebay and tailrace of the abandoned power house, as well as the concrete structure itself.

The physical inspection was performed by an experienced diver and tender team and the report submitted is attached as part of the results of the investigation.

The emphasis of all effort was to endeavor to establish the integrity of the structures and environs as completely as possible to support the feasibility of utilizing the installation for the addition of hydroelectric generating equipment. It was also to document all identifiable factors which affect the current structural capability of the dam to retain the headwater pond.

The collection of field data includes dimensions and elevations, information on previous mill structures, dye injections to provide seepage information and any other reference material useful in the documentation of the condition of the dam.

The results of the inspection and evaluation are compiled into recommendations for repair and rehabilitation work for (1) that which would be necessary to utilize the facility for power generation and (2) the minimum requirements to maintain the integrity of the dam as a retention and control structure.

PROCEDURES - 1.0

The following procedures were employed to obtain information:

1.1 The attached underwater inspection report is self-explanatory and the findings are used as a basis for the evaluation.

1.2 A visual check was made of the entire structure for condition of materials, cracking, settlements, and general deterioration.

1.3 Stations were established across the fixed spillway to record the location of significant features and the powerhouse structure was measured in detail for layout and for eventual capacity calculations.

1.4 Soundness of concrete was checked by the use of a Schmidt hammer, a calibrated impact system for establishing hardness of concrete in place.

1.5 Elevations were determined across the spillway, on the powerhouse structure, as well as the existing headwater and tailwater. Seasonal high water elevation was also recorded as near as it could be estimated.

1.6 The attached photographs were taken to record visual characteristics of the spillway, powerhouse structure, and seepage through the dam represented by the flow of green florescein dye under and through the dam shortly after being released in suspect areas above the dam.

1.7 The stream bottom was examined for type and uniformity of materials, siltation, scouring and erosion, both above and below the dam. No test samples or borings were obtained as part of this investigation.

RESULTS - 2.0

2.1 The dam construction consists of a rock fill main section with the upstream face lined with a silty clay earth fill. A concrete envelop extends from a variable length upstream apron, over the crest and downstream face of the dam to an apron extending a varying distance from the base of the dam.

2.2 At the time the dam was built the water power was utilized to operate a textile mill at the east end of the dam and a grist mill at the west end. A hydro turbine was subsequently installed at the site of the grist mill and the existing structure is what remains of that power installation, the turbines having been removed several years ago.

STRUCTURAL REVIEW - 3.0

3.1 River Channel

The soil materials on which the dam is founded are a firm, sandy, gravelly, silty clay. The underwater inspection above and below the dam indicate little or no scour in the main channels and only a slight undermining under the spillway apron.

3.2 Design Basis

The dam probably had no theoretical design basis other than a "rule of thumb" in determining the base cross section for the stone fill—the size of stones being based on what a man could handle, and the earth fill being based on what was available nearby and then filled until seepage was restricted. It has to be assumed that all materials were gravity placed with no compaction requirements.

3.3 Concrete Encasement

The use of concrete to encase the gravity section of the dam appears to have been done to stabilize that portion against erosion and scour as it was extended from the crest upstream and the base of the dam downstream. Based on the inspection it has served well in this function.

A vortex was observed at about 110 feet east of the east abutment and a dye injection disclosed seepage through the gravity structure, as well as under it, for a distance of about 70 feet, from Station 0 + 80 to 1 + 50.

The downstream apron varies in width from no projection to about 8 feet. It is apparent from material observed downstream of the dam that parts of the apron

have broken off over a period of time. However, no serious undermining was detected during the inspection.

The inspection of the powerhouse and a forebay structure is detailed in the underwater report. With the exception of a couple of damaged areas the structure appears quite sound. The south wall has a section missing on the east end and there is evidence that a portion of retaining wall south of the structure gave way, causing the observed damage. Surface erosion of the structural concrete was present in the vicinity of the walls but the concrete was generally observed to be sound and firm.

Upstream of the gate structure some drafting was noted along the wing wall and the subsequent florescein dye injection indicated that piping was present beneath the wing wall and through several openings in it. The seepage was discharging primarily under the dam and northeast corner of the powerhouse structure for a distance of 30 to 40 feet with very little delay, indicating a direct route.

STRUCTURAL EVALUATION - 3.4

3.41 Gravity Dam

The soil and rock filled gravity structure appears to be quite stable. The concrete encasement, even with a considerable crack pattern, shows no indication of movement or differential settlements. Its limited height, about 12 feet, is distributed over an approximate 40 foot wide base on a compact stable gravelly clay soil.

The limited undermining and breaching which is taking place can be restricted by relatively simple procedures. Stabilization of those problems should result in a virtual maintenance free gravity dam section for a considerable period of time.

3.42 Retaining Walls

The condition of the retaining walls and forebay wing wall indicates movements or settlements have occurred. Cracks and joints have opened sufficiently to make it evident that some corrective action would be required to maintain structural integrity. Riprap stone and bags of cement have been used to stabilize scour areas

at the west retaining. There is no undermining of the west wall or apron slab at the gates but there is along the forebay wing wall and at the intersection of the wing wall with the east wall of the powerhouse structure. Scaling off and stabilizing this area is required to prevent continual deterioration of the concrete and erosion of soils.

3.43 Powerhouse Walls

The main walls of the powerhouse structure appear to be sound with only minor corrective action required. According to the underwater inspection, those walls are also sound, with surface erosion only a minor problem. Since erosion has begun it will tend to accelerate and require corrective work eventually to maintain minimum structural integrity.

3.44 Stop Logs

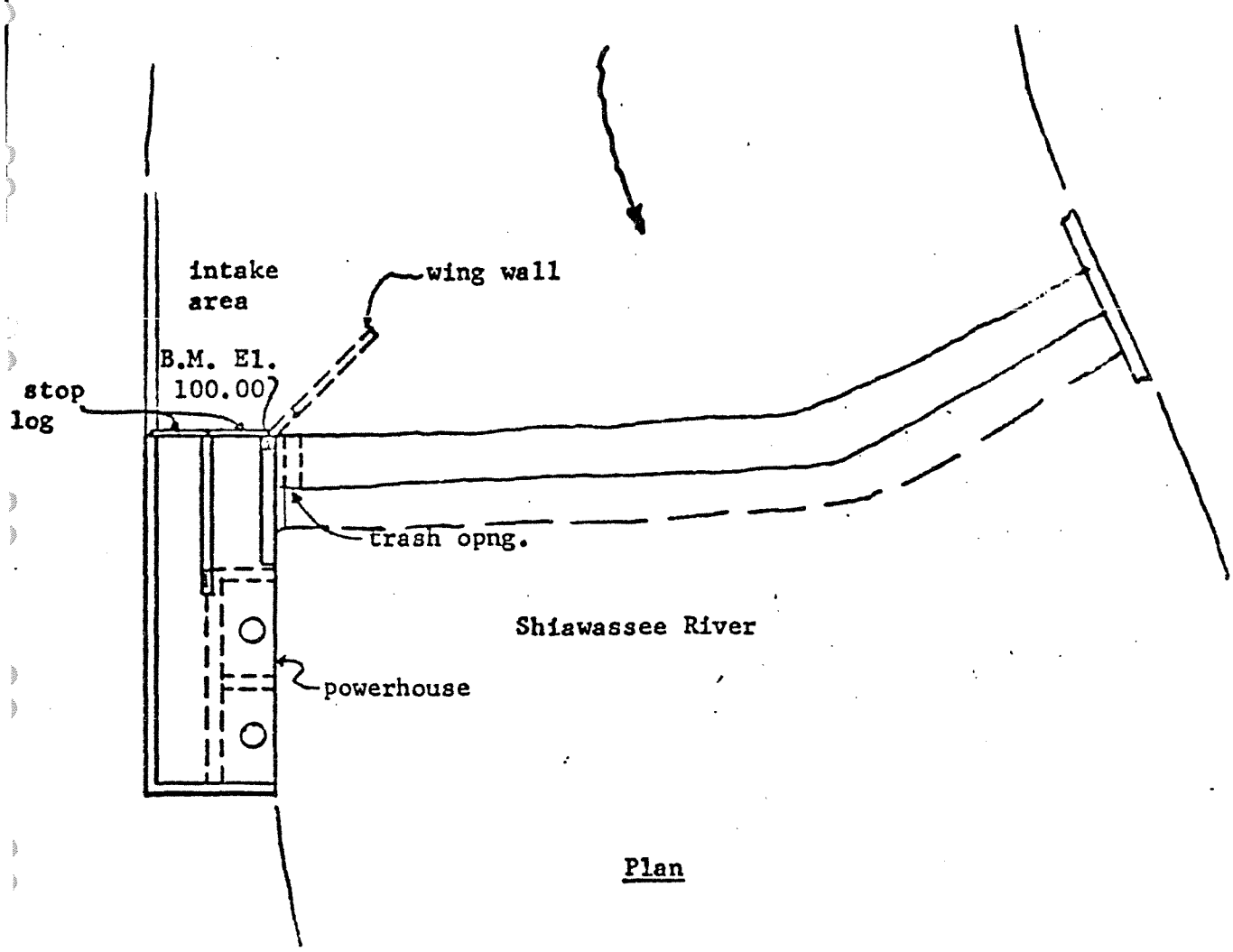
The concrete apron in the stop log bays is sound with only minor erosion evident. Debris covered the apron at the west end of the west stop log and lodged in the guide causing a gap of about an inch when the stop log gate was inserted. The gates, gate guides and apron appear to be in good condition with no undermining except at the intersection of the wing wall and east wall of the powerhouse structure.

3.45 Discharge Structure

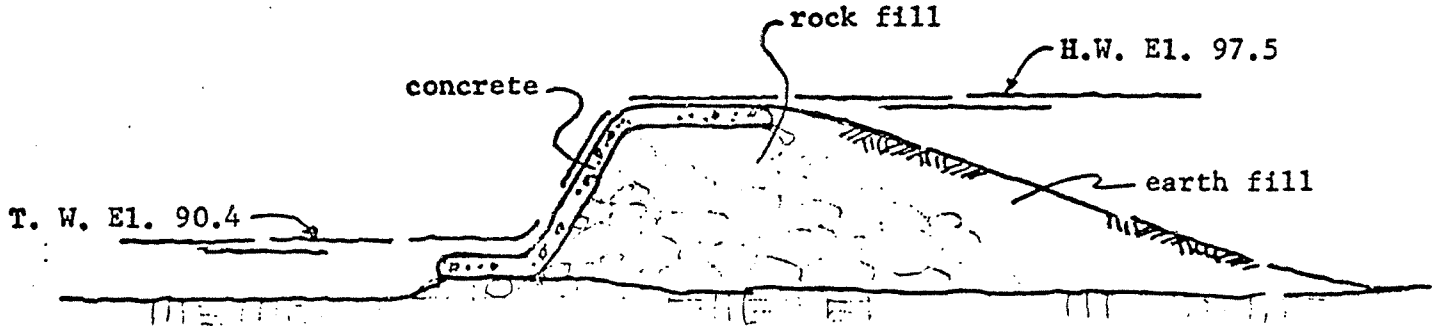
The turbine support and discharge area has only slight erosion of the concrete surfaces and otherwise the slabs and walls appear quite sound. The base slab of the north well had accumulated some gravel but probably was due to flow over the spillway.

GENERAL LAYOUT - 4.0

A layout sketch is attached to locate the general features of the dam. The photographs show some of the details and the condition of the materials.

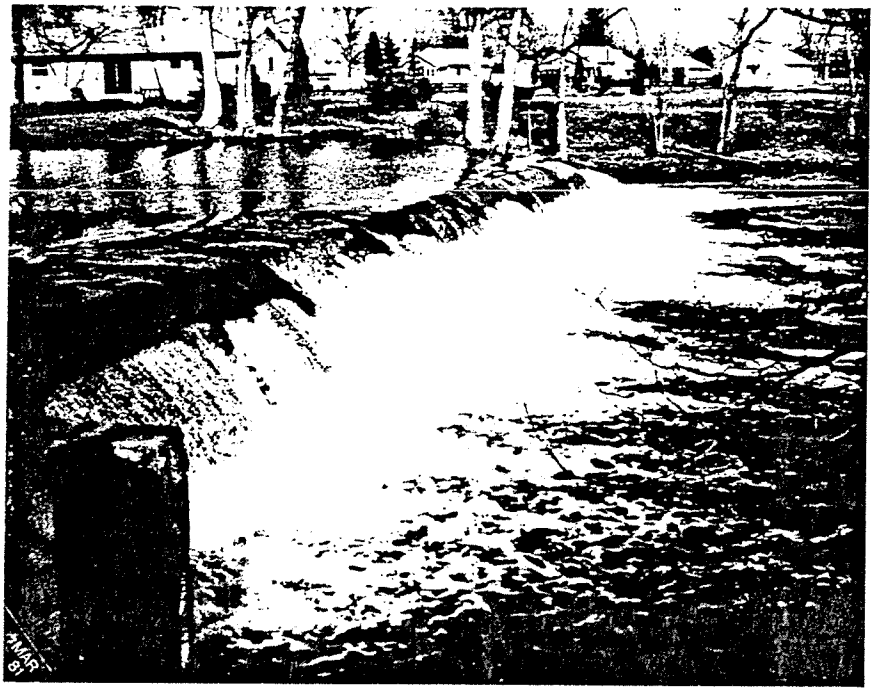


Plan



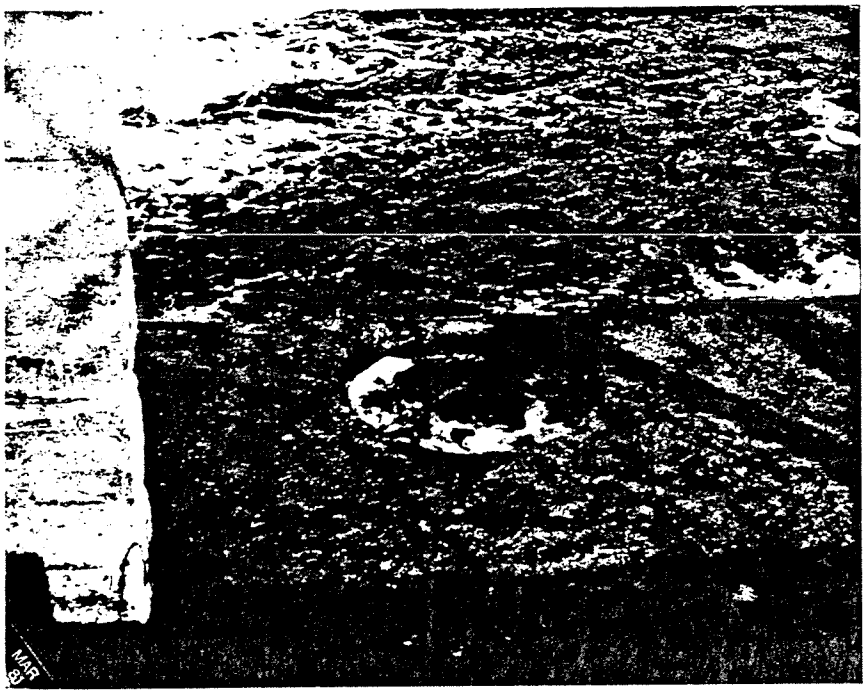
Probable Section

TITLE CORUNNA DAM		
PROJECT INSPECTION		
LOCATION CORUNNA, MICH.		
DATE -20-81	SHEET ____ OF ____	SCALE

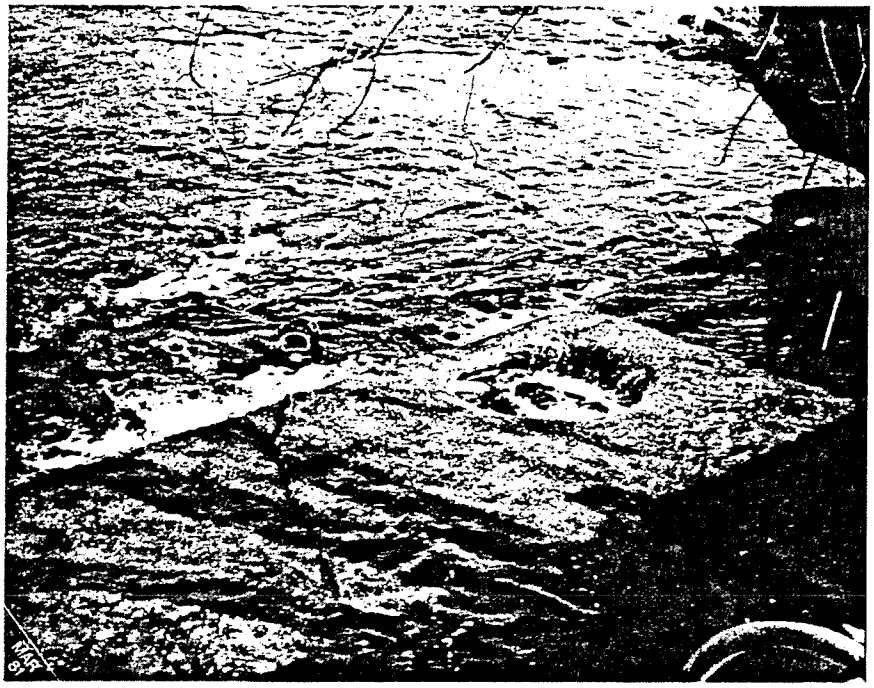


Looking East Across Dam Spillway

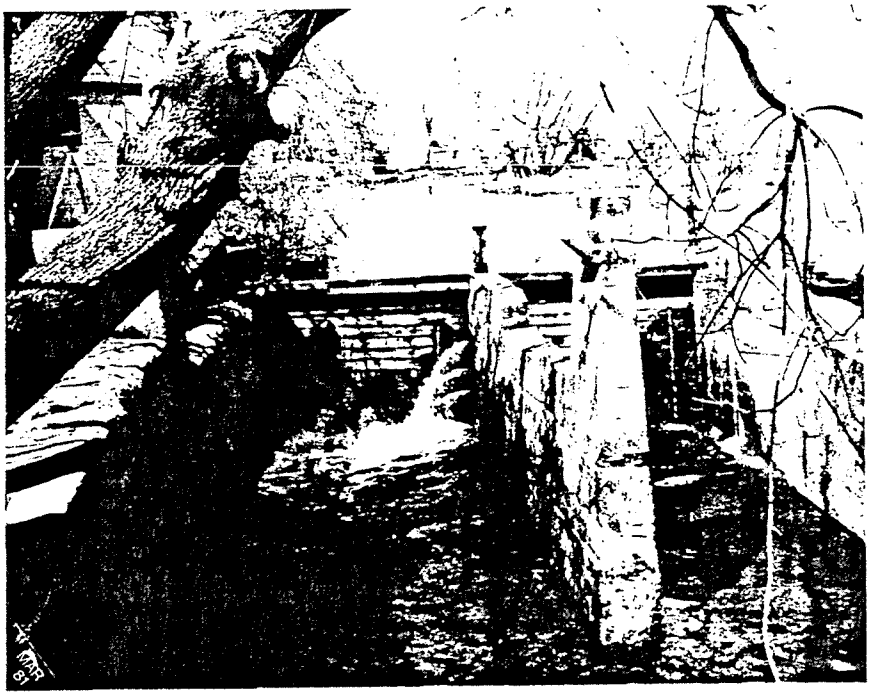
Dye Injection at Vortex 110 Feet East of Powerhouse



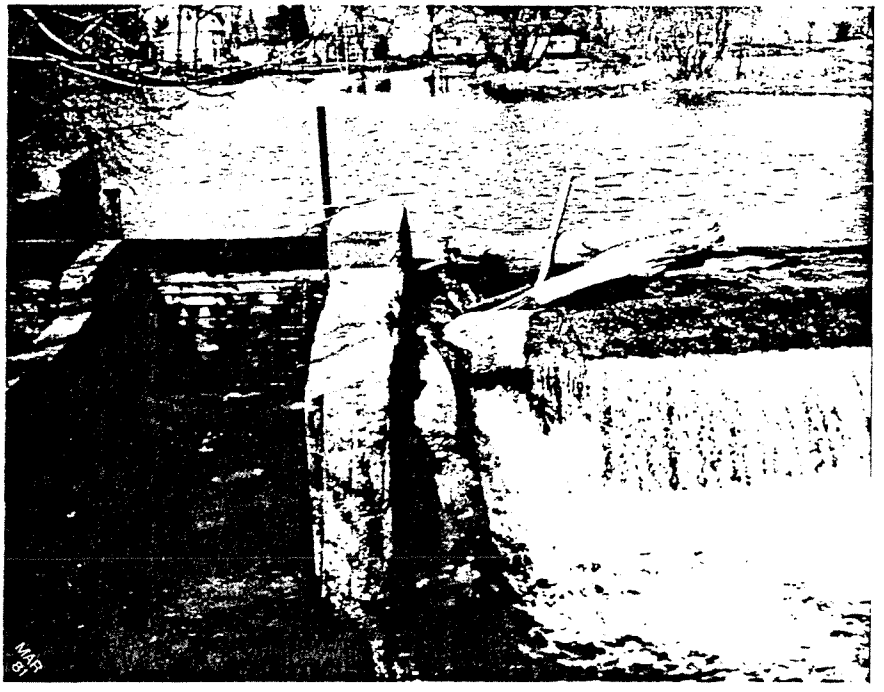
North Turbine Well



South Turbine Well

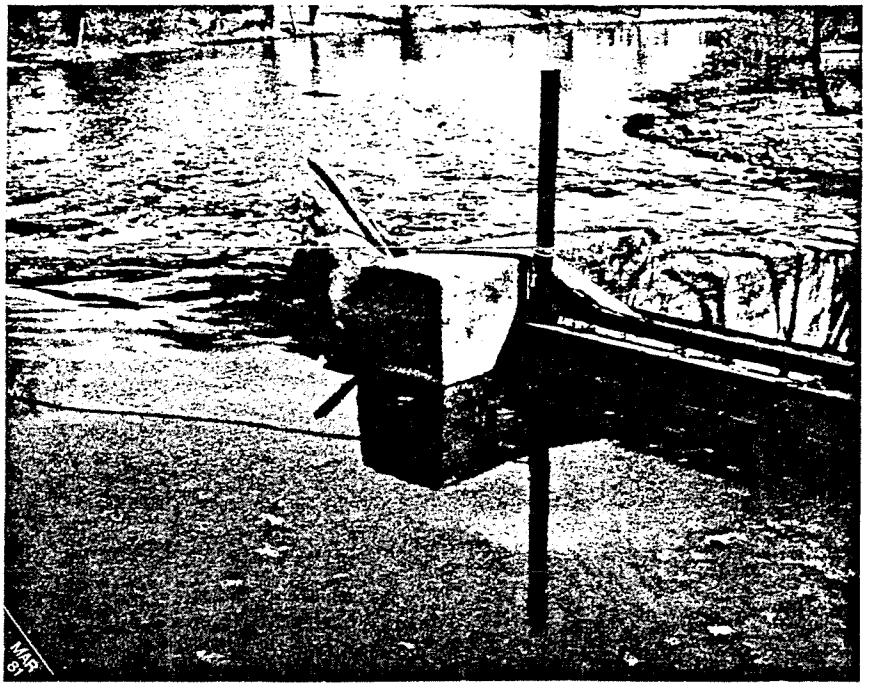


Powerhouse- Looking North Past Stop Logs



Powerhouse- Looking North- Note Trash Opening

Stop Log Gates and Powerhouse



East Wall of Powerhouse- Note Wing Wall

Left Center Under Water Surface