HAWAII VOLCANOES NATIONAL PARK WATER COLLECTION SYSTEM
Hawaii Volcanoes National Park
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Volcano vicinity
Hawaii
Hawaii

HAER HI-76
HI-76

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
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HISTORIC AMERICAN ENGINEERING RECORD

HAWAII VOLCANOES NATIONAL PARK WATER COLLECTION SYSTEM

HAER HI-76

Location: Hawaii Volcanoes National Park, Volcano vicinity, Hawaii County, HI

Present Owner: Hawaii Volcanoes National Park

Present Use: Water collection system, some components of which are no longer in use

Significance: The Hawaii Volcanoes National Park Water Collection System is significant as an example of a system designed to provide water in an area where wells are not commonly used and represents changes in water collection technology in the twentieth century. In addition, the establishment of the water collection system supported the development of the park.

Historian: Justine Christianson, HAER Historian, 2008

Project Information: The Historic American Engineering Record (HAER) is a long-range program that documents and interprets historically significant engineering sites and structures throughout the United States. HAER is part of Heritage Documentation Programs (Richard O'Connor, Manager), a division of the National Park Service, United States Department of the Interior. Laura C. Schuster, Chief, Cultural Resources Division, at Hawaii Volcanoes National Park facilitated the project. Todd Croteau, HAER, served as project leader, architect and photographer. Justine Christianson, HAER, wrote the historical report.

Part I. Historical Information

A. Physical History:

This report focuses on the water collection system that developed on the former Volcano House grounds in the park's headquarters area. Originally, the park's water collection system was located in the "Utility Area" near the park employee residences. The Volcano House hotel had a separate system to support its facilities.

1. Dates of Construction:

The old rain shed, Building No. 43, was built in 1924 by the Volcano House hotel.[1]

Six redwood tanks (Tank Nos. 7-12) had been erected next to the old rain shed by October 1947.[2]

Wood water tanks of various sizes were relocated from "Tank Hill" (located near the former Volcano House hotel) and the Civilian Conservation Corps (CCC) camp to the vicinity of the old rain shed from 1949 to 1950.[3]

Three 500,000-gallon steel tanks and one 23,500-gallon steel filter tank were in place by November 1957. An additional 500,000-gallon tank was erected the following year.[4]

A pump house containing the electric water pump, chlorination unit, and electric control system was constructed in 1957 with a sand trap located between it and the nearby filter tank.[5]

The new rain shed (Building No. 241) and trestles were completed in November 1957.[6]

Another slow sand filter tank was added sometime after 1980, as well as a clear well.[7]

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[1] Information from Form 16-54522-2 on Building 43, prepared by I.J. Castro, Assistant Superintendent, in Hawaii Volcanoes National Park Archives (hereafter referred to as HAVO Archives).
[2] Superintendent Monthly Report, October 1947, p. 1. The superintendent reports are available from the HAVO Archives.
[3] Superintendent Monthly Reports, September 1949, p. 3; October 1949, p. 2; January 1950, p. 3; and February 1950, p. 3.
[4] Superintendent Monthly Reports, November 1957, p. 1; November 1958, p. 9; Memorandum from Park Engineer to Superintendent, Subject: Engineering Report for November 1958, December 3, 1958, p. 4 in November 1958 Monthly Report.
[5] Superintendent Monthly Report, November 1957, p. 13.
[6] Superintendent Monthly Report, November 1957, p. 12.
[7] San Juan Construction, Inc., As Constructed Drawings, Rehabilitate Park Water System, Headquarters Area, "Tank Farm and Rainsheds," June 1993, Sheet 4 of 35.

The larger ground catchment (128,878 square feet in size) dates to the early 1970s, while the smaller one (51,000 square feet in size) dates to ca. 1993.[8]

Two 750,000-gallon tanks were erected ca. 1993 to replace eight of the original redwood tanks. A fifth steel tank with a 500,000-gallon capacity was also built ca. 1993.[9]

2. Architect/Engineer:
The engineers of the National Park Service (NPS) Western Office's Division of Design and Construction and the Office of the Chief Engineer located in San Francisco, California, designed the 1930s-era system with input from park personnel. The NPS Regional Office provided guidance for the design of the 1950s-era system.

3. Builder/Contractor/Supplier:
The Volcano House hotel concessioner built the old rain shed.[10]

Terminal Steel Company, Ltd. of Honolulu won the contract to build four steel tanks, including three 500,000-gallon tanks and one 23,500-gallon tank.[11] The pipes and fittings for the tanks were ordered through the General Services Administration from the Grinnell Company.[12] Pittsburg-Des Moines Steel Company of Santa Clara, California, won the contract to build the fourth 500,000-gallon steel tank.[13]

H. Sonomura of Hilo, Hawaii, built the new rain shed and trestle. The pipe work was subcontracted to P.E. Pell Company of Honolulu.[14]

San Juan Construction, Inc. of Aiea, Hawaii, erected the two 750,000-gallon capacity tanks and the last 500,000-gallon capacity tank. They also constructed the smaller ground catchment.

4. Original Plans:
Plans from 1937 and 1938 show the Volcano House hotel system, consisting of a rain shed (now Building No. 43) and an assortment of various sized water tanks, located behind the hotel. The park's system included a 54,000-gallon capacity underground concrete reservoir and pump house in the "Utility Area" of the park with tanks located at nearly all the residences and buildings. A 4,500-gallon high

[8] San Juan Construction Inc., "Site Plan," June 1993, Sheets 4, 5 and 11 of 35.
[9] San Juan Construction, Inc., "Tank Farm and Rainsheds," June 1993, Sheet 11 of 35.
[10] Form 16-54522-2, Building 43.
[11] Superintendent Monthly Reports, February 1957, p. 10; March 1957, p. 2.
[12] Superintendent Monthly Report, May 1957, p. 12.
[13] Superintendent Monthly Reports, May 1958, p. 11; June 1958, p. 9.
[14] Superintendent Monthly Reports, February 1957, p. 10; March 1957, pp. 2, 12; April 1957, p. 10. Sonomura's bid totaled $43,809.

tank was located among the park residences. The park's Fire House is now located adjacent to the reservoir, which remains in use.[15]

Plans dating to 1953 show the removal and consolidation of the tanks formerly used by the Volcano House hotel. A battery of fourteen tanks was located behind the rain shed, with plans to add six more. Fourteen more tanks of various sizes were located under the rain shed, and another was outside the rain shed at its southern corner. In addition, a collection system was still maintained at the Utility Area, consisting of a reservoir and pump house with tanks scattered at various locations. The high tank had been removed.[16]

By 1958, the water collection system had been centralized at the park's headquarters area on the site of the former Volcano House hotel system. A new rain shed supplemented the old one. Four 500,000-gallon tanks augmented the fourteen wood tanks to the rear of the old rain shed. A filter tank connected to a pump house and a chlorinator with a sand trap between them was located to the north of the tanks and rain sheds.[17]

5. Alterations and Additions:

The old rain shed has undergone the greatest number of alterations. After the installation of redwood tanks behind the rain shed in 1947, the roof had to be raised. Two years later, the rain shed was further altered with a 160' extension project from 1949 to 1950. The windward end of the rain shed was completely clad in 1955. That same year, a September cyclone damaged the building, necessitating additional repairs. In 1958, the removal of the redwood tanks housed in the rain shed caused additional alterations to be made to the roof, including the construction of new supports. A storm in January 1959 caused some structural damage after the collapse of the roof and walls. This event required further alteration to the building.[18]

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[15] U.S. Department of the Interior, National Park Service, Hawaii National Park Headquarters Area, "Map Showing Existing & Proposed Water Lines to Accompany Report by W.E. Robertson, Assoc. Eng.," Office of the Chief Engineer, San Francisco, CA, October 1937; U.S. Department of the Interior, National Park Service, Branch of Engineering, Prepared by Regional Office, "Prop. Location Plan for Water System Improvement, Headquarters Area, Hawaii National Park," ca. 1938, Sheet 1 of 3.

[16] "Water Collection & Sewer System," and "Water Distribution, Kilauea Headquarters," March 1953, Sheets 1 and 2 of 2.

[17] U.S. Department of the Interior, National Park Service, Engineering Branch, Prepared by WODC, "Water Distribution System, Kilauea Headquarters, Hawaii National Park," As Constructed Drawing, January 1958, Sheet 1 of 4.

[18] Superintendent Monthly Reports, May 1947, p. 3; June 1947, p. 3; November 1947, p. 4 and photograph caption; November 1949, p. 3; January 1950, p. 3; February 1950, p. 3; March 1950, p. 3; April 1950, p. 4; May 1950, p. 4; July 1950, p. 4; August 1955, p. 4; July 1958, p. 10; January 1959, pp. 10-12; Memorandum from Supervisor, Construction and Maintenance to Park Engineer, Subject: Monthly Report for the Month of September 1955, October 3, 1955, in September 1955 Monthly Report.

The redwood water storage tanks were rebuilt beginning in 1957 after the bases were found to be failing.[19]

B. Historical Context:

The lack of wells and running streams within Hawaii Volcanoes National Park necessitated the construction of a water collection system to supply the residences of the park's employees, as well as the buildings and structures used for visitor services and park administration.[20] Originally, the park relied solely upon a roof catchment system at each building in which rain water drained directly from the building's roof into a nearby redwood tank. It soon became apparent that a larger storage system was necessary to supplement the twenty-three redwood tanks with a total capacity of 74,000 gallons in place in the early 1930s so ample water would be available during periods of drought and to support the park's growth.[21] The first phase of development of the park's collection system occurred in the early 1930s with the construction of an underground concrete reservoir and pump house, a high tank, and the requisite pipelines. The second major phase of construction occurred in the 1950s, as the center of the collection system shifted from the Utility Area to the former Volcano House hotel's system. The work included expansion of the old rain shed, relocation of existing storage tanks and erection of new 500,000-gallon steel tanks, and construction of a new rain shed, as well as the completion of a water main distribution project. Additions have been made to the system, including the removal and replacement of eight of the redwood tanks with two 750,000-gallon steel tanks, addition of another 500,000-gallon steel tank and filter tank, and construction of two catchments and a clear well. The bulk of this work took place around 1993.

It is unknown what constituted the original catchment system servicing the Volcano House hotel or when it was constructed. By 1924, a rain shed (now known as the old rain shed or Building No. 43) was in place, built by the Volcano House hotel concessioner at a cost of $10,000. The exterior walls and roof were clad in galvanized iron, and the floor was dirt.[22] The use of galvanized iron for the roof was undoubtedly a deliberate choice since it was considered the ideal material for collecting the maximum amount of water. A discussion of the design of the Thurston Lava Tube comfort station in 1933 reveals the reason for the preference for metal roofing in the park. E.P. Leavitt, Superintendent, wrote to Thomas C. Vint of the National Park Service's Branch of Plans and Design in favor of outfitting the proposed comfort station with a galvanized iron roof, arguing it "collects and saves

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[19] Superintendent Monthly Report, March 1957, p. 2; Frances C. Jackson, *An Administrative History of Hawaii Volcanoes National Park, Haleakala National Park* (Honolulu, HI, 1972), p. 161.

[20] Hawaii Volcanoes National Park was originally known as Hawaii National Park after its 1916 establishment. At the time of its creation, it encompassed lands on both the Island of Hawaii as well as on Maui. Congress authorized the division of Hawaii National Park into two parks in 1961, with the park section on Hawaii becoming Hawaii Volcanoes National Park and that on Maui becoming Haleakala National Park. In this report, the park will simply be referred to by its current name: Hawaii Volcanoes National Park.

[21] Jackson, pp. 154-155.

[22] Form 16-54522-2, Building 43. A search of the 1924 Superintendent Monthly Reports did not reveal any information about its construction, probably because it was built by a concessioner and not the park.

almost every drop of rain that falls." This was a desirable feature in an area where "the only water supply is that gathered from rain on roofs." Wood shake or shingle roofs, Leavitt noted, did "not have the power of condensation that metal has, and what little is condensed is absorbed by the wood." The condensing power of galvanized iron meant that even on foggy and misty days, water could be collected from an iron roof. On the other hand, only heavy rains produced enough runoff for collection from a wood roof.[23]

The first phase of construction of a park-wide collection system to augment the already existing practice of collecting water at individual structures occurred in the early 1930s. This building campaign was in response to a drought lasting from 1930 to 1931 that highlighted the need for a centralized storage reservoir from which water could be pumped and transported to various points in the park. With assistance from John B. Wosky, a landscape architect with the National Park Service's Landscape Division in San Francisco, park personnel surveyed the headquarters area to determine the best location for a centralized system. They settled on a site east of the headquarters area that had a higher elevation than the surrounding area so it could support a gravity-feed system. In addition, the chosen location was in a "rain belt producing more water than any other area near headquarters." In order to utilize the site, the heavy undergrowth and timber stands would have to be cleared and an access road built.[24]

When H.B. Hommon, a Sanitary Engineer with the U.S. Public Health Service, was consulted about the proposed site, he voiced some reservations. First, he noted that the dense vegetation in the vicinity of the catchment system would produce a great deal of detritus that had the potential to periodically clog the system. In addition, the $6,000 fund for construction, of which the San Francisco Branch of Plans and Designs took 10 percent, would probably not be sufficient. Instead, Hommon believed it would be "more practicable to collect water from the roofs of the buildings already in place and to plan for additional roof surfaces when new buildings are constructed." The collected water could be stored in a 20,000-gallon capacity underground reservoir, which would be covered. The reservoir would be divided into two sections that would operate independently since each would be equipped with their own inlet pipes and drains. Next to the reservoir, a gasoline engine-driven pump with a 100 gallon/minute capability and a pressure of 100 pounds per square inch (psi) would be connected to suction lines extending to each half of the reservoir. The pump would draw water from the reservoir to an elevated steel tank, which would provide "ample pressure" for fire protection as well as for supplying individual water tanks during periods of drought. The twelve storage tanks already in place at the

[23] Letter from E.P. Leavitt, Superintendent, to Thos. C. Vint, Chief, Branch of Plans & Designs, National Park Service, San Francisco, CA, August 23, 1933, in Folder 618, Box 1178, Record Group 79, National Park Service (hereafter cited as RG79), in National Archives and Records Administration, College Park (hereafter referred to as NARA-College Park).

[24] "Report on Water Supply System for Hawaii National Park, Hawaii," by Sanitary Engineer H.B. Hommon, U.S. Public Health Service, May 14, 1932, p. 1, in File No. 660-05, Box 1180, RG 79, NARA-College Park.

headquarters area, Hommon argued, were in good condition with "no odor or color resulting from storing water" in them. Hommon's proposal included running a 3" line from the new administration building to Residence 3 and then a 4" line to a collecting tank in the Utility Area. In addition to the 3" and 4" main lines, 2" branch lines would be installed connecting the main line with the overflow of the storage tanks. Hommon estimated the system would cost $5,170.[25]

In response to Hommon's suggestions, the park made some modifications to the original plans. One modification was using gravity lines to drain the reservoir. Superintendent Leavitt also suggested making the reservoir larger with a 60,000-gallon capacity rather than the proposed 20,000-gallon size.[26] A February 1933 press release by Superintendent E.P. Leavitt described the planned collection system.

> A reinforced concrete water tank 20 by 40 feet in size, to hold 60,000 gallons, is under construction in the park....It will serve as a collection basin for the surplus water gathered from the roofs of the buildings in the park during the rainy season, which will be distributed as needed during the seasons of light rainfall. The plans call for a pipe line to be connected at the top of each wooden tank serving each building, which will convey the surplus water to the concrete tank. The supply pipes will be used as a distributing system by pumping the water back through them to the tanks where needed. A gasoline pump and pump house will be part of the system. There are no springs, wells or running streams in the park area, so all the water used must be gathered from roofs of buildings and stored.[27]

The park's collection system was finally located at the "Utility Area," a section of the park northeast of Kilauea crater and east of the Volcano House. The Utility Area also contained the mess hall, bunk, nursery, machine shop, warehouse, and fire equipment shed. Construction of the system began in 1932 on the reservoir. By January 1933, the excavation of the 20' x 40' concrete reservoir had been completed, so crews could begin installing the formwork and reinforcing steel. The County of Hawaii's road department loaned the park its concrete mixer, and the park next poured the reservoir's walls, floor and top in separate sections. The valves that drained the reservoir were enclosed in square boxes. Next, the park lay 2,950 linear feet of galvanized iron pipe, which connected the gutters of the Administration Building and Park Naturalist's quarters (Building No. 2) to the reservoir, since these were the only buildings in the park without water storage tanks directly connected to them. The redwood tanks already in place at the headquarters area were also connected to the reservoir. The final phase of construction was the building of the pump house and

[25] Hommon, "Report on Water Supply System," pp. 2-3.
[26] Letter from Superintendent E.P. Leavitt to Sanitary Engineer H. B. Hommon, September 22, 1932 and letter from Superintendent E.P. Leavitt to Director, National Park Service, January 25, 1933, both in File No. 660-05, Box 1180, RG 79, NARA-College Park.
[27] Memorandum for the Press by E.P. Leavitt, Superintendent, February 23, 1933, included in Superintendent Monthly Report, February 1933.

installation of the pump in May 1933. Located next to the reservoir, the 10' x 20' pump house sat on a concrete pad and sheltered a 1933 American-Marsh two-stage turbine driven by a four cylinder, 6-horsepower (hp) gasoline engine.[28] The pump delivered water to the 5,000-gallon high tank, constructed in 1933 and located behind Quarters No. 3 on a 14' tall tower. This pump house (designated Building No. 159) was taken out of service in April 1959, and the building was moved to a site near the junction of Chain of Craters Road and the Kalapana Trail. The building was later converted for use as an animal feed storage and equipment building for the Protection Division. The reservoir is still in use, as is the pump, which is located in the firehouse.[29]

Despite the improvements, the park was still concerned about the lack of water storage facilities. The 5,000-gallon high tank had to be pumped full once a week. In addition, the total water storage capacity of 66,000 gallons could only last two months according to Park Superintendent Leavitt.[30] To address the continuing issue of storage, Superintendent Edward G. Wingate sent a proposal detailing another construction campaign to the Director of the National Park Service (NPS) in February 1934. The proposal included a request for $6,000 to fund construction of another concrete reservoir next to the already existing one. According to Wingate, the addition was necessary because "the present system and plant are inadequate."[31] When nothing came of the proposal, the park sent another detailing a "Water Supply System Addition" to the NPS director. Once again, the park requested funds (this time the amount was reduced to $4,700) to build an identical concrete reservoir. The proposal was justified on the grounds that the system as completed in June 1933 was "lacking only in storage capacity." The reservoir was too small, resulting in a "serious fire hazard" during extended periods of dry weather.[32]

Plans of the headquarters area dating to 1937 and 1938 depict the early water collection system and its proposed changes (See Figure 1). The Volcano House Hotel Company had a collection of tanks with capacities ranging from 4,000 to 80,000 gallons scattered behind the hotel, as well as a rain shed and pump house to supply the hotel with water. The park's water collection system consisted of tanks associated

[28] Jackson, p. 155; Superintendent Monthly Reports, December 1932, p. 5; January 1933; February 1933, p. 7; March 1933, p. 6; April 1933, p. 5; May 1933, p. 3. Of the pipe laid, 1,700' was comprised of 4" pipe, 450' was comprised of 3" pipe, and 800' was comprised of 2" pipe, according to the Superintendent Monthly Report, March 1933, p. 6.

[29] Memorandum from Park Engineer to Superintendent, Subject: Maintenance Report for the Kilauea Section, March 1959, April 6, 1959, p. 3 in Superintendent Monthly Report, March 1959; Final Report, "Rehabilitation of Water System Kilauea Section Headquarters Area," September 1, 1948, p. 6 in Folder 660-05, Box 785, RG 79, NARA-College Park.

[30] Letter from E.P. Leavitt, Superintendent, to Director, National Park Service, Washington, DC, July 15, 1933 in Folder 618, Box 1178, RG 79, NARA-College Park.

[31] "Proposed Public Works Projects by Superintendent Edward G. Wingate," submitted to the Director, Office of National Parks, Buildings, Reservations, Washington, DC, February 3, 1934 in Folder 618, Box No. 1178, RG 79, NARA-College Park.

[32] Letter from Edward G. Wingate, Superintendent, to Director, National Park Service, Washington, DC, January 17, 1935 in Folder 618, Box 1178, RG 79, NARA-College Park.

with individual park structures, ranging in size from 1,470 to 5,300 gallons, the reservoir, and high tank (indicated as having a 4,500-gallon capacity). Proposed improvements to the system included a reservoir addition, as well as a 6" main of galvanized iron. The main would run west from the reservoir to the park headquarters and continue to the Volcano House hotel where it would form a loop around the hotel. Spurs would service buildings without individual tanks as well as proposed fire hydrants. The high tank, located to the southwest of the Utility Area closer to the Kilauea Crater rim was connected to the main distribution line by a 6" pipe, and there were plans to replace it with a 25,000-gallon tank. As more buildings were constructed in the area from 1937-41, the line was tapped into at additional points.[33]

The park's plans for increasing the system's capacity were not implemented. Despite the concerns of the park, the requested additional reservoir was not constructed. In 1938, a 10,000-gallon tank was erected next to the 5,000-gallon high tank using Public Works Administration (PWA) funds. Additional storage was also provided from 1939-44 with the erection of four 5,000-gallon tanks behind the repair shop and two 10,000-gallon tanks next to the wood shed in the Utility Area that could drain into the reservoir.[34]

With no substantial improvements being made to the water collection system and increasing development within the park, it was not long before there were renewed concerns about storage capacities. These concerns were fueled by another period of protracted drought in the early 1940s. By 1943, there were only 180,000 gallons of water available for use but still no expansion had been approved. In September 1946, Superintendent Frank Oberhansley attempted to ameliorate the critical situation by tying the former system used by the Civilian Conservation Camp (CCC) with the park's reservoir using 3,000' of 2 ½" pipe he obtained as surplus from the Naval Air Station in Hilo. The CCC's system, dating to ca. 1938, consisted of sixteen 10,000-gallon wood water tanks connected to a 2 ½" manifold suction line and pump. The water was delivered via a 2 ½" discharge line to a smaller grouping of tanks located above the camp. Total capacity at the camp was 40,000 gallons.[35]

Even more attention was focused on the water situation after the December 1946 collapse of a 400,000-gallon wood storage tank owned by the Volcano House Hotel. The event spurred the park to inspect its own collection of wood tanks, leading to the discovery that half of the tanks were in danger of collapse "due to decaying

[33] U.S. Department of the Interior, National Park Service, Hawaii National Park, Headquarters Area, "Map Showing Existing & Proposed Water Lines, To Accompany Report by W.E. Robertson, Assoc. Eng., Office of the Chief Engineer, San Francisco, CA," October 1937; U.S. Department of the Interior, National Park Service, Branch of Engineering, Prepared by Regional Office, "Proposed Location Plan for Water System Improvement, Headquarters Area, Hawaii National Park," 1938; Final Report, "Rehabilitation of Water System Kilauea Section Headquarters Area," September 1, 1948, p. 6, in Folder 660-05, Box 785, RG 79, NARA-College Park.
[34] Final Report, "Rehabilitation of Water System Kilauea Section Headquarters Area," pp. 3-4.
[35] Final Report, "Rehabilitation of Water System Kilauea Section Headquarters Area," pp. 4-5; Jackson, pp. 156-157.

supports." In addition, almost all of the tanks lacked a protective covering to keep rodents, birds and debris from entering them.[36] Superintendent Oberhansley requested emergency funding from the NPS Region Four office to build concrete storage reservoirs as replacements to the numerous aging tanks then in use, stating that the reservoirs would "dispose of the entire mess of assorted unsightly tanks of ancient vintage now dotting the landscape adjacent to park headquarters."[37] The proposal generated discussion between the regional office and the park. O.A. Tomlinson, the Regional Director, voiced concerns about building reservoirs, noting the head would not be "sufficient" and that they would be prone to earthquake damage. He recommended instead that the park purchase a new or salvaged tank to replace the collapsed one. Oberhansley pressed the point, stating that the Army and Navy had been building 500,000-gallon reinforced concrete tanks on the island since 1941. Furthermore, he argued, the reservoir would sit on a sand base, not bedrock as conventional design dictated. He concluded, "We cannot recommend too strongly against temporizing with wood tanks as such things have a vicious way of becoming more or less permanent. Wood tanks of this capacity are as obsolete as the horse and buggy." Despite the park's persuasive arguments, the Acting Director of the National Park Service, Hillory A. Tolson, firmly relayed to the Region Four office that no reservoir at the park would be funded due to questions about the estimate (deemed too low) and a lack of funding. Tolson also questioned the ethics of the federal government spending federal funds to repair a system owned and operated by a concessioner.[38]

The park assumed authority over the Volcano House hotel's water system after the tank collapsed and lowered its water rates to 3 cents/gallon as a courtesy to the hotel. With the takeover complete, the park moved its main collection system to the headquarters area.[39] With the question of reservoir or tank construction definitively settled in favor of tanks, park personnel searched for surplus tanks to purchase to boost the park's storage capacity. Superintendent Oberhansley reported to the NPS Regional Director in 1947 that he thought he could obtain six to eight 50,000-gallon tanks from the Wartime Assets Administration (WAA) or Army-Navy surplus, to which Acting Director Hillory Tolson wrote in the margin of the memo: "Whole area littered with tanks!"[40] The park's expansion plans involved moving the concessioner's tanks behind the rain shed so they would not be visible; installing a gravity feed system, and extending the rain shed to create additional storage space

[36] Superintendent Monthly Report, December 1946, p. 3.
[37] Memo from Frank Oberhansley, Superintendent, to Regional Director, Region Four, December 19, 1946, in File No. 660-05, Box 1180, RG 79, NARA-College Park. This quote also appears in Jackson, p. 157.
[38] Memo from O.A. Tomlinson, Regional Director, to Superintendent, December 23, 1946; Memo from Oberhansley to Regional Director, Region Four, December 30, 1946; Memo from Hillory A. Tolson, Acting Director, to Regional Director, Region Four, January 16, 1947, all in File No. 660-05, Box 1180, RG 79, NARA-College Park.
[39] Jackson states that the takeover of the Volcano House tanks resulted in capacities of 1,650,000 gallons at the shed, 360,000 in the utility area, and 200,000 in the CCC area, for a total of 2,120,000 gallons (p. 160).
[40] Memo from Frank Oberhansley, Superintendent, to Regional Director, Region Four, July 8, 1947, in File No. 660-05, Box 1180, RG 79, NARA-College Park.

and surface area. The park estimated these alterations would result in 165 million gallons of storage capacity. [41]

The park was able to obtain twelve surplus 100,000-gallon redwood tanks from the WAA, reportedly from Fort Armstrong in Honolulu, in January 1947. They were purchased for $1,920 apiece under Public Law 478 using a $10,600 allocation. Originally, the park planned to place nine of the tanks under the concessioner's rain shed. Of the remaining three, one would be erected at the former CCC camp, and two would be installed at the Utility Area next to the concrete reservoir. Park Superintendent Oberhansley was hopeful that the acquisition of these tanks would facilitate the removal of the "eye sores on tank hill."[42] Unfortunately, the tanks had been in storage for five years and had consequently sustained termite and borer bee damage as well as dry rot, so only eight of the twelve were usable. The park consequently changed its installation plans.[43]

By May 1947, two of the eight surplus tanks had been erected and fitted at the Utility Area. That same month, the park borrowed Army equipment to excavate a 40' wide x 220' long strip along the northwest side of the old rain shed where the remaining six surplus tanks were to be grouped in a battery.[44] Throughout the summer and fall of 1947, work continued on erecting the redwood tanks, which sat on concrete foundations. Photographs depicting the construction show the area was first excavated and then graded. Circular wood forms were next laid out and a reinforced mesh was placed within the formwork. The concrete was poured into the form. A wood frame foundation on which the tank would sit was then constructed on the concrete pad. The wood staves forming the tank were erected and kept in place by bands tightened using an air-driven wrench. The use of the wrench was found to save "approximately 8 ½ man days in erection of one tank." The tanks were in place next to the rain shed by October 1947. One of the redwood tanks sits on a stone foundation; the monthly reports do not indicate the reason for this different foundation.[45]

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[41] Memo from Frank Oberhansley, Superintendent, to Regional Director, Region Four, August 19, 1947, in File No. 660-05, Box 1180, RG 79, NARA-College Park.

[42] Memo from Frank Oberhansley, Superintendent, to Regional Director, Region Four, January 31, 1947, in File No. 660-05, Box 1180, RG 79, NARA-College Park; Jackson, p. 157; Superintendent Monthly Report, February 1947, p. 1.

[43] Superintendent Monthly Reports, February 1947, p. 1; April 1947, p. 3; May 1947, pp. 3, 5; Monthly Report of Assistant to Superintendent and Acting Park Engineer B.F. Moomaw for March 1947 in Superintendent Monthly Report, March 1947; Jackson, pp. 157-158.

[44] Superintendent Monthly Report, May 1947, pp. 3, 5.

[45] Superintendent Monthly Reports, June 1947, p. 3; July 1947, p. 3; September 1947, p. 2; October 1947, p. 1. Photographs available in the HAVO Archives show the construction, see Photos D50, 060 through 071, identification caption: "Construction of water system-rainshed area, F.R. Oberhansley, 1940s or 50s"; Photos D50 148 and 149, identification caption: "Water system improvement, year unknown, circa 1947"; and Photos D50 150 and 151, identification caption: "Erection of 8 new 100,000 gal. tanks was completed, October 1947."

The installation of the tanks behind the rain shed necessitated alterations to its roof to bring it in line with the tops of the tanks. The rain shed's eaves were raised by hoisting the trusses so a 27' auxiliary rafter could be inserted. The east side of the roof was raised from May to June 1947, and the west side was completed during a "Hukipau" the weekend of November 8-9, 1947 to avoid a forecasted rainstorm. A Quick-Way crane was used for the job. Water collected from the roof of the rain shed drained into the collection tanks via a "transverse flume alongside the center truss of the shed." Water from the northeast side drained into the first three tanks, while water from the southwest side drained into the other three. The rain shed contained a "large storage room and equipment storage stalls" that created "much needed shelter and security for supplies and equipment."[46]

The installation of tanks and new mains (including a 6" main connecting the pump house at the Utility Area with a main to the Volcano Observatory, a 6" main from the pump house to the new tanks, and a 6" cast iron pipe from the CCC camp to the Volcano House) required a new pump. The park obtained it from the Navy. The new pump was "coupled directly to the 500 GPM 289' head pump from the Volcano House system" and powered by a "Blue Streak" 110 hp engine.[47] By November 1947, the final connections had been made to six of the new 100,000-gallon tanks and pumping tests were completed. Park personnel discovered that the "pump developed an average discharge into these tanks in excess of 12,000 gallons per hour with a gasoline consumption of about 6 gallons per hour." The park's old pump was rebuilt and repowered with a new 55-hp Waukesha engine. Testing determined it could discharge 6,750 gallons per hour at 1,200 rpm.[48]

The completed updates to the collection system ultimately included the alteration of the Volcano House hotel's former rain shed, erection of additional water tanks and the moving and dismantling of others, and installation of a new pump and water mains. As reported in the September 1948 final report of the project, the rehabilitation cost $14,596.86.[49]

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[46] Final Report, "Rehabilitation of Water System Kilauea Section Headquarters Area," pp. 24-25; Superintendent Monthly Reports, May 1947, p. 3; June 1947, p. 3; November 1947, photograph caption; Memorandum for the Superintendent, Subject: Narrative Report for November 1947, Assistant to Superintendent and Acting Resident Engineer Moomaw, December 9, 1947, in Superintendent Monthly Report, November 1947. The photograph caption from the November 1947 Monthly Report states that the "existing shed area measures 108 ft. x 114 ft.," which differs from other available measurements of the original rain shed that give the dimensions as 110' x 182'.

[47] Superintendent Monthly Reports, June 1947, p. 3; July 1947, p. 3; Memorandum for the Superintendent, Subject: Narrative Report for August 1947 of Assistant to Superintendent and Acting Park Engineer Benjamin F. Moomaw, in Superintendent Monthly Report, August 1947; Final Report, "Rehabilitation of Water System Kilauea Section Headquarters Area," p. 7.

[48] Superintendent Monthly Report, August 1947; Memorandum from the Superintendent, Subject: Narrative Report for November 1947, of Assistant to Superintendent and Acting Resident Engineer Moomaw, December 9, 1947, in Superintendent Monthly Report, November 1947.

[49] Final Report, "Rehabilitation of Water System Kilauea Section Headquarters Area," p. 1.

These additions to the water system alleviated the immediate issue of sufficient water storage after the collapse of the Volcano House Hotel's tank. The park realized an updated, modern system needed to be put in place rather than the piecemeal, geographically disparate collection of tanks, pipelines, and associated structures then being utilized. A report on the water situation at the park issued in August 1947 by Regional Engineer Crawley encapsulates the park's strategy for administering its water resources. According to Frances Jackson's administrative history of the park, Crawley "pointed out that wooden tanks were not decorative but they were the safest, as pipes and reservoirs in earthquake areas were subject to damage." He recommended building additional water collection and storage facilities, noting that water sheds did not need to be "unsightly" or even painted red as had been done at Kilauea. He also suggested expending resources on finding a new source of water.[50] The NPS and the park explored potential sources of water other than simply collecting rainwater, including purchasing water from the Olaa Sugar Company, Ltd. The company had a reservoir at Mountain View, approximately 10 to 12 miles northwest from the park, and they were already supplying water to the Kilauea Military Camp for 3 cents a gallon. Another potential source was the Hawaiian Agricultural Company. Investigations were also made into tapping sources of groundwater within the park. Park personnel looked into "rumored springs and streams that might supply the Park" but turned up no potential sources.[51] The park instead chose to forge ahead with the expansion of its collection system as recommended by Crawley.

In 1949, the park embarked upon a water system project with multiple components: Project U-25, Rainshed Extension; Project U-26, Reconstruction of Water Tanks (also referred to Water Storage Tank Reconstruction); and Project U-27, Water Mains Reconstruction. Much of the materials were obtained from Army surplus.[52]

In November 1949, work began on a 160' extension project (Project U-25, Rainshed Extension) to the old rain shed. The project had originally been approved in the spring of 1949 but stalled due to inclement weather.[53] Once begun, work progressed rapidly in December 1949 and January 1950, with a 90 percent completion estimate given in the superintendent's monthly report for January. The February 1950 Superintendent Monthly Report states: "the roof of the old part of the rain shed was raised to bring it in line with the elevation of the extension."[54] Why it was necessary to raise the roof when it had been altered only a few years earlier and what the work involved is unknown. Costs were minimized by using salvaged materials from elsewhere in the park. For example, park personnel demolished a storage building at the former CCC camp and salvaged iron to use as the roofing material on the rain

[50] Jackson, p. 159.
[51] See Memo from Hillory Tolson, Acting Director, to Regional Director, Region Four, June 9, 1947, in File No. 660-05, Box 1180, RG 79, NARA-College Park; Jackson, p. 158.
[52] Superintendent Monthly Report, October 1949, p. 2.
[53] Superintendent Monthly Reports, November 1949, p. 3; December 1949, p. 2.
[54] Superintendent Monthly Report, February 1950, p. 3.

shed extension. By March 1950, the construction of the roof was complete, as was the painting (see Figure 2). A completion report notes: "salvaged material for additional extension (16'). Completed additional extension. Total length completed 176'. Entire length of rainshed to be painted." The suggestion in the completion report of an "additional extension" seems to indicate that the plans were changed. This may explain why in April 1950, the project was noted as only 80 percent complete when in January it had been at 90 percent. It was estimated that the extension and resulting increase of roof surface would allow the collection of 2,344,896 gallons a year, based on the "water collection formula of 59 gallons per square foot of shed per year."[55] Further work was undertaken on the building in July, when a windbreak was added at the northeast side of the building "to eliminate the possibility of damage to the building in the event of a severe windstorm and to provide better protection to the heavy equipment" stored within the building. Salvaged materials, this time from a dismantled barracks at the former CCC camp, were used in this project as well.[56]

Park personnel made minor repairs and alterations to the building in the 1950s, including riveting and soldering metal gutters, increasing the size of the downspouts, and installing side collection gutters onto 2" x 8" sills that were "slung below the rafter and joist" in 1954. The following year, the superintendent's monthly report noted the windward side of the building had been fully covered.[57]

Project U-26, Relocation of Water Tanks (also referred to as the Water Storage Tank Reconstruction Project) began on September 19, 1949. The work involved removing some of the numerous tanks operated by the Volcano House in the location of the former hotel and rain shed, an area known as "Tank Hill." The hotel's system as it existed at the time of the takeover included several redwood tanks that were more than thirty years old: one 400,000-gallon redwood tank, three 80,000-gallon redwood tanks, and three 50,000-gallon redwood tanks. There were also two 100,000-gallon tanks dating to 1944 and ten 5,000- to 10,000-gallon tanks of various ages. No specific information has been found detailing the plan to dismantle the tanks and the proposed layout of the relocated tanks. One source states that of the hotel's tanks, the park kept the 100,000-gallon, 80,000-gallon, and 50,000-gallon sizes. Eight of the smaller 5,000- to 10,000-gallon tanks were dismantled and rebuilt on "Tank Hill."[58] The superintendent monthly reports note that four tanks were removed from "Tank Hill" to the "approved site at the rainshed." A photograph in the October 1949 monthly report shows the removal of the tanks from Tank Hill and notes that one 100,000-gallon tank, three 80,000-gallon tanks, one 50,000-gallon tank, and two 10,000-gallon tanks were slated to be dismantled. Some of the tanks were in poor

[55] Superintendent Monthly Reports, January 1950, p. 3; February 1950, p. 3; March 1950, p. 3; April 1950, p. 4; National Park Service, Monthly Progress Report on Physical Improvement in March 1950 Superintendent Monthly Report.
[56] Superintendent Monthly Reports, July 1950, p. 4; August 1950, photograph accompanying report.
[57] Form 16-54522-2, Building 43. A handwritten note details the February 1954 completion report and work.
[58] Final Report, "Rehabilitation of Water System Kilauea Section Headquarters Area," pp. 11-12; Jackson, p. 160.

condition, as evidenced by a photograph depicting decaying chime joists in one tank that had been built over a steam vent.[59] In addition to adding some of the Volcano House hotel's former tanks to the system, the park also incorporated the 10,000-gallon tanks formerly in use at the CCC camp. In January and February of 1950 eleven tanks were moved from the CCC camp and installed under the rain shed at the headquarters area.[60] By 1953, there were fourteen tanks located under the rain shed with one outside the southwest corner. To the rear of the rain shed and shielded from visitor's eyes was a collection of fourteen redwood tanks grouped in two rows, with plans to locate an additional six tanks at the end of the battery (see Figures 3 and 4).[61]

The final component of the project was Project U-27, Water Mains Reconstruction, which is outside the scope of this project. It consisted of connecting the 10,000-gallon tanks at the rain shed to the main collection line, as well as to the system in place at the Utility Area. The project extended the collection line through the headquarters area, park residential area, and Volcano House hotel, ultimately connecting the two collection systems. In addition, a chlorinator was installed on the main.[62]

Despite the work undertaken on the system, it was found to still be inadequate after a drought hit the park in 1952. The surplus redwood tanks required maintenance because of leakage problems. One of the 50,000-gallon tanks had rotted.[63] An earthquake on March 27, 1955, further damaged the system, including two of the 100,000-gallon tanks. The water lines were also broken at six locations, which alerted park officials to larger problems with the distribution system. The lines had become so corroded or clogged with organic matter that the interior diameter of the pipes had been greatly reduced, in some cases a ¾" pipe had been reduced to ¼".[64] The superintendent noted in his monthly report, "it is evident that revision of our water system is in order and a special memorandum will be written on that subject."[65] In May, F. Woo, an engineer with the Territory, came to the park to examine its system after a series of monthly water tests by the Public Health Service of the Territory yielded poor results. After determining that "the entire system needs revamping," he made recommendations regarding the filtering of water and

[59] Superintendent Monthly Reports, September 1949, p. 3; October 1949, p. 2 and photographs accompanying report.
[60] Superintendent Monthly Reports, January 1950, p. 3; February 1950, p. 3.
[61] "Water Collection and Sewer System," and "Water Distribution: Kilauea Headquarters," March 1953, Sheets 1 and 2.
[62] Superintendent Monthly Reports, February 1950, p. 3; March 1950, p. 2; September 1950, p. 4; October 1950, p. 2; November 1950, p. 3; National Park Service Monthly Progress Report on Physical Improvements, March 1950, in Superintendent Monthly Report, March 1950.
[63] Jackson, pp. 160-161.
[64] Superintendent Monthly Report, March 1955, p. 3; Memorandum to the Superintendent from the Park Engineer, Subject: Monthly Report for June 1955, in Superintendent Monthly Report, June 1955.
[65] Superintendent Monthly Report, March 1955, p. 3. Damage included a 6" main of cast iron pipe being pulled apart at its joints, two 4" galvanized iron collection lines being pulled apart at the joints, and 2 ½" and 1" galvanized iron pipes being pulled apart at the joints.

improving the collection system. He also suggested constructing a new rain shed to take the place of the current practice of using individual building roofs to collect water, which he noted "contribute by far the greatest amount of leaves and other foreign matter."[66] The following month, Z.D. Harrison of the Public Health Service's San Francisco office, as well as engineers from the Territorial Public Health Service made another visit. The park's engineer detailed the group's recommendations.

> For Kilauea it was recommended that the entire water system, collection and distribution pipe lines and all piping in the houses are to be replaced as quickly as possible as corrosion and sedimentation have reduced the available waterway in the lines by as much as 60%. In addition an excessive amount of chlorine is necessary to produce even a trace of residual halfway down the system. Increasing amounts of chlorine are being tried in an attempt to get residual chlorine at the lower end of the line, but with indifferent results, which indicate an excessive amount of vegetable matter in the pipes caused by leaves in the collection system or by bacteria.[67]

There was interest in using plastic pipe to replace the system's collection of iron pipes as it was thought that plastic would better withstand earthquake damage and be easier to replace.[68]

The park embarked upon a comprehensive improvement project from August 1955 to December 1958 after Superintendent John B. Wosky's pleas for an updated system were heard. The construction centered at the headquarters area, where a new rain shed and steel tanks with a 500,000-gallon capacity were built, as well as a 23,500-gallon filter tank. The water mains were also serviced. In addition, a centrifugal pump and raw chlorinator were installed in the Utility Area. When complete, the new system consisted of the original structures (the old rain shed and fourteen redwood tanks with concrete bottoms for raw water storage as well as a wood tank for treated water system) with the addition of a new rain shed, conduit system connecting tanks, a sand filter tank, pump house, and four steel 500,000-gallon tanks for treated and chlorinated water storage.[69]

The redwood tanks, which served as raw water storage tanks, were rehabilitated over a period of two years, a project completed in February 1957. Water Storage Tank No. 30 in the Utility Area was the first to be rebuilt. It was dismantled, and a new concrete base poured. The ready-mix concrete came from Hilo in mixer trucks, which provided 26 yards of concrete. The park supplied an additional 2 yards with its

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[66] Memorandum to the Superintendent from the Park Engineer, Subject: Monthly Report for May 1955, in Superintendent Monthly Report, May 1955.
[67] Memorandum to the Superintendent from the Park Engineer, Subject: Monthly Report for June 1955, in Superintendent Monthly Report, June 1955.
[68] Memorandum, Subject: Monthly Report for June 1955.
[69] Jackson, p. 162; Superintendent Monthly Report, January 1955, p. 3.

own mixer. The specifications originally called for an 18"-thick base, but a 10" base was poured instead with the justification that "since the concrete base on which the original mudsills and chime joists were laid is 6 inches thick, it is estimated that 10 inches of new concrete will be adequate." Originally the tanks rested on chime joists, but the new design called for building a wood ring that would sit on top of the concrete base with the staves leaning against it. Petrolastic cement was used as a sealant. The park engineer noted the "wooden ring around the bottom of tank fitted very well and the staves and hoops went up as though the floor was all wood."[70] After the completion of Tank No. 30, Tank No. 8 at the headquarters area was taken apart for inspection, and the crew found its condition very similar to that of No. 30. The monthly report stated the "center 10 feet of the foundation chime joists were rotten and had let the wooden bottom sag."[71] After Tank No. 8 was completed in April 1955, Tank No. 10 was repaired. The park engineer noted "this is the third tank of 10,000-gallon capacity to be torn down, a concrete bottom poured, and the staves and roof reassembled."[72] By January 1957, the project was 80 percent complete with eleven tanks rehabilitated and three more under construction.[73] The work "mothered the invention of a device for tightening tank straps which won its inventor an award."[74] Additional pipes and valves were installed on these raw water storage tanks in August 1958 so that they could be individually cleaned and operated.[75]

In 1957, the sites of the new rain shed and 500,000-gallon tanks were surveyed and plans developed for the installation and layout of pipes, taking into account the topography and integrating the existing structures. The proposed layout allowed the "gravity flow of untreated water from rehabilitated wood tanks to filter. Water will then be pumped through a chlorinator and into 500,000-gallon steel storage tanks."[76]

Bids were next solicited for the construction of two 500,000-gallon steel tanks and one 23,500-gallon steel filter tank in February 1957. Five bids were received, with the low bidder, Terminal Steel Company Ltd. of Honolulu, winning the contract.[77]

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[70] Superintendent Monthly Reports, January 1955, p 3; February 1955, p. 3; March 1955, p. 3; Memorandum to the Superintendent from the Park Engineer, Subject: February 1955 Monthly Report, March 7, 1955 in Superintendent Monthly Report, February 1955.

[71] Superintendent Monthly Reports, March 1955, p. 3; April 1955, p. 3.

[72] Memorandum to the Superintendent from the Park Engineer, Subject: Monthly Report for May 1955, in Superintendent Monthly Report, May 1955.

[73] Superintendent Monthly Report, January 1957, p. 2. A number of photographs document the deterioration and reconstruction of the tanks. See Photos D50 208 and 209 for damage, showing the rotting support members of the foundation, identification caption: "Water tank repair, G.D. Smith, May 1955." Photos D50 264 through 267 show the dismantling of tanks, identification caption: "Water tanks and sheds, 40s or 50s." Finally photos D50 228 through 231, identification caption: "Building water tanks, D.H. Black, 1956" and photos D50 252 through 259, identification caption: "Pouring cement floor for water storage tank at rainshed, Kilauea section, Donald M. Black, October 29, 1956" depict the reconstruction process. All photos in HAVO archives.

[74] Jackson, p. 161.

[75] Superintendent Monthly Report, August 1958, p. 9.

[76] Superintendent Monthly Reports, February 1957, p. 10; March 1957, p. 11.

[77] Their bid was for $54,096 and won them Contract No. 14-10-418-14. Superintendent Monthly Reports, February 1957, p. 10; March 1957, p. 2.

The contract to construct a third storage tank was opened for bidding on April 26, 1957, and it was also awarded to Terminal Steel Company, Ltd., who had the lowest bid of $25,915.[78] Construction and fitting of the tanks (known as Tanks No. 2, 3, and 4 for the 500,000-gallon capacity tanks and Slow Sand Filter 1 for the filter tank) took place in the summer of 1957. They were in service by November.

The tanks were built on solid rock between the old rain shed and the proposed new one. The bases for the 500,000-gallon tanks consisted of a concrete retaining ring measuring 8" thick and 30" high. The interior of the ring base was filled to a height of 24" with crushed aa lava or gravel. The base required 14 yards of concrete and 350 yards of rock backfill, which was hauled by truck a distance of 12 miles. A 4"-thick sand pad finished the base. The filter tank base measured 8" thick, 22" high and had an interior diameter of 22". The bases were finished with a sloping layer of hot mix to promote drainage. By May, the bases of the rings had been completed so installation of the tanks could begin.[79] The pipes and fittings for the tanks were ordered from the Grinnell Company through the General Services Administration.[80] Tank Nos. 2, 3, and 4 were in service by November 1957 and served as supply tanks.[81]

In May 1958, bids were opened for construction of a fourth 500,000-gallon steel tank, known as Tank No. 1, and seven were received. Pittsburg-Des Moines Steel Company of Santa Clara, California, had the low bid of $26,533 and was awarded the contract to build the tank in June.[82] A temporary park crew of four was employed in constructing the tank's foundation, which was similar to those already built. The center of the fourth tank was moved an extra 12" to allow for more clearance of the connection from the outlet to the existing 6" supply line, a modification made by the Contracting Officer. By November 1958, the foundation of Tank No. 1 had been

[78] Kilauea Construction Company of Hilo bid $28,400, and Pittsburg-Des Moines of Santa Clara bid $31,900. Superintendent Monthly Report, April 1957, p. 10.

[79] Superintendent Monthly Reports, March 1957, p. 11 and photographs accompanying report; April 1957, p. 10 and photographs accompanying report; September 1957, p. 10; Memorandum to Assistant Superintendent from Supervisor, Construction and Maintenance, Subject: Report for Month of March 1957, in Superintendent Monthly Report, March 1957. Photographs documenting the construction of the bases include D50 092 through 097, identification caption: "Building of the forms for the base of the first of D50 39 program. These steel tanks will hold 500,000 gal. ea. J.C. Raftery, February1957"; D50 132 though 138, identification caption: "Water system improvements, year unknown circa 1957"; D50 085, identification caption: "Filter tank, Donald M. Black, October 14, 1957"; photo D50 198, identification caption: "Construction tank, J.A. Stites, July 1957"; photos D50 231 though 234, identification caption: "Utilities construction project, new water tank and filter pump set up. D.M. Black, February 1957." All in HAVO Archives.

[80] Superintendent Monthly Report, May 1957, p. 12.

[81] By June, Tank Nos. 1 and 2 had been almost finished (Superintendent Monthly Report, p. 10). By July, the tanks were all ready for cleaning, painting, sterilizing (Superintendent Monthly Report, p. 10). See also Superintendent Monthly Report, November 1957, p. 1. Additional photographs showing wall construction of the tanks include D50 238, identification caption: "J.A. Stites, 1957-59," in HAVO Archives.

[82] Superintendent Monthly Reports, May 1958, p. 11; June 1958, p. 9. Other bidders were Terminal Steel Company at $28,895; Graver Tank and Mfg. Co., Inc. at $32,138; Chicago Bridge and Iron Company at $34,575; Hawaii Welding Company at $39,358; Central Pacific Dollar Works, Ltd. at $42,900; and Hawaii Dredging and Construction Co. Ltd. at $59,449.80 (from May 1958 report, p. 11).

nearly completed. At this tank, the base was sealed with a pre-mix of gravel and bitumuls, and a surface coat was applied of pre-mixed sand and bitumuls. This surface coat was also applied to the bases of Tank Nos. 2, 3, and 4. The construction of Tank No. 1 was delayed until September 1958 when materials finally arrived and the walls and roof could be erected. The joints were welded, and then the entire tank was painted. During shipment and construction, the prime (shop) coat of paint had been damaged. The interior and exterior surfaces of the tank were to be primed before the finish coat was applied. An inspection of the tank's interior the following month revealed unsatisfactory conditions.[83] Mr. Stanley I. Hara, a factory representative of the Themec Paint Company, came to the park to inspect the tanks, as did representatives of Honolulu Painting Company, who had been subcontracted by Terminal Steel Company to do the painting. The superintendent reported that "the unsatisfactory condition of the prime paint, applied as a shop coat, required extensive cleaning of rust and patch painting of the scratched and scraped areas." An additional coat of primer on the interior and exterior of the tanks had to be applied.[84]

There were a number of problems with the paint used on the tanks in the late 1950s and 1960. Curtis Richey, Senior Sanitary Engineer of the Department of Health, Education and Welfare, inspected Tank No. 4 in 1958 and found a "flakey crust which crumbled into small particles at a touch," indicating proper bonding between the prime and finish coats had not occurred. In still other sections, the bond was fine but rust protrusions could be seen bulging underneath the finish coat. The columns and beams comprising the internal framework of the tank were also rusting.[85] In February 1959, Tank No. 3 was found to have the same problems with its paint as Tank No. 4.[86] The park repainted the badly rusted steel roof plates of the water storage tanks and filter tank with aluminum roof paint the following month.[87] Tank Nos. 2 and 4 were sandblasted to the bare metal, and then repainted with "Inertol Primer No. 626" and sealed with two coats of "Inertol Thick Sealer No. 95" applied

[83] Superintendent Monthly Reports, May 1958, pp. 11-12; September 1958, p. 10; October 1958, pp. 8, 11; November 1958, p. 2 and Memorandum from Park Engineer to Superintendent, Subject: Engineering Report for November 1958, December 3, 1958, p. 4. A number of photographs exist documenting the construction of Tank 1. See D50 028, identification caption: "Concrete retaining ring of tank #1, placing concrete in forms, May 1958"; D50 029, identification caption: "Concrete retaining ring of tank #1, starting placement of pre-mixed concrete in forms"; D 50 030, identification caption: "Foundation for water tank #1, setting forms to grade, erecting forms for concrete ring, May 1958"; D50 031, identification caption: "Clearing brush and small trees before resloping high cut bank in preparation of widening service road," all by J.A. Stites, June 1, 1958. Once the retaining ring had been poured, backfilling took place, see photo D50 032, identification caption: "Completed concrete ring for tank #1 before backfill, June 1958"; D50 033, identification caption: "Site of steel tank #1, erecting forms to grade for concrete retaining ring of foundation. Stockpile of backfill materials in center of tanks. May 1958"; and D50 034, identification caption: "Starting to widen service road along tank #1 before reshaping of high cut bank, June 1958," all in HAVO Archives. Painting of the completed tank can be seen in photo D50 158, identification caption: "Painting exterior of steel tank #1. Re priming of steel plates after welding of joints, and touch-up of scuffed and scratched areas before applying finish coat." All in HAVO Archives.
[84] Superintendent Monthly Report, August 1957, p. 10.
[85] Superintendent Monthly Report, December 1958, p. 11.
[86] Superintendent Monthly Report, February 1959, p. 8.
[87] Superintendent Monthly Report, March 1959, p. 9.

with a spray gun in the summer of 1960 by Modern Painting Company. A total of 84 gallons of primer and 260 gallons of sealer were used at a cost of $11,980.[88] Testing revealed that repainting the tanks negatively impacted the quality of water stored within them. Samples were sent to Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio, in an effort to determine the cause of the odor and flavor problems through a complete chemical analysis.[89]

The steel water tanks were outfitted with 4" drains in early 1959. A cross-connection "protected by a check-valve and gate valves" was made to the raw water storage system to "facilitate the interchange and recirculation of water." An automatic control system was installed to regulate the pumping of treated water into the steel storage tanks. The projects were completed in March 1959.[90]

The 23,500-gallon steel filter tank (Slow Sand Filter 1) connected to the raw water collection and settlement wood tanks by a 4" gravity supply line. At the bottom of the filter tank was a prefabricated pipe grid collection system. The filter tank contained sand (obtained from Oahu) and gravel, through which the raw water trickled. Park personnel used a motor crane with a clam bucket to move the sand into the tank. The tank's movable roof facilitated the process.[91] By May 1958, the flow of water though the filter had decreased "to the point of insufficient supply for maximum pumping operation." Once park personnel inspected the filter, the cause of the decreased flow became apparent. A thick layer of sediment had been deposited on the sand, indicating the filter had probably not been backwashed at regular intervals. Once ¼" to ½" of the top layer of the sand had been removed and backwashing completed, the filter's operation became much more efficient.[92]

The filter tank was connected to a new pump house, under construction in spring 1957. The base of the structure was 10' x 12' with a 6"-thick floor. The building was sided in corrugated metal and had a shed roof.[93] The pump house contained the electric water pump, chlorination unit, and electric control system.[94] A sand trap was located at the pipe connection between the filter tank and pump house. A photograph caption in the November 1957 monthly report detailed how it operated.

> By a proper placement of the two vertical baffle plates, velocity of the incoming water is reduced to a minimum, thus allowing deposit of any sand that may be moved from the filter tank. The sand trap is fitted with a water-tight cover over which is an air valve to bleed off trapped air. The

[88] Superintendent Monthly Reports, June 1960, p. 9; July 1960, p. 8.
[89] Superintendent Monthly Report, March 1963, p. 4.
[90] Superintendent Monthly Reports, January 1959, pp. 12-13, 16; March 1959, p. 11.
[91] Superintendent Monthly Report, November 1957, pp. 12-13.
[92] Superintendent Monthly Report, May 1958, p. 8.
[93] Superintendent Monthly Report, April 1957, p. 2. For photographs of its construction, see D50 240 identification caption: construction of pumphouse/filter tank, J.A. Stites, 1957-59; photograph D50 085, identification caption: filter tank, Donald Black, October 14, 1957; D50 139, ca. 1957; D50 160 and 161, no date, all in HAVO Archives.
[94] Superintendent Monthly Report, November 1957, p. 13.

> drain hole in the bottom of the box is so piped that any sand may be easily flushed out the drain line while the pumping operation is continued.[95]

Between the pump house and the inlets of the newly constructed 500,000-gallon steel storage tanks, crews laid a 2" pipeline in fall 1957. Water mains were also laid to connect the 500,000-gallon steel tanks with the distribution system. This work would "make a suitable cross-connection to the existing supply lines and replace old pipe lines that now supply water to the main feed tank and chlorination unit."[96] The mains connecting the steel tanks to the distribution system were laid above ground on concrete piers and "a valved cross connection was made to the service lines of the existing wood storage tanks with a continuation of piping to provide a direct flow to the present main feed tanks and chlorination unit." The layout allowed the water in the storage tanks to be directly pumped into the distribution system, "without using the inter-pipe system of the wooden storage tanks."[97] By December 1957, the work had been nearly completed.[98]

In addition to tank and pipeline construction, park personnel dismantled two of the 10,000-gallon wood water tanks housed under the old rain shed in June 1958. The materials for one of the tanks were saved, and it was rebuilt in another, unspecified, location. The remaining nine tanks (seven 10,000 gallon and two 50,000 gallon) housed under the old rain shed were drained and dismantled the following month to be sold as surplus. The removal of the tanks necessitated alterations to the rain shed since the two 50,000-gallon tanks had supported the framework. In their place, wood support columns were built and additional bracing was put in place.[99] The building had already been altered after a cyclone in September 1955 caused extensive damage. The park's Supervisor of Construction and Maintenance described the situation.

> Painting was started on the Rainshed roof and about one third complete when a whirlwind suddenly came up and ripped a section of the roof completely off damaging the frame work and water collection system. Temporary repairs were made but the entire structure is very weak. Emergency funds was [sic] provided and the lumber purchased to

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[95] See Photos D50 082 though 084, identification caption: "Utilities water system, sand trap between filter tank and pumphouse, J.A. Stites, 1957," and photos D50 160 and 161, identification caption: "View of the 23,500 gallon sand filter tank, and the shelter for pumping and chlorinator units. The 4" gravity supply line, shown at lower right and at tank from the wood collection and settlement tanks is controlled by the external valve and a float valve within the filter. The overflow line, indicator board for water level and [illegible] and connection to sand trap and drain are shown between the [illegible] and shelter." All in HAVO Archives. Superintendent Monthly Report, November 1957, photograph caption accompanying monthly report.

[96] Superintendent Monthly Report, October 1957, pp. 12-13.

[97] Superintendent Monthly Report, November 1957, pp. 12-13.

[98] Superintendent Monthly Report, December 1957, p. 11.

[99] Memorandum from Park Engineer to Superintendent, Subject: Engineering Report for June 1958, July 7, 1958, p. 2, in Superintendent Monthly Report, June 1958; Superintendent Monthly Report, July 1958, p. 10.

> strengthen the entire building. This work is going on as rapidly as possible in order to prevent future damage.[100]

Even more work on the structure was needed after a "Kona storm" on January 17-18, 1959, damaged the north end of the building, ripping off the end wall and about 10,000 square feet of the galvanized iron roof, as well as causing other minor structural damage. Equipment stored in the building sustained water damage, estimated at $7,100. Repair work consisted of adding bracing to the frame and replacing the corrugated metal roof.[101] The damage was so severe that the 16' end bay was not replaced. The original large sliding doors at that bay were relocated so as to provide better access to the storage areas. To prevent future wind damage, "all column supports were anchored to concrete foundation piers and the connections between the roof trusses and purlins were improved." Strap iron anchors were installed at the bearing columns and at the roof rafter and purlin junctions. "Inadequate" bearing post foundations were replaced with "properly anchored concrete piers" and additional purlins were put in the roof to "reduce the excessive span widths and provide more bearing and nailing surfaces.[102] The repairs had been completed by March 1959.

The often repaired and heavily renovated rain shed would be supplemented by a new rain shed, construction of which began in spring 1957. The contract for the project included construction of a rain shed and trestle. The park received six bids for the work and, on the advice of Supervising Engineer R.T. Montgomery, accepted the low bid of $43,809 submitted by H. Sonomura of Hilo, Hawaii.[103]

Construction of the new rain shed, designated Building No. 241, began with grading the site "to provide adequate drainage" in April and May 1957.[104] Construction of the foundation began the following month with crews laying the lines for the pier foundations and working around the rock outcroppings. The footings were then excavated, and the formwork put in place. The foundation consisted of concrete piers that were pyramidal in shape.[105] By July, the concrete pier foundations had been completed, and the framework could be erected.[106] The Superintendent's Monthly Report from July noted "the well organized operation for the layout of the bents with

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[100] Memorandum from Supervisor of Construction and Maintenance to Park Engineer, Subject: Monthly Report for the Month of September 1955, October 3, 1955, p. 1, in Superintendent Monthly Report, September 1955.
[101] Superintendent Monthly Report, January 1959, pp. 11-12, and photographs accompanying report. For photographs of damage, see D50 035-053, "Kona Storm Damage," J.A. Stites, January 17 & 18, 1959, in HAVO Archives.
[102] Memorandum from Park Engineer to Superintendent, Subject: Maintenance Report for February 1959, March 5, 1959, p. 3 in Superintendent Monthly Report, February 1959; Superintendent Monthly Report, March 1959, photographs accompanying report.
[103] Superintendent Monthly Reports, February 1957, p. 10; March 1957, p. 12. Sonomura subcontracted the aluminum pipe work to P.E. Pell Company of Honolulu, see Superintendent Monthly Report, April 1957, p. 10.
[104] Superintendent Monthly Reports, April 1957; May 1957, p. 12.
[105] Superintendent Monthly Report, June 1957, p. 10.
[106] Superintendent Monthly Report, July 1957, p. 10.

an extended boon on a truck-mounted tractor hoist." Once the main timber bents, which had an average height of 20', had been placed on the concrete pier foundations, the connecting beams could be secured to the frame. The roof structure consisted of purlins attached to beams with corrugated aluminum sheathing on top. Completion of the roof was delayed because of late shipment of the roofing material.[107] By October, the rain shed project was estimated to be 98 percent complete, but problems were identified with the construction. One issue was that the corrugated rubber stripping used to "close the voids under the roofing at the edge of the gutter" had not been "adequately secured." In addition, the "nailing of the roofing" was deemed to be "not up to specifications." The contractor attempted to remedy the situation, but it was not until November that a second satisfactory attempt was made.[108] The completed rain shed measured 200' x 200' with a height of 20', although current measurements indicate it is approximately 220' x 202' and encompasses 45,929 square feet.[109] It contained a pump house used to redistribute water among the tanks or to supply the tanker trucks carrying filtered water to various filtered water storage tanks throughout the park, such as the one located at Bird Park.

In 1963, the supports of the new rain shed had to be repaired because of dry rot at the bottom 24". In some cases, sections had to be removed and replaced, while in other cases, the entire support was removed. All the members were then repainted.[110]

The trestle constructed as part of the rain shed project was built of pre-framed trestle bents on which an aluminum conduit rested. The framing sat on concrete pier foundations. The structure stood as high as the new rain shed's roof so water could be collected from the roof and transferred to the existing wood tanks.[111] Pipe connections also appear to have been made from the roof gutters of the new steel tanks to a 10" aluminum conduit. This increased the rain collection area by 7,260 square feet.[112]

The completion of the water collection system allowed the second phase of construction to begin. In March 1958, the park opened bids for Contract No. 14-10-418-20, the installation of a water distribution system, including the re-plumbing of the residences and buildings in the park and the installing of pipeline. Three bidders submitted proposals, and the contract was awarded to the lowest, Isemoto Contracting

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[107] Superintendent Monthly Reports, July 1957, p. 10 and accompanying photographs; August 1957, pp. 10-11.
[108] Superintendent Monthly Report, October 1957, p. 13. The November Monthly Report praised the contractor, stating he was "most cooperative in all respects, reasonable in matters of extra work orders and suggested minor changes," p. 12.
[109] Superintendent Monthly Report, October 1957, information from caption of photograph accompanying report.
[110] Superintendent Monthly Report, October 1963, p. 4.
[111] Superintendent Monthly Report, August 1957, p. 11. For images, see D50 024 and 026, identification caption: "New water storage tank, rainshed and aqueduct to carry water, Donald M. Black, October 14, 1957" in HAVO Archives.
[112] Superintendent Monthly Report, September 1957, p. 11. The park has found that aluminum negatively impacts the quality of the water.

Company.[113] Although the distribution system is out of the scope of this project, a brief summary of the work will be provided. Copper lines were installed at the residences in June 1958.[114] The following month, layout of the main distribution lines began. The upper loop of mains consisted of two lines, an 8" main and a 3" pumping line, running parallel to one another aboveground. In those instances when the pipes crossed roads or trails, they were buried. Heavy vegetation sometimes caused bypasses through particularly dense areas. The lower loop consisted of 4" and 8" mains.[115] A separate contract was awarded in May 1958 to Hawaii Planing Mill, Ltd. for extension of the water line to the Lava Tube via 7,600' of ¾" polyethylene plastic pipe.[116] In July, a 10,000-gallon redwood tank was placed on a concrete pier foundation at the end of the pipeline at the Lava Tube, replacing the two 500-gallon wood tanks that previously collected water from the roof of the Lava Tube Comfort Station.[117] On December 18, 1958, the new system was declared complete, with service provided to all buildings, residences, and fire hydrants in the park.[118] There were problems with corrosion in the galvanized pipes, a situation that plagued pipelines throughout the island. One solution used by the park was to add hydrated lime to the water.[119]

As completed in 1958, the park had centralized the water collection system behind the former Volcano House hotel and the visitor center. A spur road extending past the visitor center and former Volcano House hotel provided vehicular access. Water was collected from the roofs of the two rain sheds and carried via pipes to fourteen wood raw water tanks located behind the old rain shed. The fourteen wood tanks were arranged in two rows and numbered from seven to twenty with odd numbers to the south and even numbers to the north. A 6" raw water main extended from the raw water collection and sedimentation tanks to the filter tank. Slow sand filtration took place in the filter. The filtered water then passed through a sand trap and into the adjacent chlorinator and pump house. The finished water was then pumped back up

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[113] Superintendent Monthly Reports, March 1958, p. 12; April 1958, p. 12. The bidders included: H. Harada Contractor, $54,844.20; Jas. W. Glover, Ltd. at $51,864.95; Isemoto Contracting Company, Ltd., at $47,924.86.
[114] Superintendent Monthly Report, June 1958, p. 10.
[115] Superintendent Monthly Reports, July 1958, p. 12; August 1958, pp. 9, 12; September 1958, pp. 7, 10; October 1958, pp. 8, 11; November 1958, pp. 9, 12. See photos D50 080, identification caption: "Pipelines of new distribution system and pump line near point 42. Lack of clearance in a heavy stand of eucalyptus trees required a bypass of the 3" pump line"; Photo D50 081, identification caption: "Pipeline and connection, J.A. Stites, December 1957"; pipeline at point 39 depicted in photos D50 056 though 059, February 1959; photographs D50 022 and 023, July 1958 of redwood tank at Lava Tube, photograph D50 080, identification caption: "Pipelines of new distribution system and pump line near point 42. Lack of clearance in a heavy stand of eucalyptus trees required a bypass of the 3" pump line"; D50 081, identification caption: "Pipeline and connection, J.A. Stites, December 1957"; pipeline at point 39 depicted in photos D50 056 though 059, February 1959. All photographs in HAVO Archives.
[116] The winning bid for the Lava Tube project was for $625.48. The other five bids were from P.S. Pell & Co. Ltd. for $703.76; Theo. H. Davies & Co. Ltd. for $727.32; GASPRO, Ltd. for $747.84; Lewers & Cooke, Ltd. for $897.56; and American Factors, Ltd. for $1019.92.
[117] Memorandum from Park Engineer to Superintendent, Subject: Engineer Report for July 1958, August 7, 1958, p. 3 in Superintendent Monthly Report, July 1958.
[118] Superintendent Monthly Report, December 1958, pp. 8, 12.
[119] Superintendent Monthly Reports, December 1958, p. 9; March 1959, p. 8.

to one of the four 500,000-gallon steel water tanks. Numbered one through four, the tanks were not only connected to the filter tank by a 2 ½" pump line but also were connected to the 6" main distribution line, which made a loop around the headquarters and residential sections of the park (see Figure 5). The 6" main was connected to the residences and buildings via 6" and 4" mains.[120] In 1962, the distribution system was extended to the U.S. Geological Survey's Hawaiian Volcano Observatory on Uwekahuna and a pump house constructed.[121]

Additions have been made to the system since 1958. After 1980, a second slow sand filter tank (designated Slow Sand Filter 2) and clear well were constructed. Around 1993, two 750,000-gallon tanks (designated Tank Nos. 18 and 19) were erected on the same site as six of the original redwood tanks. Another 500,000-gallon tank (designated Tank No. 5) was installed next to Tank No. 4. Two catchments were also installed. The larger one dates to the early 1970s while the smaller one was built ca. 1993.[122]

Part II. Site Information

A. General Description:

The Hawaii Volcanoes National Park Water Collection System, as of 2008, consists of two rain sheds, an overhead trestle carrying a 10" pipe, six redwood water tanks (with a combined capacity of 626,600 gallons), five steel tanks each with a capacity of 500,000 gallons, two steel tanks each with a capacity of 750,000 gallons, two catchments and a pump house, two slow sand filters, and a pump and chlorinator building, plus the pipes connecting the various components. The site is located behind the NPS Visitor Center and the former Volcano House hotel, now the Volcano Art Center. Another underground reservoir and pump house are located at the firehouse, but those are outside the scope of this project. Individual descriptions of the main features of the system are below.

Building No. 43

The old rain shed (Building No. 43) is a 110' x 358-1/2' frame building with a 22'-10" interior height at the center. It originally measured approximately 110' x 182'. The surface area of the roof is about 40,228 square feet. In 1950, the building encompassed 743,256 cubic feet.

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[120] U.S. Department of Interior, National Park Service, Engineering Branch, WODC, "Water Distribution System, Kilauea Headquarters, Hawaii National Park," Region IV, January 1958, As Constructed, March 25, 1959, Sheets 1 and 2; San Juan Construction, Inc., As Constructed Drawings, Rehabilitate Park Water System, Headquarters Area, June 1993, set of 35 drawings.

[121] The contract for the extension was awarded to H. Harada, Contractor, who submitted the winning bid of $15,860.90 (Contract No. 14-10-0434-860). The work was delayed due to a shipping strike, but by June the pump house and 8" main had been completed. Superintendent Monthly Reports, February 1962, p. 7; March 1962, p. 9; April 1962, p. 8; June 1962, pp. 1, 8; July 1962, p. 5.

The structure consists of 4" x 6" posts typically on 2'-tall reinforced concrete pier foundations measuring 2' square at the bottom and narrowing to 1' square at the top. Metal straps inserted into the concrete piers are attached to the posts by 5/8" bolts. The piers are typically placed in five rows on a grid about 25' x 15'-7" apart. On some of the piers, 3/8" eyebolts were drilled into the concrete piers. Wire rope bracing ran on a diagonal from the top of a nearby post to the eyebolt. This was modified by adding additional wood to the post and then securing the eyebolts to the altered post.

The frame is made up alternating truss types. The first type (labeled "Truss Type A" on the As-Constructed Drawings completed in 1993 for the park) is made up of a double 2" x 8" bottom chord and a 2" x 8" top chord to which 2" x 6" diagonal and vertical members are bolted. The distance from the bottom chord to the floor is 15'-10". Additional support is provided by a 2" x 6" horizontal girt that has a 10'-10" clearance. The second type (labeled "Truss Type B") is made up of a double 2" x 8" bottom chord and a 2" x 8" top chord to which two 2" x 6" vertical members and 2" x 6" and 2" x 8" diagonal members are bolted. Truss Type B is stepped, with the higher clearance of 16'-9" at the center of the building. Additional support is provided by a 2" x 6" horizontal girt that has a 10'-10" clearance like that in Truss Type A. The trusses are typically placed about 15'-7" apart.

Additional bracing is provided by frames placed along the center line of the structure between trusses. Eleven of the frames have a 7'-6" vertical clearance and are made up of 4" x 6" bottom and top chords with two 4" x 6" diagonal members. At the point where the diagonals cross is a 16" x 16" x 5/8" plywood gusset plate. At each corner of the frame, at the point where the diagonal members meet the posts and chords, are 12" x 12" x 5/8" plywood gusset plates. A different type of frame was located at the west end of the building between the first two trusses, both at the center line and just about 25' from the north wall. These two frames have a higher vertical clearance at 11'-6", but the basic form is the same as the predominant frame type. In addition to the higher clearance, these frames have extra 4" x 6" posts secured to the main post.

The old rain shed has a gable roof with a 1 ½: 12 rise up to the center. The roof structure is made up of 3" x 4" purlins spaced approximately 24" apart that sit on 2" x 6" rafters. The roof is now clad in corrugated aluminum. Rain running off the roof is collected via a gutter that sits on wood supports screwed to the exterior posts of the building. The gutter consists of a wood box lined with metal, and the rain is channeled into it via a piece of flashing bent downward from the roof into the gutter. Boxed outlets at various points in the gutter connect to a pipe that hangs from metal straps attached to the ridgepole and runs transverse to the other side of the building.

The rain shed is partially clad in panels of corrugated metal that have been nailed to the exterior wall frame, which is made up of horizontal and vertical members. The northwest and northeast walls are fully clad in corrugated metal, while the southeast wall is open. The southwest wall is partly closed, with the south end is open. The

corrugated metal panels have been cut at their tops to accommodate the roof purlins. The northwest end wall of the building features two sets of sliding doors. Both are constructed of corrugated metal panels and run along a track installed on the wall above the doorway opening. The door to the north is smaller than that at the south end of the wall. Above the sliding doors are three sets of windows. The two sets at the north end are identical and are made up of two side by side, six-over-six light, double-hung sash windows in wood frames. The window at the south end over the larger sliding door is made up of three six-light fixed windows in a wood frame.

The open plan of the rain shed's interior has been divided into spaces for various functions, including shop, storage, and vehicle parking. A redwood shed is located in the northeast corner of the building with a set of stairs adjacent that lead to a platform with storage space. The northwest corner of the building contains enclosed shops: the Trails Shop is to the north while the Sign Shop is to the south. A bathroom is also located in this area. At the center of the building are enclosed spaces bordered by wire fencing. The southeastern portion of the building is open and used as a carport for the park's service vehicles. The floor has been covered with hot mix, but portions of the foundations for two of the nine wood water tanks housed in the shed until 1958 are visible. Originally the southeast corner was cordoned off with wire fencing to create an enclosed space, but that was removed some time after 1993.[123]

New Rain Shed, Building No. 241

The new rain shed, designated Building No. 241, is a 219'-6" x 201'-6" frame building with an interior height of 21' from the top of the pier foundations to the top of the diagonal bracing members. The 6" x 6" support posts rest on reinforced concrete piers, which are located on a grid approximately 15'-6" off center. On the lines of posts and piers running from east to west, alternate posts are connected by 2" x 6" beams and two 2" x 6" diagonal members that cross one another to form an X. The height of these braces is 4'-6". The lines that run from north to south also have braces located between alternate posts. These braces are a bit larger, measuring 5'-6" in height, but are similar in design. Wire rope bracing provides additional stability and support to the structure.

The roof slopes down towards the center at a 2:100 slope. The roof structure consists of 2" x 8" purlins that sit in corresponding notches in the girders. The roof is clad in corrugated aluminum. A 22"-diameter flume is located on the roof's center, positioned so that each sloping side of the roof drains water into it. The conduit then leads to the catchment where the water is stored; originally, it connected to the redwood storage tanks. The drawings of the structure as constructed indicate the corrugated metal roofing was to be nailed "at every third configuration at each purlin." The laps and joints of the roof were to be sealed with mastic sealing compound.

[123] Description based on fieldwork done by Todd Croteau, HAER, in August 2008; San Juan Construction, Inc., As Constructed Drawings, June 1993, including Sheets 19, 20, 21, and 22; and Building No. 43 information sheet, March 1, 1950, in HAVO Archives.

The interior of the rain shed is open with a few enclosed areas. The original transfer pump house is located under this rain shed, near Tank No. 4.[124]

Water Tanks
There are several types of water tanks in the HAVO water collection system, representing different eras of tank technology.

The first type of tank dates to the first half of the twentieth century. The 10,000-gallon redwood tanks located behind the old rain shed are no longer in use. Originally, there were as many as fourteen arranged in two rows of seven, but eight of those have been removed. The remaining six tanks are designated Tank Nos. 7 through 12. Drawings of the removed tanks indicate that they ranged in height from 18'-6" to 16" and were 30' in diameter. The sides of the remaining tanks consist of redwood staves placed vertically around the concrete foundation with tension rods encircling them. The rods are spaced more closely together at the bottom, with the distance widening at the top of the tanks. The anchors connecting the ends of the rods are offset. Most of the tanks were constructed on a concrete pad, except for Tank No. 8, which sits on a stone platform for unknown reasons. Wood gutters encircle the conical roof of each tank to collect additional water.[125]

The second generation of tanks is made up of four steel tanks dating to the 1950s (designated Tank Nos. 1 through 4) with capacities of 500,000 gallons each. Tank Nos. 1 and 2 serve as finished water storage, while the remaining two store the raw water. The welded steel tanks measure 20' high with a 65'-interior diameter and sit on a concrete ring that rests on a foundation. They are outfitted with 6"-diameter outlets, 2"-diameter overflows, 6" drains, 2"-diameter inlets, 24" manholes, and interior and exterior ladders up the side of the tanks. A network of pipes is located at the bottom of the tanks. A girder and rafter system inside the tank supports the roof. At the peak of the conical roofs are screened vents, "sized to compensate for 300 gallon withdrawal rate." A ladder up the side of the tank provides roof access. Water was to be collected from the roofs of the tanks, so an 8"-diameter semi-circular eave trough was installed with a 4"-diameter downspout. [126]

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[124] Description based on field work done by Todd Croteau, HAER, in August 2008; San Juan Construction, Inc., As Constructed Drawings, June 1993, including Sheets 24 and 25; U.S. Department of the Interior, National Park Service, "Rain Shed," As Constructed Drawing, 1956, Sheet 3 of 7.

[125] Description based on field work done by Todd Croteau, HAER, in August 2008; San Juan Construction, Inc., As Constructed Drawings, "Demolition," June 1993, Sheet 3.

[126] Description based on field work done by Todd Croteau, HAER, in August 2008; U.S. Department of the Interior, National Park Service, Branch of Engineering, Western Office, Division of Design and Construction, As Constructed Drawing, "500,000 Gal Steel Water Tank," Kilauea, Hawaii National Park, November 1956; Terminal Steel Company, Ltd., Hawaii National Park, Kilauea, Hawaii, "500,000 Gal Steel Water Tank, Details," 1957, Sheet 2 of 7. Photographs of the completed tank include D50 142 through 145, ca. 1957; D50 164 through 170, and D50 241 through 243, all taken by J.A. Stites, August 1957. Photograph D50 165 has identification caption: "Steel water storage tank erection complete showing general view. Photos of the lightweight metal flume connecting gutters of tanks for roof drainage water. J.A. Stites, August 1957." Photograph D50 170 has identification caption:

The third generation of tanks dates to ca. 1993 and consists of two 750,000-gallon tanks and one 500,000-gallon tank built of bolted steel panels with aluminum geodesic dome roofs. The fifth 500,000-gallon tank (designated Tank No. 5) was installed to the northeast of the original steel tanks ca. 1993. This tank is used for raw water storage. The two 750,000-gallon raw water storage tanks (designated Tank No. 18, Asset #40178 and Tank No. 19, Asset #40177) that replaced the removed redwood tanks date to ca. 1993 and are built of bolted steel panels with aluminum geodesic dome roofs. The tanks sit on a reinforced concrete floor slab on 6" of "compacted granular material." The foundation is made up of a reinforced concrete ring wall. Aluminum ladders provide access to each tank's roof. The tanks are also equipped with a 6" PVC overflow pipe, a water level indicator, 6" drain, 4" inlet and 6" outlet.[127]

Ground Catchments

Two lined catchments are located to the east of the old rain shed and redwood tanks and are serviced by a pump house. The 1970s era catchment (Asset #21492) is located closer to the old rain shed and raw water tanks. It is the larger of the two with a square footage of 128,878 square feet. The adjacent, smaller catchment (Asset #21493) covers 51,000 square feet. It was built ca. 1993. Both catchments are connected to a pump station and to the raw water tanks by 4" and 6" mains. Each catchment is equipped with a suction intake and drain sump. A 24" reinforced-concrete pipe collects water from the old rain shed and delivers it to the larger catchment.[128]

Treatment

The raw water passes through one of two roughing cartridge filters and then one of the two slow sand filter tanks. One filter tank dates to 1957, while the other was constructed around 1980. The tanks have conical roofs, each equipped with a movable sector that pivots for access along with a ladder. They are outfitted with a 4" overflow pipe, 2" outlet, 3" inlet, and a water gauge. The original tank measures 20' in diameter and 10' high. The unfiltered water enters the tank via a 2" line at the top of the tank and passes through a 3' layer of sand and then a 12" layer of graded rock before exiting the tank via the bottom 2" drain. The tank is also equipped with a 2" overflow pipe. A float switch set to turn the pump on when the tank was full and turn it off when the water dropped about 2' controls the water level. A 6' water level indicator board helps park personnel monitor the tank. The original filter had a 21.8 gallon per minute (gpm) rate and a 31,416-gallon capacity per 24 hours. The clear

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"Establishing road bed around drainage sump near the 500,000 gallon steel tank. Spraying the layer of chips with bitumuls before placing a hot mix layer to seal foundation of steel tanks. J.A. Stites, 1957-59." All photographs in HAVO Archives.

[127] Description based on field work done by Todd Croteau, HAER, in August 2008; San Juan Construction, Inc., As Constructed Drawings, "Tank Farm and Rainsheds," June 1993, Sheets 11 and 12.

[128] Description based on field work done by Todd Croteau, HAER, in August 2008; San Juan Construction, Inc., As Constructed Drawings, "Site Plan," June 1993, Sheets 4, 5, and 11.

well stored water effluent from the filter tanks for use in backwashing operations, necessary to keep the sand in the filter clean.[129]

Pump House
The pump house, located adjacent to the filter tanks, has a shed roof and is clad in corrugated metal siding. Double doors provide access at the front façade while fixed windows provide natural lighting to the space. The pump house holds the pump and chlorinator, as well as a lab table.[130]

Overhead Pipe
A trestle originally carried a 10" aluminum pipe from the new rain shed to the raw water redwood storage tanks nearly 16' off the ground, but now carries water to the ground catchments. The structure is made up timber bents constructed of 2" x 6" cross and horizontal members bolted to supports sitting on concrete footings. Each timber bent is 15' long with ends measuring 6' wide at the bottom that narrow to just over a foot wide at the top. The timber used in construction of the trestle was specified as structural grade Douglas fir or better. The 10" aluminum pipe was to be furnished and installed by the contractor. The pipe rests on a wood block cut on the top with a half circle to accommodate the pipe. Horizontal members bolted to the top of the supports run alongside the pipe.[131]

B. Site Layout:
At the north end of the site are the two slow sand filters, clear well, and pump house, located a short distance from the main collection system and accessed by a road that connects to State Highway 11. To the west of the filter tanks is Building No. 241, the new rain shed. A collection of five 500,000-gallon steel water tanks are located south of the new rain shed. The six remaining redwood water tanks and two 750,000-gallon steel tanks are grouped east of the old rain shed, Building No. 43. The two catchments are south and east of the old rain shed.[132]

Part III. Operations and Process

A. Operations:
In order to provide fresh drinking water for the park's visitors and residents, rainwater has to be captured, purified, and stored or distributed.

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[129] Rigging International, Kilauea Headquarters Area, "New Slow Sand Filter, Modifications to Existing Slow Sand Filter," February 6, 1980; U.S. Department of the Interior, National Park Service, "Slow Sand Filter," As Constructed Drawing, November 1956, Sheet 7 of 7; U.S. Department of the Interior, National Park Service, Branch of Engineering, Western Office, Division of Design and Construction, "Steel Tank for Slow Sand Filter," Kilauea, Hawaii National Park, As Constructed Drawing, November 1956, Sheet 6 of 7; Terminal Steel Company, Ltd., Hawaii National Park, Kilauea Hawaii, "Steel Tank for Slow Sand Filter, Tank Details," 1957, Sheet 3 of 7.
[130] Description based on field work done by Todd Croteau, HAER, in August 2008.
[131] Description based on field work done by Todd Croteau, HAER, in August 2008; U.S. Department of the Interior, National Park Service, As Constructed Drawing, "Trestle," November 1956, Sheet 4 of 7.
[132] Description based on field work done by Todd Croteau, HAER, in August 2008; San Juan Construction, Inc., As Constructed Drawings, "Headquarters Area, Site Plan," June 1993, Sheet 4.

When the system shifted from its location in the Utility Area to the Headquarters Area in the late 1940s and early 1950s, it consisted of the old rain shed, which stored fifteen tanks of various sizes. Fourteen redwood tanks were located behind the rain shed. A pump and chlorinator completed the system.[133]

The system, as completed in the 1950s, collected rainwater from the roofs of the two rain sheds, as well as the tanks. Water collected from the new rain shed ran through a 10" overhead aluminum pipe resting on a trestle, to the north and east of the four 500,000-gallon steel tanks and between the old rain shed and redwood tanks. A 6" main ran between the two rows of redwood storage tanks, connecting to each tank's outlet. A 4" x 6" reducer allowed the raw water to be piped via a 4" main to the slow sand filter tank where a 4" x 2" reducer was located. After filtration occurred in the filter tank, the water exited the tank, ran through the adjacent sand trap, and then was pumped through the chlorinator and pump house via a 2" pump line to the four 500,000-gallon steel storage tanks. Water was distributed via inlets into the treated water storage tanks, which were also equipped with 6" drain valves connected to a 4" drain and recirculation line. Treated water entered the upper and lower loops of the distribution system through 8" mains with 3" pump lines running parallel. The movement of water throughout the system was controlled via gate and stop valves and reducers.[134]

The system now collects water from the roofs of the rain sheds and moves it directly into an open ground catchment. Water collected from the new rain shed is moved through a 10" pipe to the old rain shed, where it enters that building's drain system. The collected water then flows to the larger lined ground catchment through a 24" pipe. Water is also collected in the two lined ground catchments. The remaining redwood tanks that originally stored the water have been taken offline. A pumping station takes water from the ground catchments to the 750,000-gallon steel raw water storage tanks via a 4" line. Other 4" lines deliver the raw water to three of the 500,000-gallon steel tanks (Tank Nos. 3, 4 and 5). The raw water tanks all connect to 4" lines that deliver the untreated water to one of the two slow sand filters. The filtered water exits the filter tanks at the opposite side of the tanks. Effluent from the filter tanks is stored in the clear well for use in backwashing operations. The filtered water then goes through one of two chlorinators before being pumped via a 4" line to one of the two 500,000-gallon steel finished water tanks (Tank Nos. 1 and 2). The finished water then enters one of the two 8" main distribution lines servicing the park.

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[133] Maps, "Water-Collection & Sewer System," and "Water Distribution-Kilauea Headquarters," March 1953, Sheets 1 & 2, available in HAVO Archives.

[134] U.S. Department of the Interior, National Park Service, "Schematic Flow Diagram," As Constructed Drawing, 1956, Sheet 2 of 7; U.S. Department of the Interior, National Park Service, As Constructed Drawing, "Water Storage & Treatment System Layout," revised 1964, Sheet 4 of 4; U.S. Department of the Interior, National Park Service, Branch of Engineering, Western Office-Division of Design and Construction, "Water System Piping," Kilauea, Hawaii National Park, As Built Status as of March 1960, 1961; U.S. Department of the Interior, National Park Service, Engineering Branch, WODC, "Water Distribution System," Kilauea Headquarters, Hawaii National Park, As Constructed Drawing, March 25, 1959, January 1958, Sheet 1 of 4.

Some of the filtered water is also pumped into or from tanker trucks using the distribution pump located in Building No. 241.[135]

B. Machines:

Pumps used in the water collection system include the following: Premia 75/Solenoid Metering pump; Pono pump, ITT AC Model 606 with a 206 gpm, 179' head, 175 psi, 12/93; and Fresh Water pump, ITT AC Model 800 with 41 gpm, 38' head.[136]

C. Technology:

There were two types of filtration available when Hawaii established its collection system: slow sand filtration and rapid sand filtration. Both filters use sand as the filtering medium, but there are distinct differences in how they operated. In slow sand filters, also known as English filters since they originated and were widely used there, water filtered slowly through beds of sand without the use of chemicals. The water passes "downward by gravity through beds of sand of certain depth" leaving most of the bacteria on the sand's surface.[137] Rapid sand filters, on the other hand, use chemicals to help settle the bulk of particles out of the water via the sedimentation and coagulation processes before filtration occurs.

Slow sand filtration was used in the United States as early as 1832 at Albert Stein's plant in Richmond. Its first successful application was in a plant located in Poughkeepsie, New York, which was based on James P. Kirkwood's proposed plant for St. Louis that looked to European models of filtration.[138] The main issue with slow sand filters in this country, particularly in the Midwest, was that "the suspended particles of clay in the highly turbid waters…do not adhere to the grains of sand, but pass through the filter, bringing with them many infectious bacteria."[139] Thus, rapid sand filtration became the preferred method. In the roof collection system used at HAVO, however, such concerns about water turbidity were not present and allowed the use of the less complex slow sand filter rather than the rapid sand filter, with its need for multiple structures and chemical usage. The installation of a slow sand filter system at Hawaii Volcanoes National Park and the construction of additional collection structures supported the growth of the park and eased concerns about the availability of clean drinking water.

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[135] San Juan Construction, Inc., "Headquarters Area, Site Plan," June 1993, Sheet 5.
[136] Information provided by park staff, December 2008.
[137] James H. Fuertes, *Water Filtration Works* (New York: John Wiley & Sons), pp. 75-76; George D. Norcom and Kenneth W. Brown, *Water Purification for Plant Operators* (New York: McGraw-Hill Book Company, Inc., 1942).
[138] J. Michael LaNier, "Historical Development of Municipal Water Systems in the United States 1776-1976," *Journal of the American Water Works Association* 68, no. 4 (April 1976): p. 179.
[139] LaNier, p. 179.

Table 1: Chronology of Maps, Plans, and Events at the Water Collection System with Brief Notes. Compiled by MaryAnne Maigret, Maintenance Division Archaeologist for HAVO, Revised January 27, 2010.

Date	Maps, Plans, Events	Notes
1924	Constructed	
1932	Department of the Interior, National Park Service, Hawaii National Park, "Drainage Shed for Headquarters Area Water Supply," prepared by National Park Service, Office of the Chief Engineer, San Francisco, California, February 5, 1932.	Construction plans are drawn for a new rain shed, 100' x 200', to be constructed east of the park headquarters to collect rainwater for the Utility Area storage facilities. This was not built.
1936	Department of the Interior, National Park Service, Hawaii National Park, "Map of Land Lease, Volcano House Co. Ltd.," Submitted by Volcano House Co. Ltd., 1936.	Rain shed (Building 43) appears as rectangular structure, approximately 100 x 200 feet.
1937	Department of the Interior, National Park Service, Hawaii National Park, "Existing & Proposed Water Lines," Map to accompany report by W.E. Robertson Associate Engineer, Office of the Chief Engineer, 1937.	Rain shed labeled as 23,100 sq ft. Located west of 4 tanks (8,000, 60,000 (x2), 400,000 gallons). No tanks on north side, nor depicted under shed.
1938	Department of the Interior, National Park Service, Branch of Engineering, Region 4, "Prop. Location Plan for Water System Improvement, Headquarters Area," 1938.	Located west of 4 tanks. No tanks on north side, nor depicted under the shed. The area to the northeast of the shed consists of chicken pens.
1941	United States Department of the Interior, National Park Service, Hawaii National Park, Kilauea Section, "Re-Study Water System," Drawing No. NP-HAW 8069-A, 1941.	Plan depicts proposed placement of four 350,000-gallon reinforced concrete reservoirs under the rain shed roof.
1947, January	U.S. Department of the Interior, National Park Service, "Preliminary Headquarters and KMC, Part of Master Plan for Hawaii National Park," January 1947.	Depicts approx. 100' x 200' rain shed structure; dotted-line designation denotes status as "to be removed" and a loop turnaround road to be built in the rain shed footprint.
1947	Constructed	Six military-surplus redwood water tanks placed alongside the northeast side of the shed.
1947	Alteration	Roof of the rain shed raised to bring it in line with the new redwood water tanks.
1949-50	Relocation	Project U-26: Redwood water tanks relocated from CCC camp to beneath rain shed roof. Tanks on "Tank Hill" dismantled and moved.
1949-50	Extension	Project U-25: Extension of rain shed roof of 176'
1949-50	Reconstruction	Project U-27: Water mains installed to connect the Headquarters Area and Utility Area water systems.
1951	United States Department of the Interior, National Park Service, Landscape Division, "Headquarters Area," Drawing HAW-2035, 1951.	Rainshed has been extended to approx. 100' x 375'. Fourteen water tanks are now situated on the north side of the water shed. Area to northeast is garden.

Date	Documentation	Notes
1952	United States Department of the Interior, National Park Service, Landscape Division, "Headquarters and Vicinity," Drawing 3049-I, 1952.	Dimensions of rain shed approx. 110' x 375'. The interior tanks are not arranged in rows. The fourteen tanks on the north side are explained: three are 80,000-gallon tanks, eleven are 100,000-gallon tanks. Land area northeast of the shed is a horse pasture and stable.
1953	United States Department of the Interior, National Park Service, Landscape Division, "Headquarters and Vicinity," Drawing 3049-J, 1953.	Map is an update of the 1952 map (above), with six proposed 100,000-gallon tanks added to the map. Internal layout of shed with warehouse storage, interior shed, and fourteen tanks under the shed roof are depicted.
1953	Robert D. Jeffrey, "Water Distribution, Kilauea Headquarters," 1953.	Hydrants, distribution lines, valves, and bitumul and water tanks depicted. Six proposed 100,000-gallon tanks shown. Use of land to the northeast of the rain shed not stated.
1957	Construction	New 195' x 213' rain shed and trestles constructed, along with pump house and filter tank. Three 500,000-gallon steel tanks, one 23,500-gallon steel filter tank erected.
1955-57	Rehabilitation	Redwood water tanks at Utility Area and rain shed area dismantled, new concrete foundations poured, staves and hoops reassembled.
1958	Construction	New 500,000-gallon steel tank constructed; water distribution system constructed.
1958	Alteration	Redwood water tanks removed from under the extension portion of the old rain shed; additional bracing and new supports constructed to replace former support function of two 50,000-gallon tanks.
1959	Alteration	Wind storm damages rain shed roof and walls; bracing added to rain shed frame and corrugated metal roofing replaced; 16' end of bay not replaced.
1964	United States Department of the Interior, National Park Service, Engineering Division, Hawaii Volcanoes National Park, "Kilauea Headquarters Area, Part of the Master Plan, Hawaii Volcanoes National Park," Drawing NP-HAVO 3049-L, August 1964.	1964 Master Plan map shows the old and new rain sheds and new steel tanks.
1970s	Construction	Larger ground catchment.
Post-1980	Construction	Slow sand filter tank and clear well.
Ca. 1993	Construction	Two 750,000-gallon tanks erected after removal of eight of the original 1947 redwood water tanks.

Appendix: Figures--All images are from HAVO Park Archives and Denver Service Center Technical Information Center (TIC) files and were compiled by MaryAnne Maigret, Maintenance Division Archaeologist, HAVO.

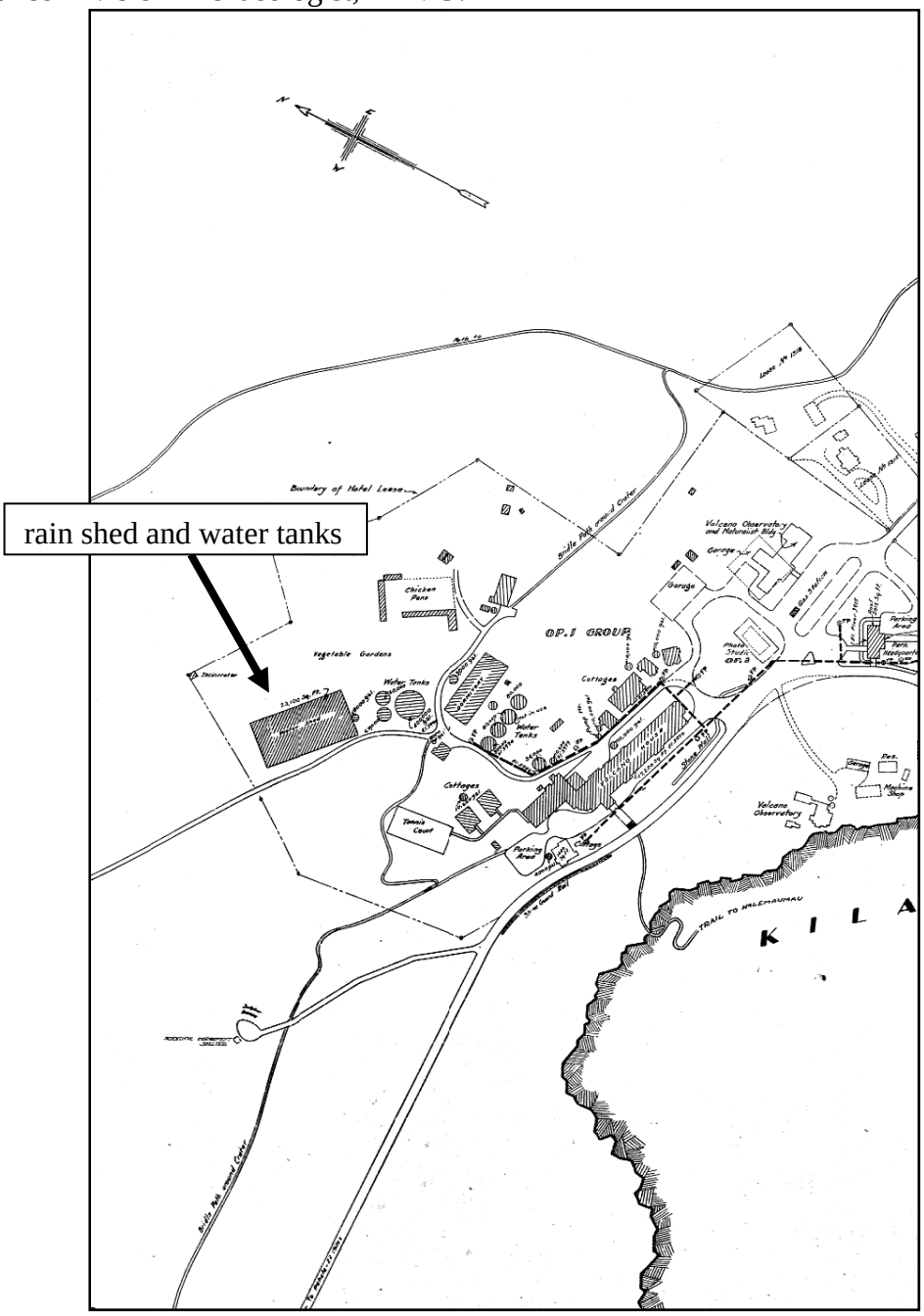

Figure 1: Map notes the square footage of the rain shed was 23,100 square feet. Note the water tanks have not yet been installed north of the shed. Detail from Department of the Interior, National Park Service, Hawaii National Park, "Existing & Proposed Water Lines," Map to accompany report by W.E. Robertson, Associate Engineer, Office of Chief Engineer, 1937.

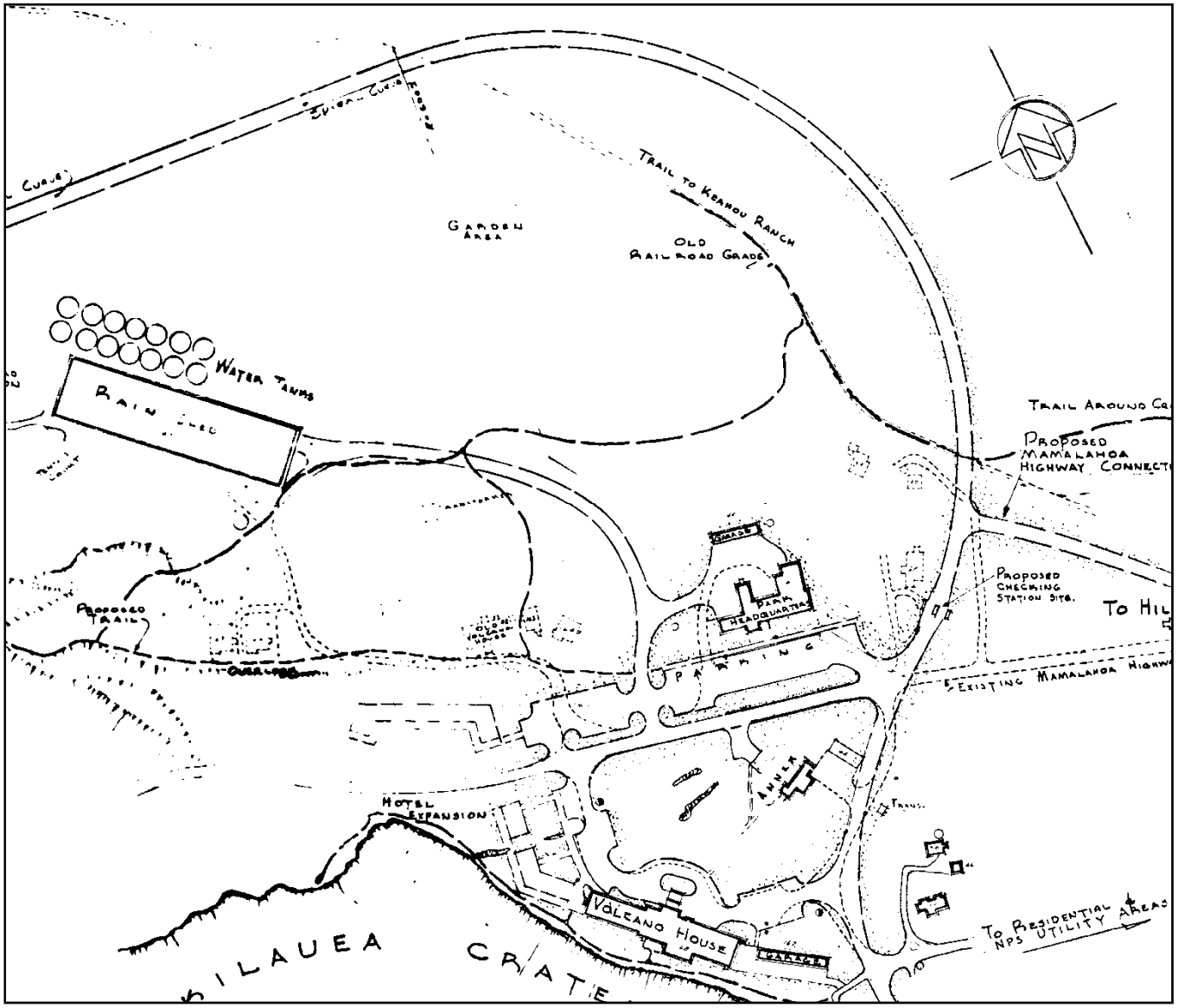

Figure 2: Detail of map showing 1949-50 extension of the rain shed by 176' to the southeast and fourteen water tanks on the northeast side of the shed and relationship of site to visitor center (delineated Park Headquarters on map) and Volcano House hotel. Note that the row of water tanks extends beyond the northwest end of the shed. United States Dept. of the Interior, National Park Service, Landscape Division, "Headquarters Area," Drawing HAW-2035, 1951.

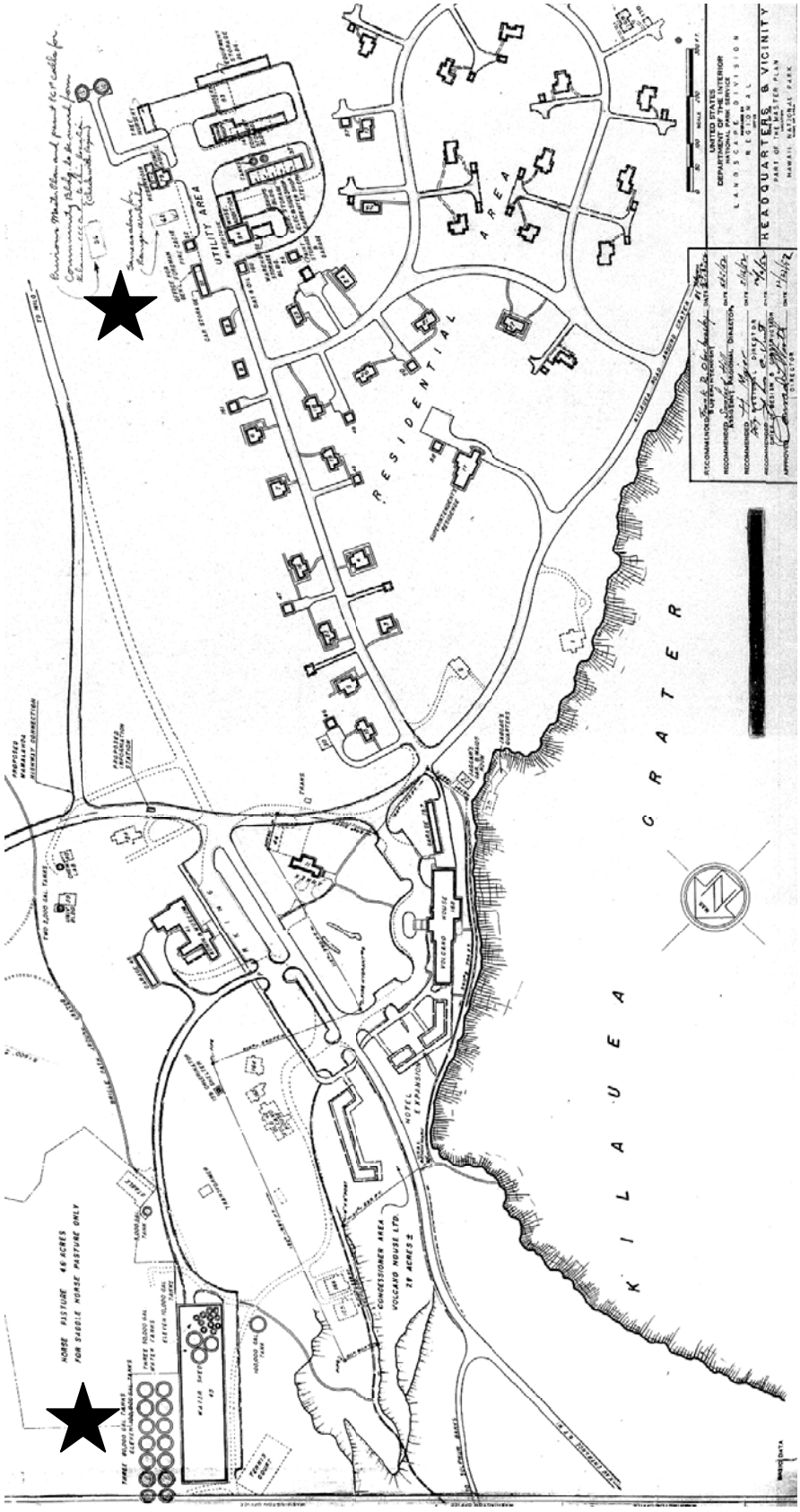

Figure 3: 1952 map detail. Star to left is over rows of water tanks extending beyond the northwest wall of the watershed. Note also the random placement of water tanks under the shed roof. The star to the right is over the Utility Area. United States Department of the Interior, National Park Service, Landscape Division, "Headquarter and Vicinity," Drawing 3049-I, 1952.

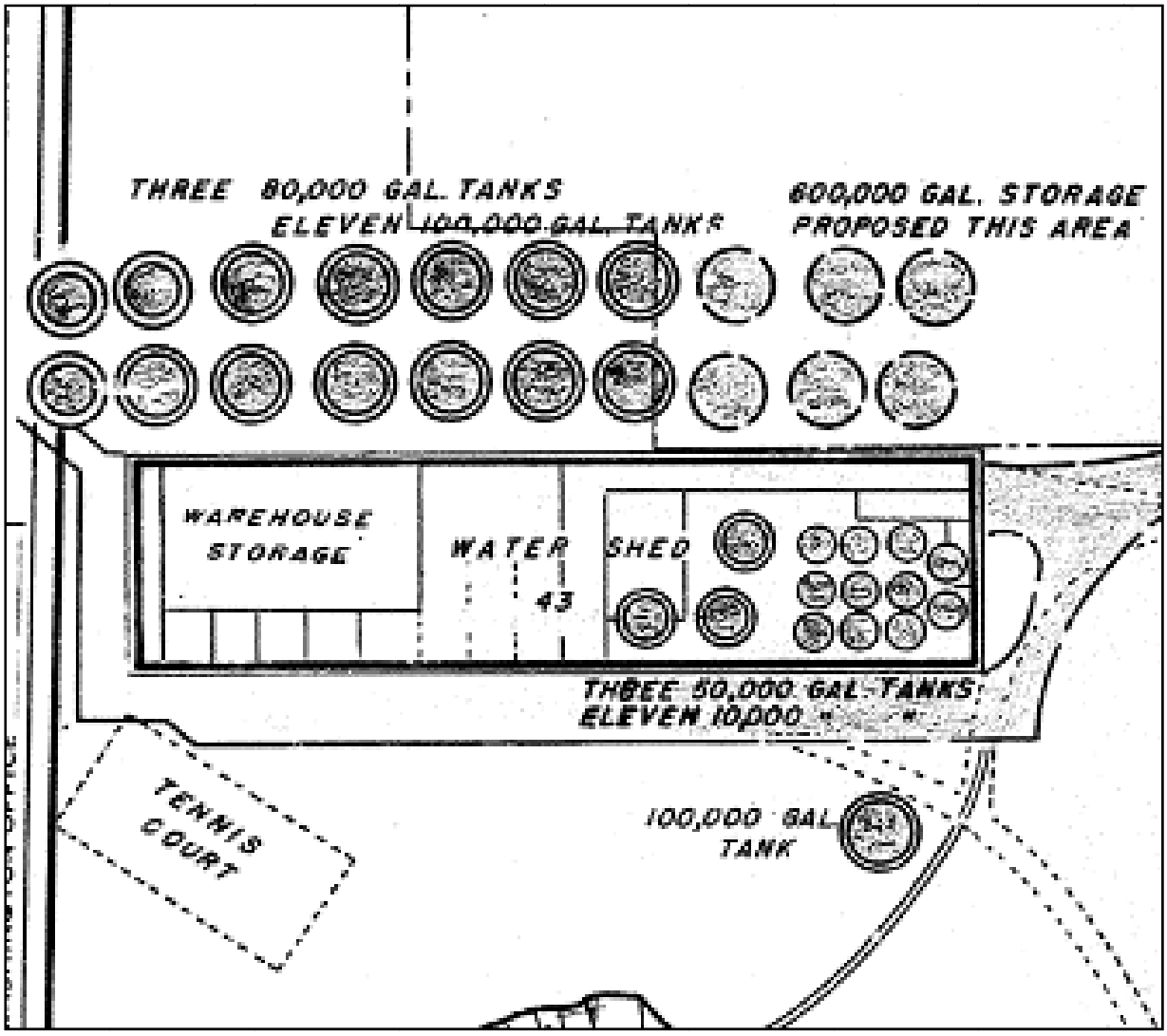

Figure 4: Detail of 1953 map depicting the interior floor plan/layout of the rain shed. United States Department of the Interior, National Park Service, Landscape Division, "Headquarters and Vicinity," Drawing 3049-J, 1953.

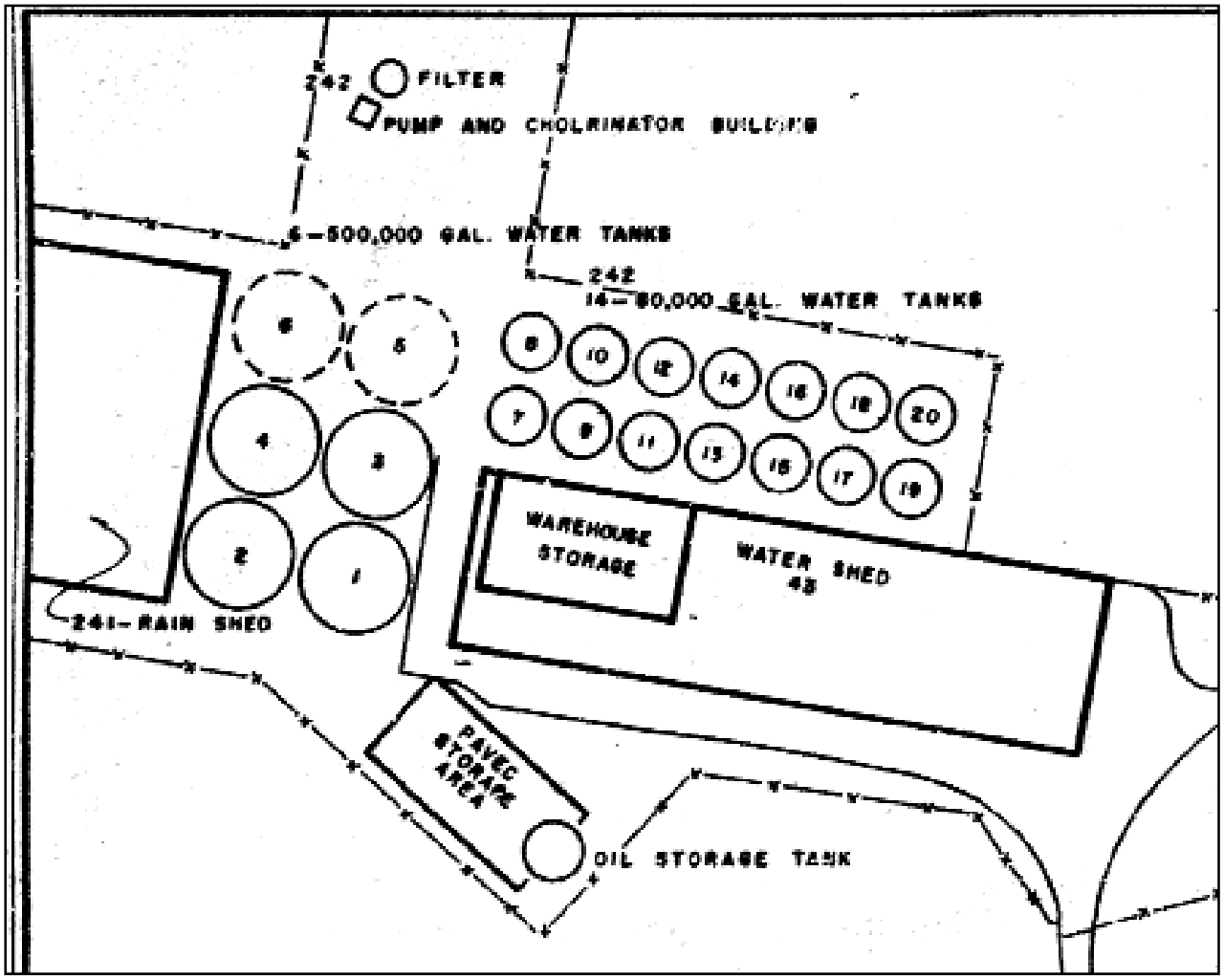

Figure 5: Detail of 1964 Master Plan showing the corner of the new rain shed (Building 241), old rain shed (Building 43), fourteen redwood water tanks (numbers 6-20), constructed and planned steel water tanks (numbers 1-6), filter, and pump house. United States Department of the Interior, National Park Service, Engineering Division, Hawaii Volcanoes National Park, "Kilauea Headquarters Area, Part of the Master Plan, Hawaii Volcanoes National Park," Drawing No. NP-HAVO 3049-L, August 1964.

Part IV. Sources of Information

A. Primary Sources

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"Water Distribution-Kilauea Headquarters," Map, March 1953.

"Water Collection & Sewer System," Map, March 1953.

U.S. Department of the Interior, National Park Service, Branch of Engineering, Western Office, Division of Design and Construction. "500,000 Gal Steel Water Tank," Kilauea, Hawaii National Park, As Constructed Drawing, November 1956.

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ADDENDUM TO:
HAWAII VOLCANOES NATIONAL PARK WATER COLLECTION SYSTEM
Hawaii Volcanoes National Park
Hawaii Volcanoes National Park
Volcano vicinity
Hawaii County
Hawaii

PHOTOGRAPHS

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