REPORT

ON

EXAMINATION OF BABELTHUAP DAM

BABELTHUAP ISLAND

PALAU ISLAND

TRUST TERRITORY OF THE PACIFIC

By

Carl J. Hoffman
Office of Chief Engineer
U.S. Bureau of Reclamation
Denver, Colorado

Summary

The present water supply for the community of Koror is served in part by water from the Gihmel River on Babelthuap Island. Supply is limited to direct flow from the stream, since a storage reservoir previously constructed by the Japanese was destroyed during World War II by bombing. Restoration of this reservoir by replacement of the dam is now being proposed.

To properly evaluate the feasibility of the proposed restoration, a study should be undertaken considering project water needs, stream yield, and engineering designs and estimated costs. Basic design data and criteria should be assembled before a complete evaluation can be undertaken. These data include the hydrology of the drainage basin, topographic surveys and mapping, and geologic and construction material exploration.

Site conditions appear adaptable for either a concrete dam with earth wings or a zoned earth and rock fill dam. Economic comparisons should be made of the alternatives to select the most feasible arrangement.

Introduction

At the time the Japanese controlled the Palau Island group by mandate, they constructed a water supply reservoir on the Island of Babelthuap to furnish domestic water to the community of Koror on Koror Island, across a narrow strait from Babelthuap Island. A small concrete gravity dam about 27 feet high, flanked by earthfill wings, formed the reservoir, which impounded an estimated 30 acre-feet of storage. The dam is situated at the southwest end of Babelthuap Island, on the Gihmel River, about a mile upstream from the point where the river empties into the sea. The river outlet spills into a mangrove-covered coral-bottomed estuary and then into the Pipiroi Strait, which separates Babelthuap and Koror Islands. Water is transported across the strait through an 8-inch pipeline, partly transite and partly rubber hosing.

During the invasion of the Islands by U.S. Armed Forces the concrete dam was partially destroyed by repeated bombings, which breached and removed the central portion and moved the left end several feet from its original position. The main breach was partially repaired about 1950 by refilling the bombed-out section with concrete to a height of about 9 feet above streambed. However, silt accumulation has mostly filled the small pond behind the repaired section so that water storage is now insignificant.

The High Commissioner of the Trust Territory is considering the feasibility of restoring the water supply reservoir by a rehabilitation or replacement of the old Japanese dam. My visit was arranged to examine the condition of the existing dam and to advise concerning studies and designs leading toward a restoration of this water supply facility.

Condition of Existing Dam

The old Japanese dam consists of a concrete gravity section founded on a basalt or andesite bedrock ledge which outcrops across the valley floor; and of flanking earthen wing embankments. The embankments enclose the ends of the concrete section and are keyed into trenches excavated into the clay banks of the abutments. The concrete dam is approximately 145 feet long, of which about 50 feet near the center comprised the overflow spillway portion. The spillway crest was about 6 feet below the top of the remaining section of the dam.

The bomb damage has breached the spillway section of the dam almost in its entirety, has displaced the top portion of the left concrete abutment section as much as 3 feet, and has tilted the top of the entire right abutment section about 12 inches in a downstream direction. Although leakage under the dam is presently not evident, because of the tilting and displacement it can be assumed that the bond between the dam and the bedrock has been destroyed by the bombing.

The wing embankments consist principally of a clay backfill material which was probably obtained from the trenches excavated into the abutments or from nearby borrow. The dam abutments and refill material consist mainly of plastic fat clays. The degree of compaction of the refill material is uncertain, but it appears that it is now relatively compact after the many years of seasoning since it was originally placed. However, the contact between the concrete and fill has undoubtedly been destroyed where the concrete has been moved by bombing, and in all probability, voids occur adjacent to the concrete faces. A bomb crater immediately downstream from the dam on the right abutment has displaced much of the earthfill on that side.

Original layout drawings of the structure are, of course, not available. A reconstructed layout, based on rough measurements and examination, is attached, Figure 1. A photograph showing the downstream face of the structure after the bombings is shown on Figure 2.

Rehabilitation of Present Dam

It has been suggested that reservoir restoration might be accomplished most economically and expeditiously by repairing the existing dam, thereby salvaging those portions of the structure still considered to be structurally sound. However, since it is suspected that most of the concrete dam has been moved or tilted by the bombings, at least it would need to be removed and replaced with a new structure. Excavations to remove the concrete footings and to expose bedrocks for new structure footings would remove major amounts of the earth wing materials. The competency of the remaining backfill in the abutment trenches will not be known until inplace density tests are made.

Whether or not these fills can be salvaged will depend on test results. In effect, therefore, a restoration of the present design will involve the removal of practically all of the existing structure and its replacement in kind.

The replacement of the existing design will involve mainly the construction of a concrete gravity section of about the length and cross section of the original structure, and the placement of embankment fill to complete the closures at the abutments. The spillway will be formed as an overflow section near the center of the dam, and diversion and operating outlets will be placed through the dam. It is estimated this design will involve the placement of upward to 2,000 cubic yards of concrete. Concrete aggregates and sands are not readily available from natural sources; these probably will have to be obtained by crushing quarried rock deposits, or by importing from outside sources. Embankments and backfills will need to be placed in relatively confined areas, precluding the use of larger construction equipment. Placement and compaction of the backfills will need to be done mainly by small equipment or more expensive hand methods.

Alternative Design

As an alternative to a concrete dam layout, a zoned earth and rock fill dam which will span the full width of the site might be considered. This scheme will utilize a concrete conduit placed under the dam for diversion and outlet releases, and a chute spillway placed on the left abutment. The zoned embankment can be constructed of an impervious core and of pervious outer shell materials. Impervious materials can be obtained from required excavations and from nearby borrow areas and placed and compacted with mechanized construction equipment. For outer zone materials, coral limestone of acceptable quality or basaltic rock can be quarried from not too distant sources. Concrete blocks and fragments produced by demolishing the existing dam can substitute for rockfill or riprap in the outer zones. It is estimated roughly that up to 25,000 cubic yards of embankment and perhaps about 400 cubic yards of concrete will be required for this alternative construction. Construction of the embankment can be mostly by mechanized equipment.

The type of dam finally selected should depend on economic comparisons based on alternative designs and estimates. To properly evaluate the alternatives, field data and basic design criteria and information should be obtained for both a concrete or an earth dam proposal.

Size of Reconstructed Development

The reservoir capacity of the original Japanese development has been estimated at approximately 10 million gallons (30 acre-feet). A part

of this storage space has since been consumed by reservoir siltation. In planning the reconstruction, studies should be initiated to determine the most desirable capacity to best suit the needs of the project. These studies should relate to watershed yield, evaporation losses, and storage depletion by sedimentation; and to projected water requirements based on expected growth of the community. These studies may indicate the need for a development larger than that constructed by the Japanese.

Data Needed for Redesign

To prepare a feasibility study for the rehabilitation of Babelthuap Dam, field data and information are needed and design criteria must be established. The following discusses the data needed to initiate design studies.

1. Mapping and Surveys.--

a. General mapping of the damsite and reservoir area, and aerial photographs. Mapping of Babelthuap Island by the Army Map Service is available, scale 1 to 25,000 showing 10-foot contours. Sheets 1044, AMS Series W856, include the area in the vicinity of the reservoir site. The location of the damsite will need to be indicated on these maps. Obtain aerial photos from which the AMS mapping was prepared. These maps and photos will serve to define the reservoir basin drainage area.

b. Survey the reservoir area by taking cross sections at about 200-foot intervals, from which a reservoir contour map can be prepared, and from which a reservoir area-capacity curve can be computed. Refer cross sections to a surveyed control traverse, preferably taking cross sections normal to the reference line.

c. Survey the damsite area and prepare a topographic map. A scale of 1 inch to 40 feet with 5-foot contour intervals is suggested. The topographic data can be taken either by plane table or by cross sectioning. The topography should extend from 150 feet upstream to 150 feet downstream of the existing dam axis, and include contours to at least 20 feet above the top of the proposed dam. The topography should be extended to include the ridge and draw on the left abutment, for a distance of about 100 feet left of the stream channel.

d. Extend one of the reservoir cross sections to include a profile through the saddle on the left rim of the reservoir, about 1 mile to the left of the damsite.

2. Geologic Data.--

a. Indicate bedrock outcrops and exposed ledge rock on the damsite topographic map.

b. Explore foundation by auger borings to determine subsurface bedrock levels. These borings will also serve to identify the properties of the overburden material. Lines of holes along the abutments and across the valley floor are suggested. At the left abutment holes should be bored on a line about 30 feet left of the concrete section and then continued downstream across the ridge and along the slope of the draw. On the right abutment, the holes should be bored on a line about 30 feet right of the concrete dam, extending from about 50 feet upstream to 50 feet downstream from the present dam. Holes across the valley on lines 50 feet upstream and 50 feet downstream from the present dam will identify valley fill materials. Holes at each end of the concrete dam to ascertain depth to bedrock are also suggested. Accurate logs should be kept describing the nature and condition of material encountered.

Test pits, one each on the right and left abutments, and a pit on the left ridge, are also suggested. The pits on the abutments should be located so that they penetrate both the backfill material of the original construction and the underlying abutment foundation. Undisturbed samples for laboratory testing should be obtained of both the clay fill material and the original foundation. At several levels in the pit, density inplace tests should be made of the material encountered.

Suggested locations for auger boring holes and test pits are shown on Figure 1.

3. Construction Material Explorations.--Locate borrow areas of suitable earth and rock fill embankment materials for the earth and rock fill dam scheme. Nearby clay materials may prove acceptable for the impervious core. For the pervious shell, the quality of the coral limestone and igneous rock deposits should be examined.

Find sources of durable rock for riprap. Locate suitable sand and gravel deposits for use in drainage zones and in the manufacture of concrete, or indicate deposits where quarry rock can be crushed for such use.

Obtain representative samples of the various materials for examination and testing.

4. Hydrology. --

a. Collect and assemble all available records of rainfall on Palau and neighboring islands. These should include daily, weekly, and annual precipitation amounts, and seasonal variations of rainfall occurrence.

b. Assemble all data of typhoon incidences on and surrounding the Palau Islands, and of typhoon tracking patterns in the western Pacific area.

c. Assemble all available streamflow data of streams on Palau or neighboring islands, including daily discharges, momentary peaks, monthly and annual volumes. For recorded flows, show drainage areas above point of measurement.

A gaging station should be established as soon as practicable on the stream, near the present damsite, and daily readings made. Even short-time records will be valuable in evaluating streamflow potentials.

d. Estimate maximum streamflows to be expected during the construction period.

e. Make evaluation of annual sediment depletions from reservoir storage.

f. Determine annual evaporation rates to be used in planning reservoir storage capacity, based on evaporation experience or data in the general area.

g. Survey stream below dam to develop stage-discharge tailwater data. Survey a stream profile and cross sections for 200 feet below dam; furnish photographs showing condition of stream channel, alinement, obstructions, undergrowth, vegetation, etc.

5. Project Water Requirements. --

a. Make study of project water needs, based on evaluation of present and future per-capita consumption, and forecast of future growth of the community.

b. Estimate outlet requirements, indicating contemplated release demands for full project development.

Acknowledgments

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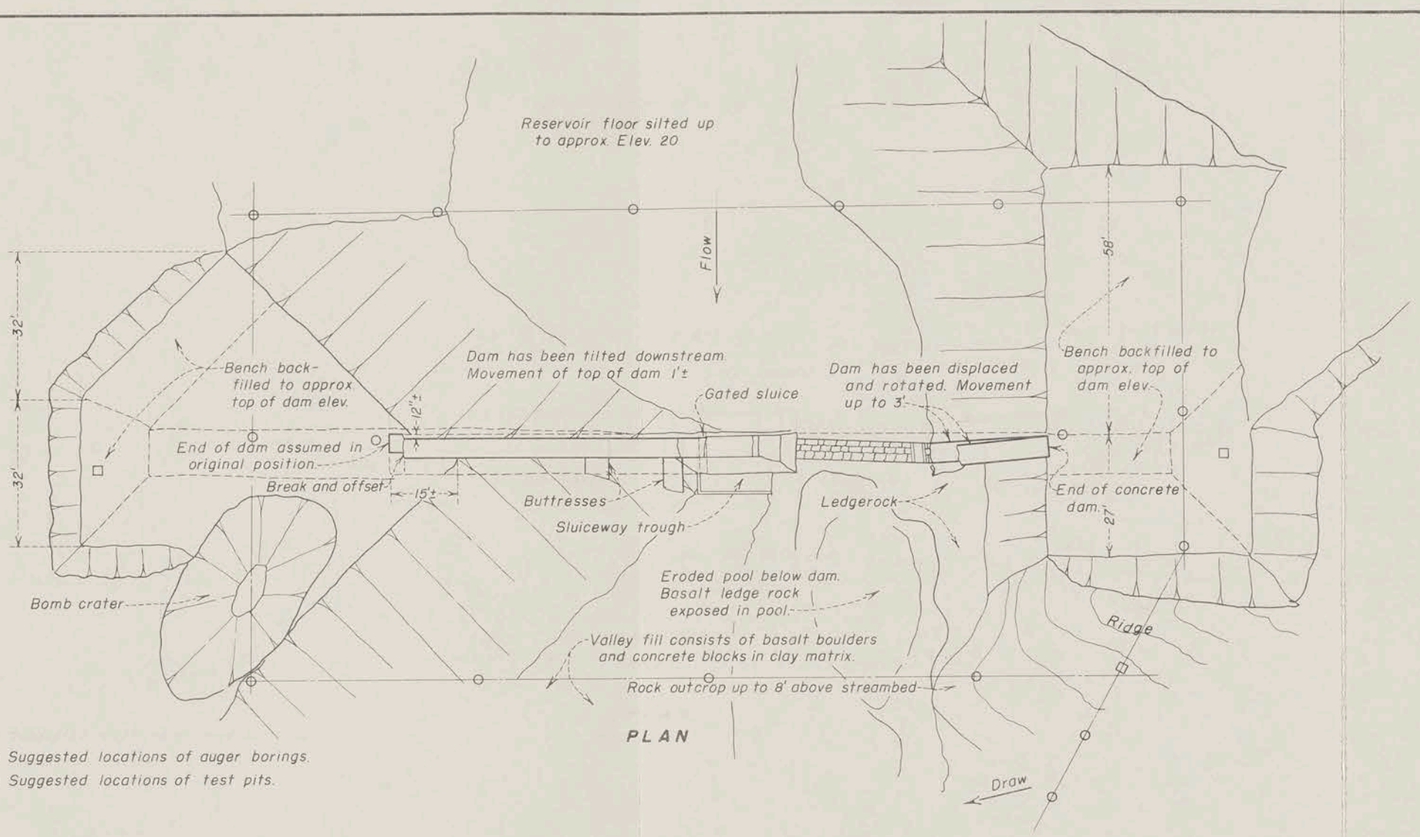
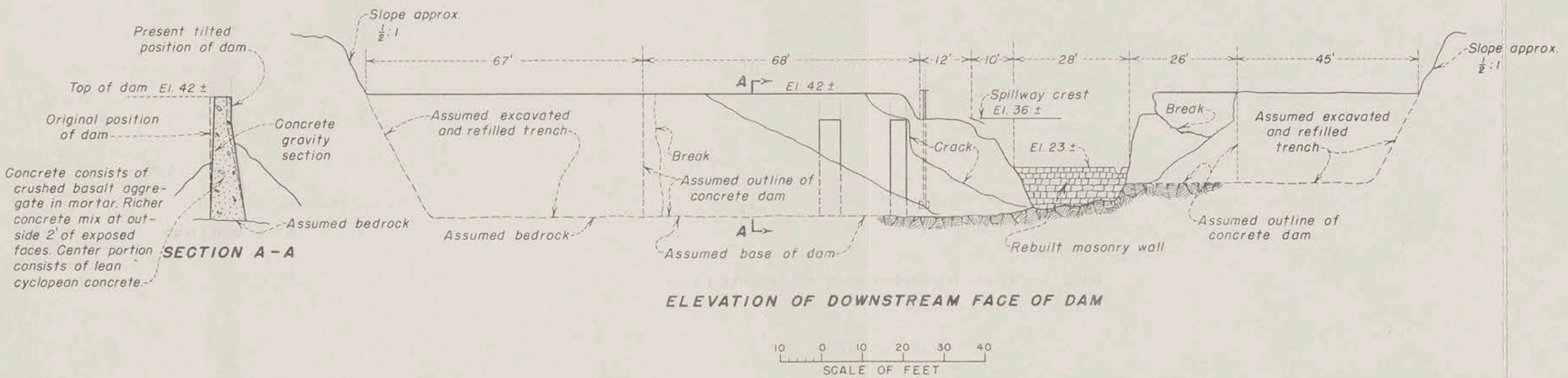
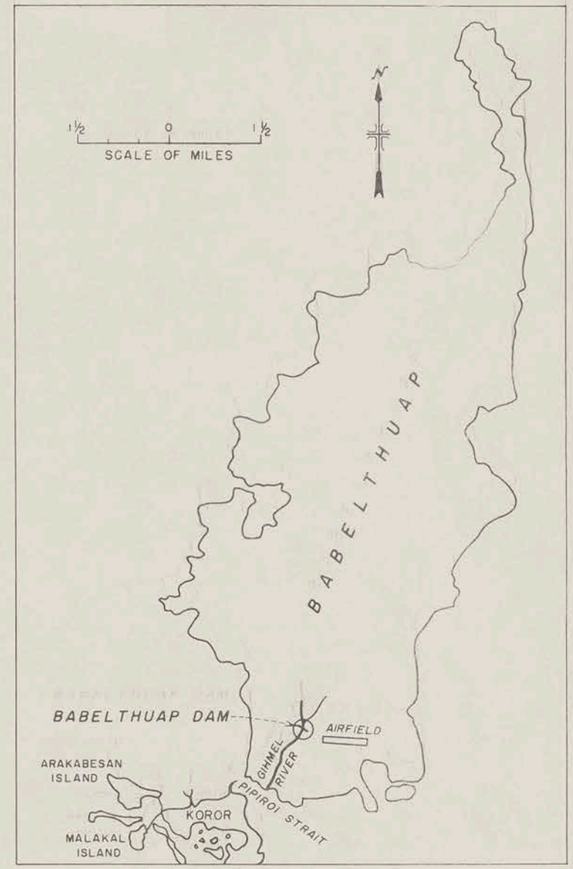
Itinerary

The visit was arranged to correspond with another assignment which brought me through Guam on January 14, 1964. Transportation to Palau and return to Guam was furnished by Trust Territory planes. My itinerary during this assignment follows:

January 14, 9 p.m.--Arrived in Guam via Pan American Airlines
January 16, 7:30 a.m.--Departed Guam via Saipan and Yap--Stayed in Yap overnight
January 17, 10:30 a.m.--Departed Yap, arrived in Koror at 11 a.m.--Examined site of reservoir on Babelthuap in p.m. and on January 18
January 19, 12 noon--Departed Koror--Arrived in Guam, 7:30 p.m.
January 21, 9:30 p.m.--Departed Guam via Pan American Airlines







LOCATION MAP

TRUST TERRITORY OF THE PACIFIC

EXISTING CONDITION OF WATER SUPPLY DAM ON BABELTHUAP, PALAU ISLANDS

SKETCH ACCOMPANYING EXAMINATION REPORT

BY CARL J. HOFFMAN
U.S. BUREAU OF RECLAMATION
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Figure 2.