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TRINITY RIVER DIVISION FEATURES

OF THE

CENTRAL VALLEY PROJECT

Technical Record of Design and Construction

Volume I--Design

Volume II--Construction

VOLUME I

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

A Water Resources Technical Publication

CENTRAL VALLEY PROJECT
Trinity River Division, California

General Information

The Trinity River division is the name given to a group of structures all of which are either physically or hydraulically interconnected for the purpose of transmountain diversion of Trinity River water. The Trinity River division is in the Bureau's Central Valley project and is located in Trinity and Shasta Counties of northern California. The Trinity division plan provides for the regulation and control of Trinity River, and for the transbasin diversion of surplus Trinity River water to the Sacramento River to augment the supply and utilization of water in the Central Valley project.

Utilization of the power potential is accomplished at four generating stations, consisting of Trinity, Lewiston, Clear Creek, and Spring Creek Powerplants. Operation of the power system is integrated with the Central Valley project through the facilities of Keswick Powerplant. Energy generated at Trinity, Clear Creek, and Spring Creek Powerplants is conveyed to the Keswick Switchyard for distribution in the Central Valley project transmission system. Power generated at Lewiston Powerplant is intended primarily for local utilization.

Trinity Dam

Location: About 8 miles (13 kilometers) north of Lewiston, Calif., on the Trinity River
Type: Zoned earthfill
Constructed: 1957-1962
Reservoir: Clair Engle Lake
Total capacity to top of active conservation level, elevation 2370 (722.4 meters): 2,447,654 acre-feet (3,019,181,000 cubic meters)
Active capacity: 2,135,023 acre-feet (2,633,551,000 cubic meters)
Surface area: 16,400 acres (6,637 hectares)
Maximum reservoir elevation: 2387 (727.6 meters)
Dam dimensions:
Structural height: 537.5 feet (163.8 meters)
Top width: 40 feet (12.2 meters)
Maximum base width: 2,680 feet (816.9 meters)
Crest length: 2,600 feet (792.5 meters)
Crest elevation: 2395 (730 meters)
Volume: 29,250,889 cubic yards (22,364,000 cubic meters)
Outlet works:
The outlet works has a design capacity of 7,200 second-feet (204 cubic meters per second) at a water surface elevation 2370 (722.4 meters). It consists of a concrete intake structure with diversion inlet, a concrete-lined 28-foot-diameter (8.5-meter) tunnel with a gate structure and shaft housing a 10-foot (3.05-meter) by 20-foot (6.1-meter) fixed-wheel gate, a 28-foot-diameter (8.5-meter) concrete conduit, a concrete control house for two 84-inch (2.1-meter) ring-follower gates and two 84-inch (2.1-meter) hollow-jet valves, a concrete stilling basin and an outlet channel. A 16-foot-diameter (4.9-meter) steel penstock extends from the gate structure to the powerplant manifold, and an 11-foot 3-inch diameter (3.4-meter) steel outlet pipe extends from the powerplant manifold to the outlet works control house manifold where the manifold branches to two 84-inch-diameter (2.1-meter) pipes.
Auxiliary outlet works:
The auxiliary outlet works has a capacity of 2,520 second-feet (71.4 cubic meters per second) at a water surface elevation 2370 (722.4 meters). It consists of a concrete intake structure, a 7-foot-diameter (2.1-meter) concrete conduit, a concrete-lined 7-foot-diameter (2.1-meter) tunnel to the gate chamber, which houses an 84-inch (2.1-meter) ring-follower gate and an 84-inch (2.1-meter) jet-flow gate, and a concrete-lined 8-foot (2.4-meter) ovate tunnel from the gate chamber to the spillway tunnel.

The intake structure has embedded stoplog guides and seats to provide for future installation of stoplogs. Because of the probable excessive depth of water, it is very unlikely that the intake structure will ever be closed with stoplogs.
Spillway:
The spillway has a capacity of 22,400 second-feet (634 cubic meters per second) at a water surface elevation 2387 (727.6 meters). It consists of a 54-foot-diameter (16.5-meter) uncontrolled morning-glory concrete crest structure, a concrete-lined 20-foot-diameter (6.1-meter) inclined shaft and tunnel, a concrete chute, and a concrete flip bucket. The auxiliary outlet works discharges into the spillway tunnel approximately 1,000 feet (305 meters) upstream from the lower portal of the spillway tunnel.

Trinity Powerplant

Location: Immediately downstream from Trinity Dam about 8 miles (13 kilometers) north of Lewiston, Calif.
Constructed: 1960-1963
Structure: Indoor type; reinforced-concrete substructure and intermediate structure; superstructure of structural-steel framing with reinforced grouted brick masonry walls and metal siding; built-up roofing on wood sheathing; metal doors and windows; 300-ton (272-metric-ton) overhead traveling crane. The structure is about 141 feet (43 meters) long, 122 feet (37 meters) wide, and about 126 feet (38 meters) above the lowest point in the foundation.
Generators: Two 55,555-kv.-a., 90 percent power factor, 13,800-volt, vertical-shaft, 200-r.p.m., alternating-current, hydraulic-driven generators. The two generators are paralleled at generator voltage, and connected to three 23,220/30,960/38,700/43,333-kv.-a., 13.2- to 230-grounded wye/132.8-kilovolt, single-phase, outdoor power transformers through generator voltage circuit breakers.

Turbines: Two vertical-shaft, Francis-type, each 85,000 horsepower at 426-foot (129.8-meter) head, with high-head runner; 70,000 horsepower at 334-foot (101.8-meter) head with low-head runner

Lewiston Dam
- Location: On Trinity River, approximately 1 mile (1.6 kilometers) north of Lewiston, Calif.
- Type: Zoned earthfill
- Constructed: 1961-1963
- Reservoir: Lewiston
  - Total capacity to active conservation level, elevation 1902 (579.7 meters): 14,660 acre-feet (18,083,000 cubic meters)
  - Active capacity: 2,890 acre-feet (3,565,000 cubic meters)
  - Surface area: 750 acres (303.5 hectares)
  - Maximum reservoir elevation: 1902 (579.7 meters)
- Dam dimensions:
  - Structural height: 91 feet (27.73 meters)
  - Top width: 25 feet (7.62 meters)
  - Maximum base width: 430 feet (131.06 meters)
  - Crest length: 754 feet (229.8 meters)
  - Crest elevation: 1910 (582.17 meters)
  - Volume: 403,477 cubic yards (308,478 cubic meters)
- Outlet works: Located in left dam abutment and consists of a concrete intake structure, a 4-foot-diameter (122-centimeter) conduit, a gate chamber, and an 8-foot-diameter (24.4-meter) horseshoe conduit
  - Capacity: 320 second-feet (9.06 cubic meters per second) at elevation 1902.0 (579.7 meters)
- Spillway: Located in right dam abutment and consists of a concrete-chute-type structure 65 feet 6 inches (199.6 meters) wide, controlled by two radial gates
  - Capacity: 30,000 second-feet (849.5 cubic meters per second) at elevation 1902.0 (579.7 meters)

Lewiston Powerplant
- Location: Immediately downstream from Lewiston Dam
- Constructed: 1961-1963
- Structure: Indoor type, reinforced concrete; structure also contains river outlet regulating gates. The structure is about 27 feet (8.2 meters) in length, 23 feet (7 meters) in width and 37 feet (11.3 meters) above lowest point in foundation
- Generator: One 438-kv.-a., 480-volt, 80 percent power factor, 600-r.p.m., alternating-current, vertical-shaft, hydraulic-driven generator
- Turbine: Vertical-shaft, Francis-type, nameplate rating of 525 horsepower at 60-foot (18.3-meter) head

Clear Creek Tunnel
- Location: Between Lewiston and Whiskeytown Reservoirs
- Constructed: 1957-1962
- Length: About 10.8 miles (17.4 kilometers) or 56,668 feet (17,272.4 meters)
- Diameter: 17 feet 6 inches (5.33 meters) circular--concrete lined throughout except for 385 linear feet (117.3 meters) of 15-foot 8-inch diameter (4.8-meter) steelplate lining at outlet end
- Capacity: 3,200 second-feet (90.6 cubic meters per second)

Clear Creek Powerplant
- Location: At downstream end of Clear Creek Tunnel, approximately 15 miles (24 kilometers) northwest of Redding, Calif.
- Constructed: 1960-1963
- Structure: Indoor type, reinforced-concrete substructure and intermediate structure; superstructure of structural-steel framing with reinforced grouted concrete block masonry walls and metal siding; built-up roofing on wood sheathing; metal doors and windows; 300-ton (272-metric-ton) overhead traveling crane
- Generators: Two 74,444-kv.-a., 90 percent power factor, 13,800-volt, vertical-shaft, 225-r.p.m., alternating-current, hydraulic-driven generators. The two generators are paralleled at generator voltage and connected to three 35,000/46,667/58,333-kv.-a., 13.2- to 230-grounded wye/132.8-kilovolt, single-phase, outdoor power transformers through generator voltage circuit breakers.
- Turbines: Two vertical-shaft, Francis-type, each with a nameplate rating of 93,500 horsepower at 535-foot (163-meter) head

Clear Creek Switchyard
- Location: About 340 feet (104 meters) southeast of Clear Creek Powerplant
- Initial installation: Terminal facilities for a 230-kilovolt single circuit from Trinity Powerplant; a 230-kilovolt single circuit from Clear Creek Powerplant, and for two 230-kilovolt circuits to Keswick Switchyard, utilizing four bay positions and a bus tie bay; power circuit breaker in bus tie bay, and disconnecting switches in others
- Ultimate installation: Switchyard area is sufficient to accommodate seven 230-kilovolt bays, three 115-kilovolt bays, and a 230- to 115-kilovolt transformer bank

Whiskeytown Dam
- Location: On Clear Creek, approximately 10 miles (16 kilometers) west of Redding, Calif.
- Type: Zoned earthfill
- Constructed: 1960-1963

Reservoir: Whiskeytown
Total capacity to normal operating level, elevation 1210 (368.8 meters): 241,096 acre-feet (297,392,000 cubic meters)
Active capacity: 213,554 acre-feet (263,419,000 cubic meters)
Surface area: 3,220 acres (1,303.1 hectares)
Maximum reservoir elevation: 1220.5 (372 meters)
Dam dimensions:
Structural height: 281.5 feet (85.8 meters)
Top width: 30 feet (9.1 meters)
Maximum base width: 1,492 feet (454.8 meters)
Crest length: 4,070 feet (includes dikes), (1,240.5 meters)
Crest elevation: 1228.0 (374.3 meters)
Volume: 4,535,094 cubic yards (3,467,000 cubic meters) volume includes dike
Outlet works: Located in left dam abutment and consists of a concrete intake structure with a 19-foot-diameter (5.8-meter) pressure tunnel, a gate chamber, and a 19-foot-diameter tunnel housing outlet pipes. An upper level intake system has an intake structure, 6-foot-diameter (1.8-meter) vertical shaft, then a 6-foot-diameter (1.8-meter) horizontal tunnel, and gate chamber.
Capacity: 900 second-feet (25.5 cubic meters per second) at elevation 1110.0 feet (338.3 meters)
Spillway: Located in left dam abutment and consists of a concrete glory-hole inlet structure, a 21-foot-diameter (6.4-meter) tunnel, a flip bucket and an outlet channel
Capacity: 28,780 second-feet (815 cubic meters per second) at elevation 1220.5 feet (372 meters)

Spring Creek Power Conduit
Location: Between Whiskeytown and Keswick Reservoirs
Constructed: 1960-1963
Length: About 3.1 miles (5 kilometers)
Diameter:
Tunnel 1--8,062 linear feet (2,457.3 meters), concrete lined to 18 feet 6 inches (5.6 meters); 232 linear feet (70.7 meters) at outlet end, steel lined to 17 feet (5.2 meters)
Tunnel 2--220 linear feet (67 meters) at inlet end, steel lined to 17 feet (5.2 meters); 3,015 linear feet (919 meters) concrete lined to 18 feet 6 inches (5.6 meters); 1,165 linear feet (373.6 meters) at outlet end, steel lined to 17 feet (5.2 meters)
Tailrace tunnel--567 linear feet (173 meters), horseshoe, concrete lined to 21 feet (6.4 meters)
Structures:
Tunnel 1--Ungated intake facility and emergency gate structure
Rock Creek Siphon--About 3,090 linear feet (942 meters), steel lined to 17 feet (5.2 meters), blowoff and turnout facilities for domestic water supply to town of Redding
Tunnel 2--18-inch-diameter (45.7-centimeter) air vent, surge tank and penstock valve structure
Tailrace tunnel--Inlet and outlet structure
Capacity: 3,600 second-feet (101.9 cubic meters per second)

Spring Creek Powerplant
Location: At west bank of Keswick Reservoir, about 1.5 miles (2.4 kilometers) northwest of Keswick Dam and Powerplant
Constructed: 1960-1964
Structure: Indoor type; reinforced-concrete substructure and intermediate structure; superstructure of structural-steel framing with reinforced grouted concrete masonry walls and metal siding; built-up roofing on wood sheathing; metal doors and windows; 300-ton (272-metric-ton) overhead traveling crane
Generators: Two 83,333-kv.-a., 90 percent power factor, 13,800-volt, vertical-shaft, 225-r.p.m., alternating-current, hydraulic-driven generators. The two generators are paralleled at generator voltage and connected to three 34,800/46,400/58,000/65,000-kv.-a., 13.2- to 230-grounded wye/132.8-kilovolt single-phase outdoor power transformers through generator voltage circuit breakers.
Turbines: Two vertical-shaft, Francis-type, each with a manufacturer's rating of 105,000 horsepower at 544-foot (166-meter) head

Spring Creek Debris Dam
Location: On Spring Creek, about 1.8 miles (2.9 kilometers) northwest of Keswick Dam and Powerplant
Type: Earth and rock fill
Constructed: 1961-1963
Reservoir: Spring Creek Reservoir
Total capacity to top of active conservation level, elevation 795.0 (242.3 meters): 5,874 acre-feet (7,246,000 cubic meters)
Active capacity: 5,812 acre-feet (7,169,000 cubic meters)
Surface area: 87 acres (35.2 hectares)
Maximum reservoir elevation: 809.5 (246.7 meters)
Dam dimensions:
Structural height: 196 feet (59.7 meters)
Top width: 30 feet (9.1 meters)
Maximum base width: 1,040 feet (317 meters)
Crest length: 1,110 feet (338 meters)
Crest elevation: 816.0 (248.7 meters)
Volume: 1,891,279 cubic yards (1,446,000 cubic meters)
Outlet works: Extends up the face of the dam to provide for raising the intake sill, and includes a 6-foot-diameter (1.8-meter) circular conduit, a gate chamber, a stilling basin, and an outlet channel
Capacity: 710 second-feet (20.1 cubic meters per second)

Spillway: Consists of an approach channel, an uncontrolled chute-type spillway, 25 feet (7.6 meters) wide, a stilling basin, and a channel
Capacity: 5,260 second-feet (148.9 cubic meters per second)

Note: Metric equivalents are in parentheses ( ). See appendix I for conversion factors and appendix K for conversion diagrams.

PART I--INTRODUCTION

CHAPTER I. HISTORY AND DESCRIPTION

1. The Trinity River Division. The Trinity River division (figs. 1 and 2), a multiple-purpose development in Trinity and Shasta Counties of northwestern California, will provide irrigation, power, recreation, fish and wildlife conservation, and water quality control. The Trinity River division is an integral part of the Central Valley project.

The development includes as a major storage feature Clair Engle Lake (formerly Trinity Reservoir), with a capacity of about 2-1/2-million acre-feet, to store waters of the Trinity River. Releases from the reservoir will be utilized by a 100,000-kilowatt powerplant which will in turn supply much needed electrical energy to northern California. Downstream releases from the dam or powerplant will be reregulated in a small reservoir formed behind the Lewiston Diversion Dam. It is at this point that the Trinity River waters are separated into appropriate quantities. Lewiston Dam contains outlets to release adequate water to meet downstream requirements of the Trinity River basin, including those of the important Trinity River fishery. Energy in these releases is converted to electrical power by the small (350-kilowatt) Lewiston Powerplant.

Water not needed in the Trinity River basin will be diverted through the Clear Creek Power Conduit to the 134,000-kilowatt Clear Creek Powerplant and then into the 241,000-acre-foot Whiskeytown Reservoir on Clear Creek, a tributary of the Sacramento River. From Whiskeytown Reservoir the diverted Trinity River water and any surplus water obtained from Clear Creek will be released through the Spring Creek Power Conduit to the 150,000-kilowatt Spring Creek Powerplant with final discharge being into Keswick Reservoir on the Sacramento River, and also eventually south to that portion of the Bald Hills area which lies north of Cottonwood Creek.

By proper distribution of the Trinity division water supply usable for irrigation, and making maximum use of return flows and available surplus flows, a yield of 1,422,000 acre-feet per year should be available to help serve expanding requirements of the Sacramento Canals unit, lands in the Delta-Mendota Canal service area, Shasta County, and other areas of the Central Valley project.

2. Need for the Project. The Trinity River basin encompasses an area of about 2,965 square miles lying between the northernmost part of the great Central Valley and California's north coastal area. The Trinity River is a 130-mile-long tributary of the Klamath River which flows westerly into the Pacific Ocean.

Each year, hundreds of thousands of acre-feet of water, which could be developed for irrigation and hydroelectric power, flowed down the Trinity River and were lost into the sea.

Investigations concluded that the fullest and most economic conservation and utilization of the water resources of the Trinity River for the widest possible public benefit would be obtained by the diversion of surplus water into the Central Valley basin. The water thus diverted could be put to beneficial use for irrigation in the Central Valley without impairing in any way consumptive requirements within the Trinity and Klamath River basins. Hydroelectric power essential to the industrial growth of the northern counties and the entire State could be produced by dropping the water some 1,800 feet in the 20 miles between the Trinity and Sacramento Rivers. (See hydraulic profile of the Trinity River division features in figure 3.)

(a) *Irrigation Needs.*--Surplus Trinity River water is needed to assist in meeting the expanding requirements for water in the Central Valley of California. It is needed to help place into maximum crop production thousands of acres of farmland now restricted by inadequate supplies of irrigation water. The increased production of foods and fibers is needed to meet the requirements of the growing population in California.

Among the areas in the Central Valley suitable of early development, and for which additional irrigation water supplies were required, are lands adjacent to the Sacramento River, including the Cow Creek unit of the Trinity River division, Bald Hills area of southwestern Shasta County, the Sacramento Canals unit of the Central Valley project1/ and lands along the Delta-Mendota Canal. The Sacramento Canals unit involves both sides of the Sacramento River, and ultimately should place over 200,000 acres of land in the Sacramento Valley under irrigation.

Because of failing ground-water supplies, portions of the southern San Joaquin Valley were in immediate need of supplemental irrigation water. To meet this need, the Central Valley project, as initially authorized, provided for the construction of Friant Dam to store waters of the San Joaquin River and transfer them south through the 160-mile-long Friant-Kern Canal. This, however, precluded future use of San Joaquin River water for irrigation along the lower portion of the river. Therefore, stored water released into Sacramento River is carried across the Delta, then along the west side of the San Joaquin Valley by the Delta-Mendota Canal to Mendota Pool where it restores the flow of the San Joaquin River. The Delta-Mendota Canal, extending from the Tracy Pumping Plant in the Delta, 117 miles up the San Joaquin Valley to the Mendota Pool, was designed to convey an average of about 800,000 acre-feet of water per year to the Mendota Pool to meet the exchange contract demands of lands formerly irrigated from the San Joaquin River. In addition, the canal was constructed with provision of capacity for future use.

1/Public Law 839, 81st Congress, 2d Session.

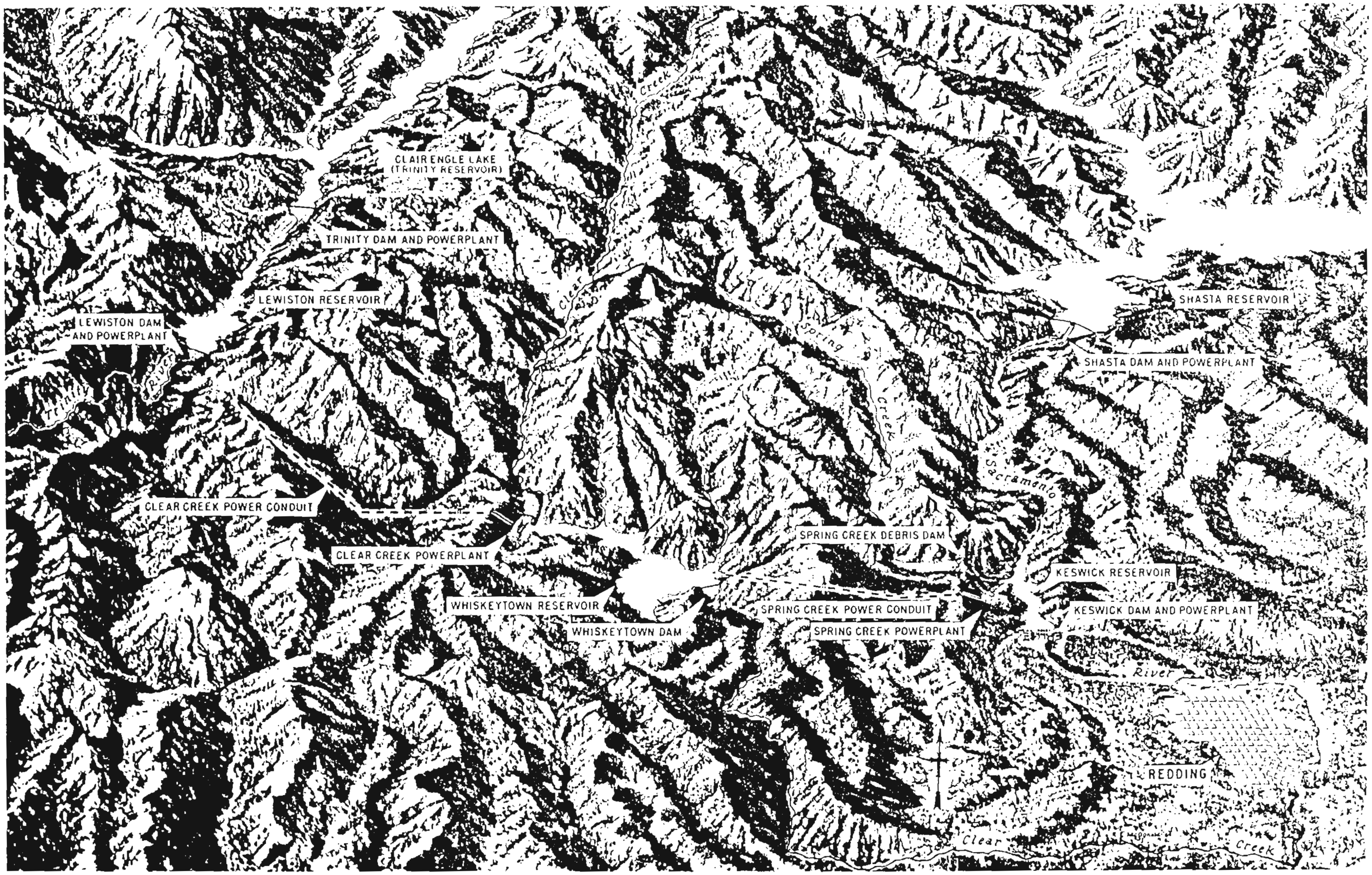

Figure 1. --Trinity River division features--Artist's conception. P416-D-43865

Figure 2. --Trinity River division features location map. From drawing No. 416-D-2685

Figure 2. --Trinity River division features location map. From drawing No. 416-D-2685

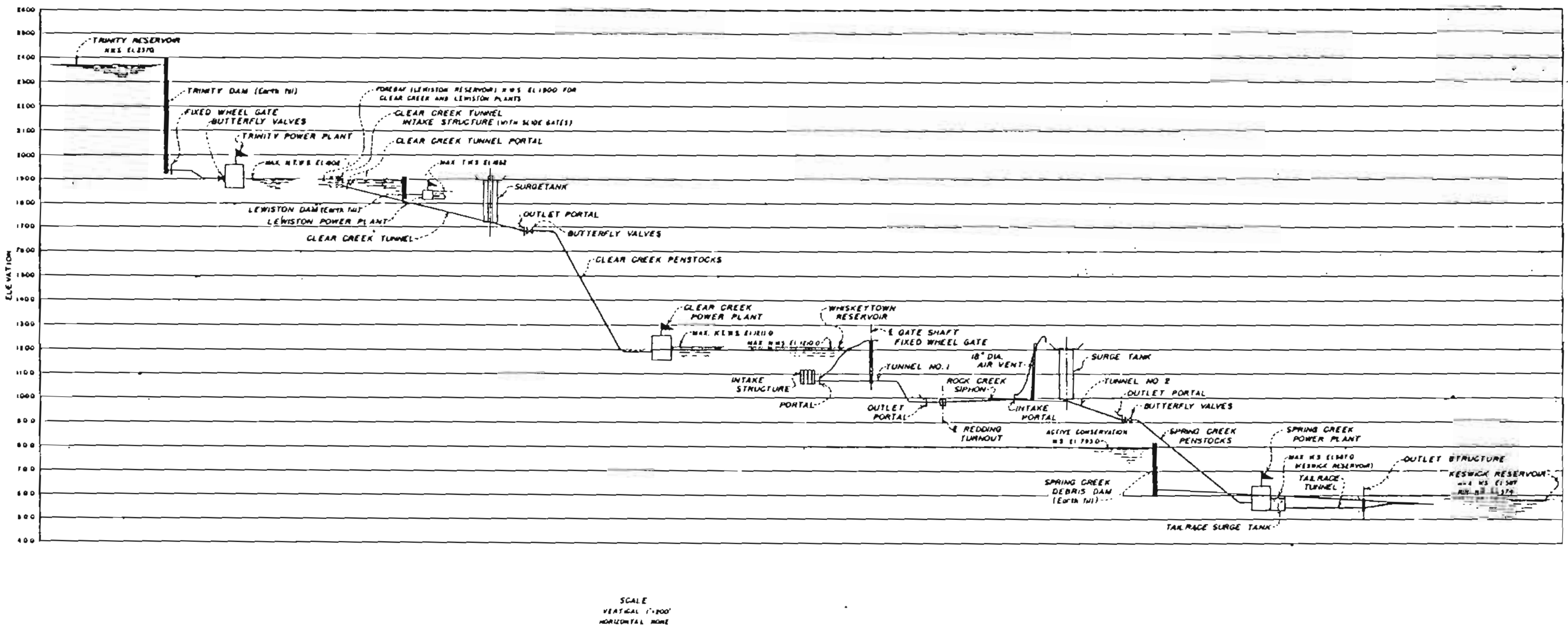

Figure 3. --Power system hydraulic profile. From drawing No. 416-D-2803

(b) *Need for Hydroelectric Energy.*--All of northern California is in need of increasing amounts of electric power for farms, homes, and rapidly developing industries. An increasing population, more irrigation pumping, and expanding industries are placing a burden on existing facilities. Additional construction of generating and transmission works is needed to assure a long-range power supply. Dependable capacity margins are below those considered adequate to meet the expected load growth.

Maximum development of hydroelectric plants making use of renewable water resources is desirable for conservation of dwindling fuel reserves. Generation at the hydroelectric power installations discussed in this publication corresponds to the consumption of over 2,000,000 barrels of fuel oil each year in steam-electric powerplants.

3. The Trinity River Basin. (a) *Climate.*--Precipitation in northern California, including the Trinity River basin, results primarily from frontal storms. Westerly winds moving in from the coast carry with them the numerous storm fronts which originate far out over the Pacific Ocean. These storms, occurring primarily during the winter months, are forced to rise and lose their moisture by the topographic barrier formed by the mountains of the upper Trinity River basin. The average annual precipitation in the upper Trinity River basin varies from about 40 inches near Lewiston to nearly 80 inches at some of the higher elevations. Precipitation falls in the form of snow in the higher elevations and this results in a snowmelt pattern of runoff at the stream gaging station near Lewiston. The lower portion of the basin receives most of its precipitation in the form of rain, which is typical along the Coast Range.

In general, the climate of the area is mild. The average annual temperature at Weaverville, the county seat, is 53.2° F.; extremes have varied from a minimum of 3° below zero to a maximum of 113° F.

(b) *History.*--The remoteness of the area from industrial and market centers and the fluctuating demands for the basin's raw materials have had a marked influence on its history. A century ago, soon after the discovery of gold on the American River, gold was discovered in the upper Trinity River basin. As a result, gold seekers invaded the area and founded several small towns, some of which have survived to the present. Trinity Center, for example, was an important supply center and stage stop on the old California-Oregon trail, the main line of commerce between the two States before the railroad along the Sacramento River was completed in the 1880's.

(c) *Population.*--The population of the area and its sources of livelihood have varied considerably. As the placer operations for gold were either worked out or became uneconomical, some of the residents left the country while others turned their efforts toward developing other natural resources, including various mineral deposits, timber, and agriculture. The gradual change from mining to the development of these resources resulted in a more stable population.

During World War II, many people left the basin for military service and for defense industrial work. This outward migration was somewhat replaced by entry of those interested in the development of the basin's critical minerals, particularly chromites and manganese. Another factor of balance was the growth of logging operations. Since World War II the population of the basin has grown slowly but steadily as a result of increased logging operations and establishment of forest products industries. In the 30-year period, 1930 to 1960, population of Trinity County increased from 2,800 to 9,700.

The basin is still only sparsely settled. Most of the population is centered in the small communities of Hayfork, Weaverville, and Lewiston. The largest of these communities is Weaverville, with a population of about 1,700.

(d) *Economy.*--The economic base for the upper Trinity River basin is founded upon the utilization of its natural resources. This sparsely populated area, with settlements virtually surrounded by forests, retains some aspects of a frontier. Livestock raising, mining, and lumbering are the chief industries. The provision of goods and services to local residents, vacationists, and sportsmen comprises the remainder of the economic base. Industrial development of the basin, however, has been limited and largely dependent upon the marketing of the region's raw materials.

With the exception of gold mining and the utilization of agricultural land, the resources of the basin are virtually untouched. Chief of these is water, but timber, minerals, and recreation are fertile fields for economic expansion. Increased capital investment and improved highways and roads will accelerate the development of these resources. A basic requirement for continued development, however, is an abundant supply of power at lower cost than energy now available (1957). A higher level and permanent increase in the forest products industry can be accomplished under a program of sustained yield management. The existence of a large supply of saw timber in the area offers raw materials for industrial development. Local smelting and processing of the region's minerals constitute important industrial possibilities. Tourist and resort establishments, now profitable outlets for retail and wholesale trade, are expected to expand with an increased development of the recreation resource.

Agricultural activity in the basin is limited by rough topography and extensive forests; opportunities for development of irrigation within the basin are very limited. The Trinity River basin will benefit from the transbasin diversion primarily through increases in available local power supply which will make possible the expansion of extractive and processing industries; and through development of facilities for tourists and recreationists that will result from the creation of two lakes on Trinity River and one on Clear Creek.

4. Clear Creek and Trinity River. The Trinity River is one of the principal tributaries of the Klamath River and drains an area of 2,965 square miles. The average annual runoff (using 30-year averages from

Oct. 1921 through Sept. 1951) of Trinity River at its confluence with the Klamath River is about 4,000,000 acre-feet, or about one-third of the Klamath flows discharging into the Pacific Ocean. The upper portion of the Trinity River basin above the proposed point of transbasin diversion drains about 713 square miles which contributes an average annual runoff of about 1,075,000 acre-feet.

Required releases past Lewiston damsite are estimated to be 171,000 acre-feet annually (120,000 for fish and 50,000 spill), as compared to an average runoff at that point of over 1,000,000 acre-feet, thus leaving a large proportion of the runoff surplus to the basin.

The greater portion of upper Trinity River runoff occurs during the late winter and early summer months, as is typical of snowmelt streams. Roughly 75 percent of the runoff thus occurs during the months of February through June.

Clear Creek, the other stream with which the development is directly concerned, a minor tributary of the Sacramento River, has a drainage area of about 228 square miles above the gaging station at Igo. The Igo gage, which is maintained by the Geological Survey, is located about 10 miles above the confluence of Clear Creek with Sacramento River. The average annual runoff at this point was estimated to be 227,000 acre-feet. The corresponding average annual flow of Clear Creek at Whiskeytown damsite, which is about 6 miles above the Igo gage, was estimated to be 194,000 acre-feet annually.

5. Use of Trinity River and Clear Creek Prior to Project. While the water resources of Trinity River and Clear Creek had not been developed appreciably prior to construction of the Trinity division features, some water had been used in the past for mining purposes and a small amount was being used for irrigation. There were no storage reservoirs within either the Trinity River or Clear Creek basins; consequently, all of the heavy winter and spring runoff was wasted to the ocean.

Preliminary studies indicated that the existing consumptive use of water within the Trinity and lower Klamath River basins was small and would remain small in relation to total flows available. There are no major diversions from the rivers below Lewiston.

The principal need for a substantial flow in the Trinity River at the present time is to support the fishery resources, particularly the salmon and the sports fishery, and to maintain the aesthetic value of the stream.

The principal existing diversion works on Clear Creek were located at the Seltzer Dam about 4 miles downstream from the Igo gage. The dam is a concrete gravity structure about 18 feet high with a maximum possible diversion capacity of about 15 second-feet. This diversion is used to irrigate a small acreage and to furnish water for a small millpond.

6. Integrated Operation with Other Features of Central Valley Project. Shasta and Folsom Reservoirs within the Sacramento Valley basin are operated coordinately to meet the requirements for irrigation, municipal and industrial uses, navigation, fish protection, and power production as well as for control of floods. The addition of Trinity River water and Clear Creek water to the Central Valley project introduces an average (30-year average) additional water supply of about 943,000 acre-feet each year and additional hydroelectric powerplants of 384,350-kilowatt capacity. The geographical location of the new features as related to Shasta, Keswick, and Folsom Dams and Reservoirs, enhances the possibilities of exchanging both water and power among the various features, thereby providing much greater flexibility in the operation of the whole system. The location of the Trinity system is particularly advantageous, for Trinity releases not only are able to supply water to areas of demand below Keswick, but in so doing can generate approximately three times the amount of hydroelectric energy which would be produced if the same amount of water were released from Shasta Reservoir. This, of course, is due to the fact that the Trinity system has about three times the power head of Shasta Powerplant.

In addition, the location of the Trinity system makes possible the routing of the Trinity transbasin diversions, as well as Clear Creek diversions, through Keswick Powerplant for the generation of additional energy without the expenditure of additional funds for generating facilities. Although, during extremely wet years when Shasta Lake is spilling, there will be more flows past Keswick Dam than can be utilized by Keswick Powerplant, the occurrence of such conditions will not be frequent and will not adversely affect the plan of integration.

The construction of the Trinity Reservoir to store winter surplus runoff, and the completion of the transbasin diversion tunnels to convey Trinity River water to the Central Valley basin,will increase the irrigation yield of the Central Valley project. Whiskeytown Reservoir will regulate Clear Creek flows, reregulate water releases from the Clear Creek Power Conduit, act as a forebay for the Spring Creek Powerplant, serve ultimately as a diversion reservoir for a potentially irrigable area along Cottonwood Creek in Shasta County, and also hold a substantial reserve for irrigation when needed during critical dry years.

7. Authorization. The Trinity River division, Central Valley project, was authorized on August 12, 1955, by the 84th Congress, 1st Session, Chapter 872 (All 69 Stat. 719, Public Law 386) and by the Secretary of the Interior pursuant to Section 9a of Reclamation Project Act of 1939, January 2, 1953.

A. Features of the Trinity Division

8. General. This technical record presents detailed information on Trinity Dam and Powerplant because of their classification as major structures. In addition, a detailed discussion of both Spring

Creek and Clear Creek Power Conduits has been included because of their being unique in size, complexity, and methods of design and construction.

In addition, other features necessary to the project understanding and which are essential to the publication and future records, have been included in a brief functional presentation.

9. Trinity Dam. Trinity Dam is located in Trinity County, Calif., on the Trinity River; within the Trinity National Forest, approximately 8 miles north of Lewiston, Calif.

Trinity Dam contains about 29,251,000 cubic yards of earth, sand and gravel, and rock. The crest, at elevation 2395, is 40 feet wide and 537.5 feet above the foundation. The crest length is 2,600 feet and the maximum base width is 2,680 feet. The reservoir, Clair Engle Lake (formerly Trinity Reservoir), at active conservation capacity level 2,370, has a total capacity of 2,447,654 acre-feet. At this elevation it has a surface area of 16,400 acres. Releases from the reservoir will normally be through the 100,000-kilowatt Trinity Powerplant.

The embankment consists of four zones of selected materials. The central zone 1 forms the impervious watertight barrier. The material for this zone is a selected weathered rock which breaks down into clay, silty sand, and rock particles during excavation and compaction.

The zone 2 portions of the embankment, which flank each side of the core, were designed to utilize material from a left abutment slide area, stripping from the rock source, and selected material from required structural and foundation excavations.

Zone 3 portions of the embankment form the pervious outer zones of the dam. Materials in this zone, consisting of sand, gravel, cobbles, and boulders were obtained from excavations for the dam foundation and from borrow areas in the river channel upstream and downstream from the dam.

The upstream and downstream toes of the dam are rockfills, designated as zone 4. The upstream slope of the dam is covered with a 3-foot layer of riprap as protection against reservoir wave action, and the downstream slope is surfaced with a 24-inch layer of rock to prevent erosion of the underlying material.

The outlet works, located in the left dam abutment, consists of a concrete intake structure with diversion inlet, a concrete-lined 28-foot-diameter tunnel with a gate structure and shaft housing a 10- by 20-foot fixed-wheel gate, a 28-foot-diameter concrete conduit, a concrete control house for two 84-inch ring-follower gates and two 84-inch hollow-jet valves, a concrete stilling basin and an outlet channel. A 16-foot-diameter steel penstock extends from the gate structure to the powerplant manifold and 11-foot 3-inch-diameter steel outlet pipe extends from the powerplant manifold to the outlet works control house manifold where the manifold branches into two 84-inch-diameter pipes. The outlet works has a design capacity of 7,200 second-feet at water surface elevation 2370.

The auxiliary outlet works, located in the left abutment, consists of a concrete intake structure, a 7-foot-diameter concrete conduit, a concrete-lined 7-foot-diameter tunnel to the gate chamber, which houses an 84-inch ring-follower gate and an 84-inch jet-flow gate, and a concrete-lined 8-foot ovate tunnel from the gate chamber to the spillway tunnel. The auxiliary outlet works has a design capacity of 2,520 second-feet at water surface elevation 2370.

The spillway, located in the left dam abutment, consists of a 54-foot-diameter uncontrolled morning-glory concrete crest structure, a concrete-lined 20-foot-diameter inclined shaft and tunnel, a concrete chute, and a concrete flip bucket. The auxiliary outlet works discharges into the spillway tunnel approximately 1,000 feet upstream from the lower portal of the spillway tunnel. The spillway has a design capacity of 22,400 second-feet at water surface elevation 2387.

10. Trinity Powerplant. Trinity Powerplant is located immediately downstream from Trinity Dam. The structure is of the indoor type with a reinforced-concrete substructure and intermediate structure. The superstructure is of structural-steel framing with reinforced grouted brick masonry walls and metal siding. The roof is constructed of built-up roofing on wood sheathing. The structure has metal doors and windows. A 300-ton overhead traveling crane has been installed for equipment installation and maintenance. The structure is about 140 feet 8 inches in length, 122 feet 4 inches in width, and its height is about 126 feet above the lowest point in the foundation.

Two hydraulic-driven generators, each rated as follows, are installed in the plant: 55,555 kilovolt-amperes, 90 percent power factor, 13,800 volts, vertical shaft, 200 revolutions per minute, alternating-current type. Two Francis-type turbines drive the generators and each is rated as follows: vertical shaft, 85,000 horsepower at a 426-foot head with high-head runners, and 70,000 horsepower at a 334-foot head with low-head runners.

11. Lewiston Dam, Powerplant, and Reservoir. Lewiston Dam is located in Trinity County, Calif., on the Trinity River, approximately 1 mile north of Lewiston, Calif. The reservoir has a capacity of 14,660 acre-feet and a surface area of about 750 acres. The dam provides a means whereby water is diverted into the Clear Creek Power Conduit.

The dam is an earthfill structure about 91 feet high above the foundation and has a crest length of 754 feet and a volume of 403,477 cubic yards. Immediately downstream of the dam is a small indoor powerplant which houses a small (438 kv.-a.) generator. The power generated is generally for use in the immediate area.

12. Clear Creek Tunnel. Clear Creek Tunnel is the major portion of the power conduit used to convey water from Lewiston Reservoir on the Trinity River to Clear Creek Powerplant which is located near the upper end of Whiskeytown Reservoir. The circular tunnel is about 10.8 miles in length and lined throughout with concrete to a finished diameter of 17 feet 6 inches except for a length of 385 feet at the outlet end which is lined with steelplate to a diameter of 15 feet 8 inches. At its outlet end the conduit divides into two 10-foot 6-inch diameter Clear Creek Powerplant penstocks. The tunnel has a capacity of 3, 200 second-feet.

13. Clear Creek Powerplant. Clear Creek Powerplant is located at the downstream end of Clear Creek Power Conduit, approximately 15 miles northwest of Redding, Calif. The structure is of the indoor type with a reinforced-concrete substructure and intermediate structure. The superstructure is of structural-steel framing with reinforced grouted concrete block masonry walls and metal siding. The roof is constructed of built-up roofing on wood sheathing. The structure has metal doors and windows. A 300-ton overhead traveling crane has been installed for equipment installation and maintenance. The structure is about 142 feet 4 inches in length, 75 feet in width, and its height is about 120. 6 feet above the lowest point in the foundation.

Two hydraulic-driven generators, each rated as follows, are installed in the powerplant: 74, 444 kilovolt-amperes, 90 percent power factor, 13, 800 volts, vertical shaft, 225 revolutions per minute, alternating-current type. Two Francis-type turbines drive the generators and each is rated as follows: vertical shaft, 93, 500 horsepower at 535-foot head.

14. Whiskeytown Dam and Reservoir. Whiskeytown Dam, which was dedicated by the late President John F. Kennedy on September 28, 1963 (fig. 4), is located in Shasta County, Calif., on Clear Creek, approximately 10 miles west of Redding, Calif. The dam will capture and reregulate releases of Trinity River water from the Clear Creek Powerplant and will divert this water, plus the usable flow of Clear Creek, into the Spring Creek Tunnel which in turn conveys the water to the Spring Creek Powerplant.

The main dam embankment is approximately 2, 250 feet long at crest elevation 1228.0 and has a height of approximately 272 feet above the bed of Clear Creek. Additional embankments, one over 1, 050 feet long and 75 feet high and one over 700 feet long and 20 feet high, are required in saddles on the right abutment.

The zone 1 portion of the dam embankment consists of selected weathered rock (clay, silt, sand, and gravel sizes) compacted by tamping rollers to 6-inch layers. The zone 2 portions of the dam embankment consists of selected weathered rock (silt, sand, and gravel sizes, and rock fragments to 8-inch maximum size) compacted by tamping rollers to 12-inch layers. The zone 3 portions of the dam embankment consist of selected rock fines compacted by crawler-type tractor to 12-inch layers. The zone 4 portion of the dam embankment consists of rockfill placed in 3-foot layers. The upstream slope of the dam embankments above elevation 1095 is protected by riprap and the downstream slope is protected by a rock blanket.

The spillway consists of glory-hole inlet structure, a concrete-lined transition from a 24-foot 6-inch diameter to a 21-foot diameter, a 21-foot-diameter concrete-lined tunnel, a flip bucket structure, and an outlet channel. The spillway has a design capacity of 28, 780 second-feet at water surface elevation 1220. 5.

The outlet works consists of a concrete intake structure with a 19-foot-diameter conduit and concrete-lined tunnel, and an upper level system consisting of a concrete intake structure and shaft with a 6-foot-diameter concrete-lined tunnel leading to the gate chamber for three 2-foot 9-inch by 3-foot 9-inch gates; a 19-foot-diameter concrete-lined tunnel and conduit enclosing two 45-inch-diameter steel outlet pipes from the gate chamber to the control house; a control house for two 2-foot 9-inch by 3-foot 9-inch gates and a 10-inch jet-flow gate; and an outlet channel. Concrete retaining walls were constructed at the downstream ends of the flip bucket and control house structures. The outlet works has a design capacity of 900 second-feet at water surface elevation 1110. 0. The reservoir has a total capacity of 241, 096 acre-feet and a surface area of 3, 220 acres.

15. Spring Creek Power Conduit. Spring Creek Power Conduit includes the waterways for the headrace and tailrace system of the Spring Creek Powerplant.

The headrace system conveys water from Whiskeytown Reservoir, located on Clear Creek, to the Spring Creek Powerplant located on Spring Creek, which forms near its mouth an arm of Keswick Reservoir. The headrace system is comprised of two circular, concrete-lined tunnels, an inverted siphon connecting the two tunnels, and a steel penstock section. The overall length of the headrace conduit is a little less than 3-1/3 miles. The approximate lengths, inside diameters, and maximum operating heads of the conduit excluding the penstocks are as presented in the following tabulation:

Feature	Diameter, feet and inches	Approximate length, feet	Lining	Approximate maximum operating head, feet
Tunnel 1	18-6	8, 060	Concrete	240
Tunnel 1	17-0	230	Steel	240
Rock Creek Siphon	17-0	3, 090	Steel	240
Tunnel 2	17-0	220	Steel	225
Tunnel 2	18-6	3, 060	Concrete	300
Tunnel 2	17-0	1, 165	Steel	390

The power conduit has a capacity of 3, 600 second-feet.

Figure 4.--The late President John F. Kennedy dedicating Whiskeytown Dam on September 28, 1963. Composite of P416-200-30 and P416-200-17.

The tailrace system conveys water from the end of the Spring Creek Powerplant draft tubes to Keswick Reservoir on the Sacramento River. The tailrace system is comprised of a tunnel and an excavated channel. The tunnel consists of a 21-foot-diameter concrete-lined horseshoe conduit 567 feet in length.

16. Spring Creek Powerplant. The Spring Creek Powerplant is located on the west bank of Keswick Reservoir, about 1-1/2 miles northwest of Keswick Dam and Powerplant. The structure is of the indoor type with a reinforced-concrete substructure and intermediate structure. The superstructure is of structural-steel framing with reinforced grouted concrete masonry walls and metal siding. The roof is constructed of built-up roofing on wood sheathing. The structure has metal doors and windows. A 300-ton overhead traveling crane has been installed for equipment installation and maintenance. The structure is about 163 feet 2 inches in length, 75 feet 4 inches in width, and its height is about 128 feet above the lowest point in the foundation.

Two hydraulic-driven generators, each rated as follows are installed in the powerplant: 83, 333 kilovolt-amperes, 90 percent power factor, 13, 800 volts, vertical shaft, 225 revolutions per minute, alternating-current type. Two Francis-type turbines drive the generators and each is rated as follows: vertical shaft, 105, 000 horsepower at 544-foot head.

17. Spring Creek Debris Dam and Reservoir. Spring Creek Debris Dam is located on Spring Creek about 1.8 miles northwest of Keswick Dam and Powerplant. The dam contains about 1, 891, 000 cubic yards of earth and rock fill. The crest elevation is 816.0, the crest length is 1, 100 feet, and the crest width is 30 feet. The dam rises 196 feet above foundation.

The embankment is constructed of two zones, a selected weathered rock zone upstream and a miscellaneous fill zone downstream. A 10-foot layer of selected miscellaneous material underlies the downstream miscellaneous zone. The upstream slope is protected by 3 feet of riprap on 18 inches of bedding, and the downstream slope is covered with a 12-inch-thick blanket of rock above elevation 770.

Spring Creek Debris Dam serves two purposes: First, to prevent the building up in Spring Creek of a sediment delta which would obstruct the tailrace of Spring Creek Powerplant, and secondly to provide temporary storage of Spring Creek water which carries a high concentration of heavy metals and acid which originate in the abandoned mine and smelter dumps until such flows can be properly diluted.

The reservoir has a gross storage of 7, 286 acre-feet (including 1, 412 acre-feet of surcharge), an active storage of 5, 812 acre-feet, and an inactive or dead storage of 62 acre-feet. Maximum water surface elevation is 809. 5.

The outlet works, with a total length of well over 1, 000 feet, is located in the center of the dam. It has a concrete intake structure, a 6-foot-diameter circular concrete conduit, a concrete gate chamber which houses two 2-foot 3-inch by 2-foot 3-inch high-pressure regulating gates, then a 6-foot 6-inch horseshoe-shaped conduit which terminates in a stilling basin. The outlet works has a capacity of 710 second-feet at maximum water surface elevation 809. 5.

An ungated, concrete. chute-type spillway is located in the left dam abutment. The crest of the 25-foot-wide spillway is at elevation 795.00. The spillway capacity is 5, 260 second-feet at maximum water surface elevation 809. 5.

18. Cost Summary. Table 1 summarizes the total estimated cost of each of the major features that comprise the Trinity River division of the Central Valley project. The summary is based on information submitted by the Regional Director on June 3, 1964. All amounts shown in the table represent actual costs recorded through March 31, 1964.

Table 1.--Total estimated cost of selected Trinity River division features

Feature	Total cost	Direct cost			Total direct cost	Indirect cost					Total indirect cost
		Construction contracts	Materials	Force account labor		Construction facilities	Field office	Regional office	Preliminary surveys and investigations	Denver office	
Trinity Dam and Reservoir	$73,442,125	$61,875,270	$ 3,254,757	$25,409	$65,155,436	$1,334,312	$3,182,349	$1,909,022	$228,479	$1,632,527	$ 8,286,689
Trinity Dam and Reservoir--Land	4,097,578	3,170,529	50	11,529	3,182,108	20,871	326,530	568,069			915,470
Trinity Powerplant	7,631,051	2,730,018	3,307,657	4,532	6,042,207	153,584	435,743	194,927	29,266	775,324	1,588,844
Lewiston Dam and Reservoir	3,717,818	2,747,952	142,792	3,778	2,894,522	121,280	266,646	108,921	13,576	312,873	823,296
Lewiston Dam and Reservoir--Land	356,040	307,907			307,907	6	13,649	34,478			48,133
Lewiston Powerplant	377,613	222,958	61,988	277	285,223	7,042	18,393	11,896	534	54,525	92,390
Clear Creek Tunnel	49,110,711	45,110,527	76,130	4,136	45,190,793	680,134	1,496,256	1,135,638	131,946	475,944	3,919,918
Clear Creek Tunnel--Land	67,194	45,936			45,936	1,161	10,925	9,172			21,258
Clear Creek Powerplant	10,826,355	4,169,515	4,789,566	5,249	8,964,330	209,402	615,085	262,374	32,794	742,370	1,862,025
Whiskeytown Dam and Reservoir	10,883,813	8,628,383	110,239	20,038	8,758,660	331,859	1,078,189	287,437	48,794	378,874	2,125,153
Whiskeytown Dam and Reservoir--Land	1,775,093	1,465,937		42	1,465,979	3,344	119,696	186,074			309,114
Whiskeytown Dam and Reservoir--Highway 299 Relocation	4,453,313	4,057,687	69		4,057,756	52,315	68,672	243,649		30,921	395,557
Spring Creek Tunnel	15,033,596	12,915,376	99,670	2,674	13,017,720	356,363	738,360	485,264		435,889	2,015,876
Spring Creek Tunnel--Land	52,077	40,193			40,193	5	5,820	6,059			11,884
Spring Creek Powerplant	11,517,775	5,902,498	3,709,607	11,408	9,623,513	250,965	547,633	281,948	36,572	777,144	1,894,262
Spring Creek Debris Dam	3,914,731	3,163,287	70,215	704	3,234,206	113,168	314,274	118,197		134,886	680,525
Spring Creek Debris Dam--Land	21,077	18,498			18,498	19	709	1,851			2,579
Total	197,277,960	156,572,471	15,622,740	89,776	172,284,987	3,635,830	9,238,929	5,844,976	521,961	5,751,277	24,992,973

Costs as of March 31, 1964