

INTERNATIONAL BOUNDARY AND WATER COMMISSION
UNITED STATES AND MEXICO

**JOINT REPORT OF THE PRINCIPAL ENGINEERS REGARDING
WORKS OF AN EMERGENCY NATURE THAT SHOULD BE PERFORMED
PROMPTLY FOR TREATMENT OF SINKHOLES THAT HAVE
DEVELOPED IN THE RESERVOIR AT AMISTAD DAM**

February 22, 1995
El Paso, Texas

To The Honorable Commissioners,
International Boundary and Water Commission
United States and Mexico
El Paso, Texas and Ciudad Juarez, Chihuahua

Sirs:

According to your instructions, we respectfully submit for your consideration this joint report regarding the works of an emergency nature which should be performed promptly for the treatment of sinkholes formed on the Mexican side of the reservoir at Amistad Dam.

The Joint Report of the Principal Engineers "Concerning the Division of Operation and Maintenance Costs of Amistad Dam" of December 1, 1969, which forms an integral part of Minute No. 235 of this Commission, entitled "Division of Operation and Maintenance Costs at Amistad Dam", signed December 3, 1969, provides:

"Should it become necessary to perform operation, maintenance, or repair work of an extraordinary or emergency nature which, if not performed promptly might result in risk of serious damage to the project, or in increased cost of its performance, the Commission shall order those works executed which it finds advisable and shall allocate them between the two countries for their performance as soon as possible, understanding that the performance by each Government of the work allotted to it, cannot be undertaken until it has made the necessary financing arrangements therefor."

INTRODUCTION

Since September 1994, the low storage level in the reservoir at Amistad Dam has permitted the observation of formation of sinkholes on the Mexican side of this reservoir, located 265 meters from the toe of the dam's embankment slope. Afterwards, up to 10 sinkholes were discovered, reason for which this Commission proceeded to undertake observations and studies of this phenomenon in order to evaluate the situation and propose the necessary

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works to assure the safety of this hydraulic structure. For Mexico's part, the following studies and activities were carried out:

-Immediately after discovery of the first sinkholes, daily inspections were initiated in the sinkhole area, as well as at all the springs and weirs installed downstream of the dam curtain to collect part of the seepage water from the sinkholes.

-On October 27, November 9 & 15, 1994, independent inspections were carried out by the Technical Advisers of this International Commission.

-Between November 9-25, 1994, the first part of a geophysical investigation was conducted in an area of approximately 100,000 square meters between the curtain of the Amistad International Dam and the sinkhole to determine the geologic, geohydrologic and geotechnical characteristics of the subsoil, and by this means try to define the pattern of water circulation through the sinkholes. Afterwards, the geophysical studies were continued to the end of January 1995.

-On December 5, 1994, exploratory soundings were taken with specialized equipment and core sampling at sites close to the sinkholes to determine the thickness of the loam that covers the Georgetown limestone formation and to correlate the data with any detected geophysical anomalies.

-The information concerning the treatment given to the faults discovered in the foundation during construction of the embankment was analyzed, to include the grout injection treatment.

-During the observation period, and on various occasions, tracer dye was applied to the sinkholes to determine the connections between the downstream springs and the sinkholes.

-On December 5, 1994, the clean-up and vegetation removal was initiated at the springs where the dye applied to the sinkholes was observed.

-On December 20, 1994, the United States through its Army Corps of Engineers conducted a sounding of the sinkhole using a video camera to determine the dimensions of the same.

-Also, during January 11, 12, & 13, 1995, two meetings and an inspection tour of the sinkhole area as well as the area of springs downstream of the dam curtain were conducted at Amistad Dam, in which the Advisers of both countries analyzed all the information available in this matter and jointly arrived at the following conclusions:

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CONCLUSIONS OF THE IBWC ADVISERS

On January 13, 1995 at a technical meeting of the International Boundary and Water Commission with the Advisers of both countries at Amistad Dam, the information compiled in the above referred to studies and activities was analyzed, and the conclusion was reached that the dam in its present state does not reflect conditions of risk in the short term as far as its safety is concerned. Nevertheless, the sinkholes must be closed immediately, and works to reinforce the impervious grout curtain must be undertaken as soon as possible in view of the fact that the data reviewed concerning the injection of the grout curtain effected during construction reveals that there exists the possibility of zones of flow below the foundation of the dam. The memorandum of the joint meeting of the Technical Advisers Group of January 11-13, 1995, at Amistad Dam is enclosed.

Taking the above into consideration, the Advisers recommended the following repair work of an emergency nature, which if not performed promptly may result in risk of serious damage to the project:

1. Construct a grout curtain starting with a first reach centered at Station 7+150 and extending for 300 meters to each side. This curtain should extend to elevation 300 meters MSL coinciding with the location of the existing curtain. The construction of this first reach will permit the mitigation of the seepage from the sinkhole.

The construction of these grout curtains in other reaches will be defined after analysis of the information concerning the original grouting in a similar manner to that effected for the reach from Station 6+500 to Station 7+500 and taking into account the results of the grout reinforcement of the first reach.

2. In order to begin the treatment for the initially discovered two sinkholes, a cofferdam must be constructed around them to elevation 332 meters MSL and which will also contain the fissure from which air was expelled during the isolation test for the sinkholes. This treatment will consist of the placement of a metal tube 12 inches in diameter in the first sinkhole down to its deepest part to prevent its closure from cave-ins, and allow sealing with mortar. Next, the sideslopes of the sinkholes will be made more shallow to stabilize them and to uncover the entrance orifices and facilitate the placement of an inverted filter. The extent of these excavations will be defined in accordance with periodic observations by the IBWC Advisers.

3. The two sinkholes closest to the dam curtain within the reservoir should be filled with gravel up to a level 20 cm above the water level. Next, a layer of compacted clay at least 2 meters thick should be placed on top.

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4. In order to carry out the above works, it will be necessary to maintain the reservoir level at an elevation no greater than 331 meters MSL during these activities.
5. Install at least 3 piezometric stations with 3 independent elevation points each, at the downstream toe of the dam, at Stations 6+950, 7+150, and 7+350. The tips should be 2 meters long, and the deepest one installed at approximately elevation 300 meters MSL, and the other two will be defined according to the results of the bore hole samples of the deepest piezometer, trying to place these tips at the most pervious elevations.
6. Activities 2, 3, and 5 should be accomplished before the initiation of construction of the reinforcement grout curtain.
7. In order to improve the knowledge of the stratigraphy and structural geology of the area of influence of the seepages on the right side of the embankment of the dam and in order to anticipate future problems, it is recommended to make a surface geologic study of the area.
8. The general specifications to carry out these activities and their estimated costs will be prepared jointly by engineers of the Comision Nacional del Agua (National Water Commission) and the Comision Federal de Electricidad (Federal Electricity Commission of Mexico). Later, they will be submitted for consideration to the IBWC for its review and approval.
9. Once the above recommended actions have been approved, the activities related to Points 2 and 3 should be initiated immediately, even if the other specifications are not yet available.
10. During the progress of the above activities, it is recommended to schedule joint evaluation visits of the Advisers of the IBWC, for their review and in order to propose, as necessary, the modifications which they consider pertinent.
11. As a complement to the above activities, it is proposed:
 - a) To continue with the systematic gaging of the spring weirs as well as the qualitative observation of those that have no weirs.
 - b) To determine the elevations of the outlet rims of all springs and of the bore holes that are being drilled.
 - c) To continue with the periodic inspections along the dam.
 - d) To measure the water levels in the sinkholes with the necessary frequency.

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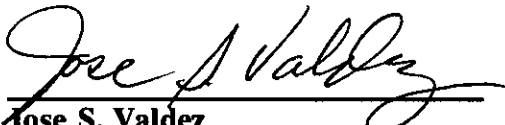
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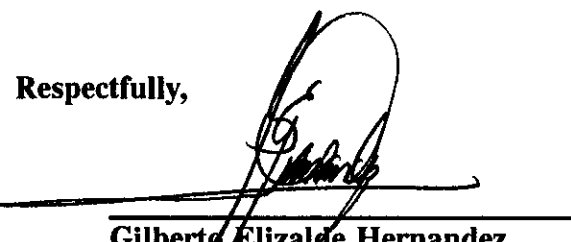
RECOMMENDATIONS

Based on the above conclusions and with which we are in total agreement, we respectfully recommend:

1. That the International Boundary and Water Commission, United States and Mexico, approve the above recommended actions proposed by its Advisers, which are of an emergency nature, which if not performed promptly may result in serious damage to the project.
2. That the Commission order the above emergency nature works executed as soon as possible, consistent with the following schedule:
 - a) That the filling of the sinkholes be carried out before the reservoir is filled since its filling would delay the repair works and cause the cavity beneath the dam to enlarge and cause the possible failure of the structure;
 - b) That the treatment of the sinkholes should be undertaken immediately before a period of 30 to 60 days; and
 - c) That the remaining activities, including the grout curtain that can be undertaken independently of the lake elevation, should be undertaken in a period of six months to a maximum of one year from January 1995.
3. That the Commissioners, establish by a Commission Minute, consistent with Minute No. 235, the distribution between the two Governments of costs of the referenced work to allow each Section of the Commission, to take the necessary actions in its respective country to obtain the funds necessary for their execution in the shortest possible time.

Respectfully,



Jose S. Valdez
Principal Engineer
United States Section

Gilberto Elizalde Hernandez
Principal Engineer
Mexican Section