355

HISTORY OF THE DEVELOPMENT OF WATER HARVESTING IN THE HAWAIIAN ISLANDS

by

Gary Frasier and Wayne Williamson[1]

APPENDIX

Introduction

Water resources in the State of Hawaii are primarily derived from precipitation. However, unlike many parts of the world, Hawaii's water supply problems are not caused by a general shortage of precipitation. Instead, they result from temporal and spatial variabilities in the rainfall distribution and insufficient numbers of water storage facilities. Some parts of the islands are classified as desert with less than 200-mm annual rainfall, while other nearby areas a few miles distant receive some of the largest quantities of precipitation in the world, often exceeding 10,000-mm per year. The rainfall distribution, combined with the mountainous topography and relatively porous soils, makes development of Hawaii's water resources both difficult and costly.

The early Hawaiians started the development of the water resources by constructing simple ditches to bring runoff water from the wetter areas of the islands to irrigate small patches of land for growing taro. With the arrival of the "haole" settlers, more extensive collection and conveyance ditches were constructed to increase the water supplies for a more diversified agriculture. This system supplies sufficient water to meet the needs of several years.

In the early 1880's, the farmers realized that seepage losses were significant from the unlined ditches and small holding reservoirs. To meet the water

[1]Research Hydraulic Engineer, Southwest Rangeland Watershed Research Center, 442 East Seventh Street, Tucson, Arizona 85705, and Account Manager, Wisdom Industries, Inc., Honolulu, Hawaii.

demands of the expanding population, industry, and agriculture, it became necessary to efficiently utilize the existing water supplies and to develop new water sources.

About 1900, various methods of reducing seepage losses from the unlined ditches and reservoirs were tried in an attempt to conserve the existing water supplies. Some of the initial methods consisted of spraying the soil with an "oil" coating or using a pressed "mud" lining. Other membrane linings consisted of materials such as asphalt-impregnated felt planking, asphaltic concrete, sand plaster with poultry wire reinforcement, and exposed or buried asphaltic barriers. These water conservation methods sufficiently extended the existing water supplies to meet the needs for several more years. By 1940, a new water supply method, "water-harvesting," began to receive considerable interest for supplying water to livestock.

Water-Harvesting and Seepage Control

Water-harvesting is the process of collecting and storing natural precipitation from prepared watersheds for beneficial use. Harvesting precipitation from prepared areas, such as collecting water from the roofs of buildings for household use, had been used for many years in other parts of the world. The concepts of water-harvesting were especially attractive and feasible for the Hawaiian Islands because of the many areas which receive high annual precipitation. Large quantities of good quality water could be obtained by covering or treating small areas of land to produce essentially 100% runoff efficiency. Water-harvesting basically consists of two operations -- collecting precipitation runoff, and storing the collected water until time of need.

Initially, water-harvesting systems if Hawaii were developed to supply drinking water for various types of livestock, and consisted of sloping sheet-

metal roof catchments and wooden or metal water storage tanks located directly underneath. The roofs shaded the water surface and reduced evaporation losses. Later, similar sheet-metal roof-type catchments were constructed on the ground, and the water was carried downslope in pipes or channels to the water storage tank. Another early-type catchment consisted of spreading fine cinders on the soil surface and spraying them with an asphalt emulsion. A second similar layer was applied and rolled into a compact, dense covering. These catchments were relatively expensive, but were successful for livestock water. In 1959, the potential of this type of catchment for water-harvesting was evaluated near Holualoa Kona. The rainfall runoff from an experimental catchment, made by spraying hot mix asphalt directly onto the soil, was measured for three years. Even with the limited guidelines for design and construction, the results indicated that catchments did offer a solution to the problem of obtaining water supplies in areas where there were no perennial streams and where groundwater sources were too expensive to develop.

By the early 1950's, lightweight and relatively inexpensive thin plastic films or sheetings had become available, and showed considerable promise for water-harvesting and seepage control. Special care was required during preparation of the subgrade to remove any sharp objects, such as sticks or stones, which might tear or puncture the film during lining installation. Some of the plastics also had poor resistance to deterioration by sunlight. To reduce further mechanical damage and chemical deterioration in reservoir linings, a graded or screened soil cover was placed over the linings. This limited the shapes of ponds and reservoirs suitable for treatment to ones with relatively flat sideslopes; otherwise, the soil cover would gradually slide to the bottom. Other problems, such as plant growth on the soil cover, difficulty in placing the soil cover without damaging the plactic, and making water-tight seams, all

all tended to limit the use of plastic sheetings for seepage control. For water-harvesting, the plastic sheetings were placed directly on the soil surface. To reduce potential wind damage, woven wire fencing was placed on top of the plastic and held in place with sandbag weights. Even when weighted, wind would cause the sheeting to vibrate and cause small holes to wear through the plastic. On several catchments, wind penetrated under the sheeting and completely lifted the plastic, wire, and weights from the soil surface, destroying the catchment.

In the 1960's, synthetic rubber sheetings (butyl) became available for water-storage liners. The rubber sheetings were considerably stronger and more durable than the plastic films, and were sufficiently light-weight, weather resistant, and easily installed with adhesive-sealed water-tight seams. Many reservoirs were successfullfy lined with butyl in Hawaii for a variety of uses, including irrigation, stock water, industrial, and household. The most impressive lined reservoir, covering 42 hectares (104 acres) on the island of Molokai, has a storage capacity of over 5.3 billion liters of water. Water from this reservoir has permitted several industries and businesses to develop which would not have been possible without an adequate water supply.

With the introduction of artificial rubber membranes for reservoir linings, users soon found that a simple catchment could be constructed by extending the lining upslope for a water-collection area. During the past 15 years, this type of combination catchment and storage has been successfully used in many places in Hawaii.

Problems were encountered with wind uplift, materials sliding downslope, and poor quality butyl sheeting. Cooperative studies in Hawaii and on the mainland between federal research agencies, industry, and users led to the incorporation of a reinforcing fabric within the butyl sheeting for added

strength to control sheeting elongation, and to improve the weathering performance of the rubber compounds.

Research by state and federal agencies is continuing in cooperation with local industries to develop other lower-cost methods of controlling or stopping seepage losses from ponds and reservoirs. These methods include new types of laid-in-place asphalt fiberglass or asphalt polypropylene-reinforced linings and various types of chemical agents which can be applied directly to the soil. Hopefully, these methods will expand the locations where seepage control methods can be used effectively.

Water-harvesting research is also continuing in an attempt to develop additional methods and materials which can be used to treat Hawaii's volcanic cinders and soils to provide water which will meet the current Environmental Protection Agency's requirement for potable water. The goals of these studies are to insure that Hawaii will always have a dependable supply of good quality water for all future needs.

SELECTED REFERENCES

1. Anon., "Water Resources in Hawaii," Hawaii Water Authority, 148 pp., Mar., 1959.
2. Anon., "Water Resources Development, Molokai," Bulletin B16, State of Hawaii, Dept. of Land and Natural Resources, Division of Water and Land Development, 69 pp., Feb., 1966.
3. Anon., "Field Covers Catch Rain," Irrigation Engineering and Maintenance, pp. 18-19, Apr., 1967.
4. Bischoff, C. H., "Ditch Lining at Waialua Agricultural Co., Ltd. Assoc.," Hawaiian Sugar Tech. Rpt. Annu. Meet., 19:61-63, 1939.
5. Chinn, S. S. W., "Water-Supply Potential from an Asphalt-Lined Catchment near Holualoa Kona, Hawaii," USGS Water-Supply Paper 1809-P, U.S. Government Printing Office, Washington, D.C., 25 pp., 1965.
6. Frasier, Gary W., editor, "Proceedings of the Water Harvesting Symposium, Phoenix, Arizona, Mar 26-28, 1974," ARS W-22, 329 pp., Feb., 1975.
7. Taliaferro, W. J., "Rainfall of the Hawaiian Islands," Hawaii Water Authority, 349 pp., Sept., 1959.
8. Wadsworth, H. A., and H. R. Shaw, "Developments in Irrigation Practices," Hawaiian Sugar Planters Assoc. Proc. 51:507-554, 1932.

THE USE OF WAX-FIBERGLASS AS A CATCHMENT SURFACE FOR WATER HARVESTING IN HAWAII

Circular C79

By Gary W. Frasier

UNITED STATES DEPARTMENT OF AGRICULTURE
Science and Education Administration
Agricultural Research

in cooperation with

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

Honolulu, Hawaii
March 1979