UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

- - -

REPORT ON
KESWICK DAM AND POWER PLANT
CENTRAL VALLEY PROJECT
KENNETT DIVISION
CALIFORNIA

- - -

Denver, Colorado,
April 1, 1940.

HYD-
FILE COPY
BUREAU OF RECLAMATION
HYDRAULIC LABORATORY
NOT TO BE REMOVED FROM FILES

UNITED STATES

DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

REPORT ON PRELIMINARY DESIGNS AND ESTIMATES FOR KESWICK DAM AND POWER PLANT CENTRAL VALLEY PROJECT KENNETT DIVISION CALIFORNIA

By

LEWIS J. WORKMAN, ASSOCIATE ENGINEER

Submitted by

W. E. BLOMGREN, SENIOR ENGINEER

Under Supervision of

K. B. KEENER, SENIOR ENGINEER

In Charge of Dam Division

Denver, Colorado,

April 1, 1940.

Denver, Colorado, April 1, 1940.

MEMORANDUM TO CHIEF DESIGNING ENGINEER
(W. E. Blomgren - Through K. B. Keener,
Senior Engineer, Dam Division.)

Subject: Report covering preliminary designs and estimates for Keswick Dam and power plant, Central Valley project - Kennett division, California.

1. There is submitted herewith the report covering the preliminary studies and estimates for the Keswick Dam, which were initiated in December 1939, because of the requirement for a fish barrier and trapping facilities in connection with the Shasta Dam program for conservation of migratory fish.

2. Preliminary design studies and estimates were prepared by Associate Engineer Lewis J. Workman, under the direction of the writer. Valuable assistance in the preparation of this report was received from the electrical division, principally from Mr. M. H. Kight, who made the economic studies necessary for the evaluation of power, which apparently will determine the dam site to be selected, and Mr. D. C. Hillard, who furnished a power-plant layout and estimate for this feature, and also from M. H. Fresen who prepared a preliminary layout of scroll case and draft-tube lines for the power plant.

- - -

W. E. Blomgren.

CENTRAL VALLEY PROJECT
KENNETT DIVISION
PRELIMINARY DESIGNS AND ESTIMATES
KESWICK DAM

Summary and Conclusions

1. Investigations and studies of the Keswick Dam, located on the Sacramento River about nine miles below Shasta Dam and about five miles above Redding, California, were initiated because of the suitability of this site as a location for a barrier for trapping migratory fish in connection with facilities, which it appears must be provided in proposed plans for fish conservation at Shasta Dam. Since preliminary studies of the Central Valley project indicated the Keswick afterbay would be necessary for the regulation of fluctuating releases from Shasta Dam, it was concluded that Keswick would be a more desirable location for fish-trapping facilities than Shasta Dam. Particularly, on account of the possibility that Keswick Dam might be required shortly after the completion of Shasta Dam and the fact that plans and provisions for trapping facilities at Shasta Dam might retard the completion of plans for the power plant and delay construction work.

2. Rough estimates of cost for a dam at the Keswick site (State site) based upon a tentative layout on a State topographic map were prepared for preliminary consideration and information in connection with studies for fish conservation, which estimates were the basis for costs indicated in Chief Engineer's letter of January 22, 1940. Field investigations and drilling for the preparation of more detailed studies were started in December 1939. Subsequent investigations, together with consideration of the purposes and possibilities of the ultimate Keswick development, indicated that the originally proposed site was not suitable for the most desirable plan, particularly the larger power plant, which studies indicated should ultimately be constructed. The necessity for greater width to accommodate the power plant and the indicated desirability of developing the maximum possible power head in this vicinity lead to investigation and consideration of other sites, which were designated Flat Creek, Upper and Lower Spring Creek, and Upper and Lower Rock Creek sites, all of which appeared from geologic and physical conditions to be equally adequate for the proposed dam. The Flat Creek site farthest upstream was eliminated because of the lower power head and also because this site was not economically suitable for power development of water which may be diverted from the Trinity River on the Pacific slope via Spring Creek to the Sacramento River some time in the future.

3. Comparative estimates of dams located at the lower Spring Creek and Rock Creek sites were prepared and the results of these studies are herewith presented. All estimates are based upon the assumption that the major consideration in the ultimate development is power production and that sufficient excavation and powerhouse substructure work should be done in the initial stage of construction to eliminate expensive cofferdams and river-diversion expense for future power-plant construction. All estimates provide for an average of 15 feet of excavation under the greater part of the dam area and somewhat deeper excavation in the abutment sections, which assumption is now believed to be more liberal than necessary for required stability considerations.

4. Summary of Data.

Keswick Dam and Power Plant

	Lower Spring Creek site study 2 A	Upper Rock Creek site study 3 A	Lower Rock Creek site study 4 A
Maximum storage capacity - Acre-feet	20,000	24,000	24,000
Live storage capacity for power - Acre-feet	7,000	7,000	7,000
Maximum storage W.S. elev.	590	587	587
Minimum power storage W.S. elev.	576	576	576
Dead storage level elev.	537	537	537
Maximum spillway capacity - Second-feet	250,000	250,000	250,000
Top of dam elev.	595	595	595
Turbine hydraulic capacity - 3 units - Second-feet	13,000	13,000	13,000
Turbine capacity - 3 units - Horsepower	105,000	117,000	117,000
Generator capacity - 3 units - Kv.-a.	75,000	84,000	84,000
Maximum power head - Feet	80	89	89
Summary of Cost Data			
Estimated cost of recommended initial construction	$ 4,580,702	$ 4,616,401	$ 4,827,908
Estimated cost of provisions for power in recommended initial construction	$ 1,742,629	$ 1,719,918	$ 1,733,992
Total estimated costs of completed reservoir, dam, and power plant	$11,525,169	$11,561,868	$11,773,375
Estimated total cost of reservoir, dam, and power plant per kw. installed capacity	$ 153.67	$ 137.64	$ 140.16

*Estimated Yearly Expenditures - Upper Rock Creek - Plan No. 3 A

F. Y. 1941 -	$1,200,000
F. Y. 1942 -	1,600,000
F. Y. 1943 -	1,316,000
F. Y. 1944 -	500,000

*Includes recommended provisions for power-plant substructure, but no allowance for superstructures and equipment.

5. Power possibilities. The plan of development and selection of site hinges upon the power feature. While the estimated cost of power development, when compared to early estimates, may appear high, it is, in fact, a relatively economical power plant on the basis of cost per kilowatt of installed capacity, which should justify construction in the near future and the above-indicated increased first cost of these plans. Attention is called to one of the main justifications for Keswick Dam, the necessity for river regulation, which might not be necessary. The operation of the Shasta power plant will depend upon the rate structure for the sale of electrical power and energy which is now being studied. If the Shasta power plant is operated on a base load, assuming that a constant power output will be absorbed or sold, the benefits of Keswick to Shasta are practically nothing and the need for river regulation may be eliminated. If the Shasta power output follows the load fluctuations of the distribution system, the benefits will consist of the ability of the Keswick Dam to regulate the daily fluctuations of discharge with reference to downstream structures and facilities, and the value of the additional firm power that could be developed under these conditions. The fluctuating load is the most probable condition and even if the initial power sale is set up on base load production, this condition may be changed under future power contracts. The increased power output that can be developed under the higher head (9 to 11 feet) at the Rock Creek site will easily justify the additional cost of construction at this site. The dam at the Rock Creek site, with a maximum water surface at elevation 587, is much preferred with reference to tail water at Shasta Dam because of the fact that the maximum water surface is three feet lower than for a dam at the Spring Creek site (elevation 590). In addition to the lower backwater elevation, the dam at Rock Creek also provides additional storage capacity for river regulation, if needed.

6. Conclusions and recommendations. The selection of the most suitable site for the dam primarily depends upon the con-

sideration given to the ultimate power possibilities at this site. Under one assumption, the ultimate dam will provide an additional power plant for which there may be a questionable market. The fairly steady power output at Shasta Dam under this assumption would also eliminate to some extent the necessity for river regulation which, with the immediate necessity of providing a fish barrier, is now the major justification for the dam, and it might appear that the increased first cost of provisions for the ultimate plan is not warranted by present requirements. However, since the ultimate development will provide a relatively economical power plant, it would be a short-sighted policy not to plan for the ultimate power possibilities.

On the basis of first cost, with only limited consideration given to a smaller future power plant, the upper Spring Creek or State site would probably be the most economical location for a dam to meet immediate requirements for a fish barrier and regulation afterbay. However, additional data from investigations indicating increased excavation for foundations and spillway and provisions for river diversion during construction will probably increase the rough preliminary estimates. Practicable and economical river diversion plans require a coordination of power plant and spillway locations and more excavation in both locations than was first assumed.

It appears that the spillway section must be completed and gates installed in order to provide sufficient storage capacity above the dam for river regulation.

Since the probable value of the future additional power produced by the higher head at the Rock Creek site will justify the increased cost of construction, it appears that the dam should be located at this site. Geological conditions here are not so good as the Spring Creek site, because of the existence of a zone of crushed rock that crosses both the upper and lower sites. However, since the proposed dam is essentially a buttress-type structure consisting mainly of piers which carry water loads, with mass concrete between these to form the crest of the spillway weir and entrance transitions for power intakes, it will not be difficult or costly to provide adequate cut-offs through the weak zones and secure adequate foundations for piers. All stability factors are high and stresses are relatively low.

It is, therefore, recommended:

(a) That the dam be located at the Rock Creek site. Preliminary estimates indicate the upper site to be the most economical

because of the extensive cut-off that appears to be required through the weak and shattered rock forming the right or west abutment of the lower site. However, further consideration and construction of a deep cut-off across this same zone which is under the foundation of the dam at the upper site may offset any indicated economy for this site.

(b) That excavation and concrete quantities be reduced in final designs by limiting excavation under portions of dam that carry no water load to only that necessary to get reasonably stable rock for the concrete covering. While some of the saving in excavation may be offset by increased unit costs, there will be considerable economy in concrete.

(c) That consideration be given in both designs and model tests to a shorter and more economical spillway apron. The spillway is located on the east side of the river where the apron will rest upon the sound meta andesite formation which should withstand the effects of high velocities without excessive scour.

CENTRAL VALLEY PROJECT
CALIFORNIA

Preliminary Designs and Estimates for Keswick Dam

1. History. The Keswick dam site, located on the Sacramento River about nine miles below Shasta Dam and about five miles above Redding, California, was found by investigation parties of the state in 1921, during the search for dam sites for Sacramento River storage. It was not considered suitable for a high dam but was recommended for a low dam which would utilize the power drop between Shasta Dam (Kennett site) and Redding, and also provide an afterbay for regulation of irregular releases from the Shasta reservoir so as to maintain a uniform flow in the downstream portions of the river. The estimated cost of a 95-foot high dam and 50,000-kilowatt power plant at this site, as proposed by the state's engineers, was $5,500,000 (page 242, bulletin No. 26, "Sacramento River Basin," report of Division of Water Resources, Department of Public Works, State of California, prepared in 1931). This development was considered an essential feature of the Kennett Dam and reservoir, one of the major units of the coordinated state plan of development of water resources, described in the State Water Resource's report, bulletins 25 to 36, inclusive. However, because of the limitation to total expenditure, made by Congress, it was not included in the Central Valley project as authorized by Act of Congress approved April 8, 1935 (49 Stat. 115) and supplemental congressional acts for this project under the $170,000,000 total authorization. The necessity of providing for river regulation below Shasta Dam was called to the attention of this office by Supervising Engineer Young of Central Valley project in letter of August 17, 1937, relative to the location of a gaging station below Shasta Dam. Studies of facilities and construction required for the conservation of migratory fish which were affected by Shasta Dam indicated the advisability of constructing a barrier for fish at this location as an initial feature of the ultimate plan for a power and regulation afterbay dam.

2. Design data. The following data were available in preparing this estimate:

Memorandum to designing section by E. B. Debler under subject: Effect of Keswick afterbay on tail-water elevations at Shasta power plant dated December 6, 1937, copy of which is included in the appendix.

Memorandum to designing section by J. R. Riter under subject:

Hydraulic data for use in the preparation of estimates for the Keswick afterbay - Central Valley project, dated February 13, 1940, copy of which is included in the appendix.

Memorandum to Chief Engineer by D. C. McConaughy under subject: Migratory-fish control, Sacramento River - Central Valley project, dated November 7, 1939.

Topography furnished by project office as follows:

(a) For Spring Creek site - Drawing No. 214-D-4114 traced from project office print 214-P-719(c).

(b) For Rock Creek sites - Drawing No. 214-D-4421 traced from photostatic enlargement of project office print 214-P-747.

Exploration and foundation conditions at dam sites as follows:

(a) Letter from Construction Engineer to Chief Engineer under subject: Keswick Dam - Investigations and surveys for preparation of plans for fish barrier as initial feature of final development Shasta Dam - Kennett division - Central Valley project, dated January 31, 1940, with enclosures and map.

(b) Letter from Construction Engineer to Chief Engineer under subject: Preliminary geologic report on Rock Creek dam site - Migratory-fish control - Kennett division - Central Valley project, dated January 27, 1940, with enclosed Geologic Report and map.

(c) Memorandum to the Chief Designing Engineer by Head Geologist under subject: The Keswick, Rock Creek, and Flat Creek sites - Sacramento River - Shasta Dam - Central Valley project, dated December 19, 1939.

(d) Letter from Geologist F. A. Nickell to Chief Engineer under subject: Keswick dam site - Geological report - Kennett division - Central Valley project, dated April 23, 1937, with enclosures.

(e) Drill-core records and other correspondence relative to this subject.

3. Reservoir. The reservoir area is limited to a section of the Sacramento canyon below Shasta Dam and the storage developed by a dam at any of the sites under consideration will be

relatively small. The storage capacities shown were based on calculations made from small-scale topography and estimated values. Approximately 7,000 acre-feet of regulation or active power storage will be available at either site for the control of diurnal fluctuations of flow from Shasta power plant.

Spring Creek site.—The total storage capacity with water surface at elevation 590 will be about 20,000 acre-feet, of which 13,000 acre-feet are below the minimum power operation level, elevation 576.

Rock Creek sites.—Approximate computations of volume between the Spring Creek and Rock Creek sites indicate a maximum storage capacity of about 24,000 acre-feet at Rock Creek with the water surface at elevation 587. The storage below elevation 576, the minimum water surface for power production, will be about 17,000 acre-feet. This provides about 7,000 acre-feet of regulation storage at the Rock Creek sites with 3 feet lower tail water at Shasta Dam and with an average of at least 9 feet increase of head on the turbines over that at the Spring Creek site.

Dam Sites

Keswick Dam will be located on the Sacramento River between Redding and Shasta Dam. Two general sites were studied, the upper one being the original Keswick site near the abandoned town of Keswick referred to in this report as the Spring Creek or State site and the lower one about one mile downstream, called the Rock Creek site.

Spring Creek site.—This site is located in the SE¼ of Sec. 17, T. 32 N., R. 5 W., or about 8½ miles below Shasta Dam and about 5 miles upstream from Redding. Spring Creek enters the Sacramento River from the right side about one quarter of a mile above the site. Spring Creek drains an area denuded of vegetation and at times carries considerable silt and mine tailings. However, the dam site is believed far enough below the mouth of the stream to avoid silting in the power-plant intake area. The site has had some foundation exploration by drilling although the majority of the holes lie upstream of the axis used for this preliminary design. This was due to the initiation of drilling before design studies were undertaken. In plan 2-A, the axis was moved about 450 feet downstream of the axis first proposed by the Construction Engineer and the field geologist. The lower site provided considerable saving in excavation with better approach conditions for the power intake and spillway. The narrowness of the canyon

is probably due to hard rock exposed along both banks of the river. The rock shows the effects of an intrusion of quartz diorite into a meta andesite. Although the rock will provide an adequate foundation for a low dam, the intrusion has resulted in much jointing and selective weathering along joints. Above the flood level lies an overburden of weathered rock and residual soil. A cut-off under the entire length of the structure to sound rock has been provided. Under the remainder of the structure the estimate was based on excavation to assumed firm rock. The drilling program has been completed and a geology report will be submitted from the project office in the near future although its use for the site used in the estimate will only be of relative value.

Rock Creek sites.--Two dam sites about 900 feet apart were studied at the Rock Creek location. These sites are located in the W½ of the SW¼ of Sec. 21, T. 32 N., R. 5 W., a little over a mile below the upper site at Spring Creek or about 9½ miles below Shasta Dam and 4 miles above Redding. Rock Creek enters the Sacramento River directly below the sites from the right.

The nature of the foundation is very complex. Exposures in the railroad cuts show meta andesite highly sheeted and weathered to below the track level. The river bottom is in a box canyon bordered by fresh rock terraces up to flood levels. Along the low-water terraces the rock is a fine-grained schist cut by igneous dikes and quartz veins. A weak zone of soft, strongly weathered schist cuts laterally across the river canyon passing under the upper site on the right bank of the river and possibly extending over the canyon wall into the deep ravine on the left bank of Rock Creek. A drill hole in the saddle on the top of the right bank seems to prove this condition. A rib of hard rock is located opposite the lower site on the top of the right abutment about 50 feet above river level. A drilling program is in progress on the right abutment of the upper site and will progress across the river bed.

At the dam located at the lower site, a concrete cut-off wall is provided across the weak zone of weathered schist on the right bank and upstream of the dam. At the upper site no great difficulty should be experienced in treating the weak zone by excavating the cut-off under the power intake structure to solid rock. Grouting in this zone of soft schist would be of doubtful value due to clay deposits in the weathered seams and joints. Excavation of the cut-off to solid rock and the remainder of the structure area to firm rock should provide a good foundation at either site for the proposed type of structure.

Dam

The dam is a concrete structure composed of a spillway, fishway and traps, and a power-plant intake. Short gravity sections are used at the abutments. The arrangement at all sites is similar with the spillway on the left bank, the fishway in the center, and the power intake on the right side.

The fish ladder and trap was located between the power plant and spillway sections in accordance with recommendations of the aquatic biologists of the U. S. Bureau of Fisheries.

Except for the short abutment sections, the dam structure consists essentially of piers and blocks which carry the water load. A mass concrete filling between spillway-gate piers provides a low overflow crest and mass concrete is also used to form the foundation and entrances between gate and trashrack piers in the power intake structure. Stability factors are, therefore, high and foundation stresses relatively low. This type of design will provide possibilities for economy in final design by the reduction of foundation excavation between piers and the substitution of lighter reinforced concrete construction for mass concrete between the power intake piers, if more economical.

The length exclusive of abutment sections is 478 feet. A roadway, 20 feet in width, to be used for utility and service purposes, is provided across the structure. The abutment sections have a top width of 26 feet and a downstream slope of 0.7.

The foundation being of a jointed character, a cut-off 10 feet in width at the bottom with 1/4 to 1 side slopes is provided across the entire structure beneath the upstream edge. The cut-off was carried down to solid rock with the remainder of the structure assumed as being excavated to firm foundation. A water-tight curtain would be secured under the upstream edge by means of a single row of grout holes ranging from 25 to 50 feet in depth. The foundation would be drained downstream of the cut-off, where possible, by drilling drainage holes after grouting the foundation and connecting these holes to headers leading to the downstream face. Vertical porous drains located in the upstream face of the spillway and abutment sections, connect to the drain headers. No grouting of contraction joints was considered necessary because of low type of structure proposed and slow rate of construction required by conditions at this site. Metal water seals should be adequate, although some type of an asphalt well with a heating device might be considered desirable at the upstream edge of each joint.

Spillway

The spillway is located on the east side of the river in all proposed plans because of the harder and more resistant rock formation (meta-andesite) for the spillway apron which exists at river level on this side of the river at all three sites.

The spillway for all sites is of the concrete overflow type and very similar except for the depth of the bucket, height of gates, and required excavation. A maximum flood of 250,000 second-feet can be passed without encroachment of the water surface above elevation 590. The elevation of the crest was set at 537. Control is provided by four 50-foot wide stoney gates operated by electrical hoists located in the house above. The gates are counterweighted on the downstream side thus eliminating the counterweight wells in the piers. The piers are 10 feet in width giving a total of 230 feet for the spillway width inside the training walls. Grooves for stop logs are provided in the piers upstream of the gate which will allow the installation of structural-steel stop logs and servicing of the gates without loss of power head or river regulation. The bridge is of structural steel with a concrete floor slab which will allow it to be constructed without the use of temporary bents during the diversion of the river through the spillway structure. Slots covered with metal plates are located in the bridge deck to permit the placing and removal of emergency stop logs.

The shape of the crest is determined by the trajectory of a high velocity jet flowing beneath the gate through a narrow opening and under full reservoir head. The conventional design for free flow over the crest would produce a shape which allows the jet to leave the surface and probably would cause cavitation unless aeration is provided. The piers were extended upstream to obtain better flow conditions in the neighborhood of the gate slots under free flow conditions. The approach channel is excavated to elevation 515.

The uplift under the sloping apron will be relieved by use of gutter pipe laid on the foundation and connected to ejector-type drains. The transverse contraction joints located in the middle of the gate openings give the piers more stability when the crest is only partially placed during the diversion stage. The training walls are of the cantilever type and are lower than the tail water caused by extreme floods. The diffusion-type bucket is recommended with excavation of the outlet channel carried down to the top elevation of the diffusion blocks.

The tail water for the higher discharges will cause partial submergence of the crest. The operating conditions which will be most common will find the gates raised to partial openings and discharging a high velocity jet into a low tail water. The extreme difference between these conditions makes it difficult to design the spillway apron for the desirable dissipation of energy under all conditions. Therefore, it is recommended that a diffusion bucket at the end of a sloping apron be used to dissipate the energy. With Shasta Dam providing some degree of flood control, the frequency of occurrence of the maximum floods is reduced and it is, therefore, believed that spillway design should be controlled by the generally prevailing conditions for flows of 150,000 second-feet or less.

It is also believed, that the occurrence of fresh, hard rock below the spillway apron will also permit economies in apron design.

Spring Creek site.—Spillway control is furnished by four 50- by 53-foot high stoney gates providing storage to elevation 590. Submergence of the crest will occur at a discharge of about 110,000 second-feet. A sloping apron with a slope of 8 to 1 and a radius of 70 feet at the junction of the crest and apron was used for the estimate. The diffusion-bucket datum elevation is set at elevation 498. The top elevation of the diffusion blocks is 510 which is also the floor elevation of the excavated outlet channel. The top of the training walls was set at elevation 550 equivalent to a tail-water height for 185,000-second-feet discharge. The over-all length of the spillway from upstream face of the weir to the end of the bucket is 220 feet.

Rock Creek sites.—The spillways at this location are identical except for excavation and concrete quantities. The control is furnished by four 50- by 50-foot high stoney gates which provide storage to elevation 587 without overtopping. The maximum discharge of 250,000 second-feet is obtained with reservoir surface at about elevation 589. The crest is submerged by the tail water at elevation 537 equivalent to a discharge of 205,000 second-feet. The top of the training wall is set at elevation 535 equivalent to a tail-water height for a discharge of 190,000 second-feet. The apron has a slope of 5 to 1 and a 60-foot radius at the junction of crest and apron. The diffusion-bucket datum plane is set at elevation 485 with the top of the diffusion blocks and outlet channel at elevation 497. The total length from the upstream face to the end of the bucket is about 228 feet.

Power Intake and Plant

The proposed power-plant layout used in these preliminary plans is similar for all sites. The layout shown is believed to be the most economical for the proposed type of installation which consists of a concrete scroll case and a reinforced-concrete intake structure. Alternate estimates were made of a concrete gravity section for the dam, with steel penstocks, a reinforced concrete trashrack and coaster-type gates at the inlets. These studies showed that the open-type, reinforced concrete intake was the most economical one to use. A steel penstock could be used with the open-type of intake but would require a longer powerhouse, requiring greater width in the powerhouse bays than for a concrete scroll case. Moreover, a steel penstock would require the center line of the intake structure to be offset from the center line of the power unit which would cause the power plant to be moved farther into the canyon wall and increase the excavation.

The power intake consists of three 68-foot wide bays, which is the required spacing of units in the power plant, with an over-all length of 204 feet. The inlet floor is at elevation 535 at the upstream end. An economic study for the proper elevation of the intake floor based on stability of the structure and excavation of intake channel should result in some savings when final designs are made. The distance from the upstream face to the downstream side of the intake is 68.5 feet. Nine service gates of the fixed-wheel type are provided. There are three for each unit which are operated by a traveling gantry crane of about 75-ton capacity. Gate slots upstream of the service gates also provide for an emergency closure. The emergency gate slots will be provided with removable slot fillers which improve the hydraulic conditions in the intake. A skimming rack is located at the upstream edge to prevent floating debris from entering the forebay and lodging beneath the bridge where its removal is difficult. The trashrack has provisions for a rake and trash sluice if required.

The intake structure is designed to be stable under full reservoir heads with no powerhouse in place. This will allow it to be used as a dam until the powerhouse is complete. A concrete cut-off to recommended stripping depths with a bottom width of 10 feet and side slopes of 1/4 to 1 is provided at the upstream edge. The remainder of the structure is to be excavated to firm rock. The factors for overturning, shear-friction factor, and other stability factors of the suggested preliminary design are high

and amply safe. It should be possible to eliminate considerable of the mass concrete in construction designs and still provide ample stability. A single row of grout holes 25 to 50 feet in depth are provided under the upstream cut-off. The uplift is relieved by rows of gutter pipe laid on the foundation and drained to the powerhouse sumps.

The station-service power will be supplied by a 6,900-volt line from Shasta power plant. Provision is made in the estimate for this line as well as a high-tension switching station and transmission line. Excavation for the power plant was included in the estimate in the recommended plan of initial construction. The completion of all excavation when the initial cofferdams are in place, would undoubtedly reduce the ultimate cost. The amount of excavation in proposed plans at the Rock Creek and Spring Creek sites varies in accordance with differences in foundation conditions, tail-water height, and draft-tube elevation. The tailrace is excavated to a 4 to 1 slope.

Under the assumptions made for excavation, the difference in cost between the Rock Creek and Spring Creek sites is very slight compared to the total costs. Mr. H. H. Kight of the electrical division prepared a study in which a comparison was made of the annual value of a plant located at Spring Creek or Rock Creek in terms of power revenue, which indicates that the additional cost of construction could be absorbed in a few years. Mr. Kight's summary is as follows:

"Spring Creek vs. Rock Creek Dam Sites

"From drawing 214-D-497 the critical month is August 1934 with reference to power required from Shasta power plant, and the reservoir release during this month is 240,000 acre-feet or an average of 3,870 second-feet for the month.

"13,000 second-feet at Spring Creek site will produce 75,000 kw.
13,000 second-feet at Rock Creek site will produce 84,000 kw.
3,870 second-feet at Spring Creek site will produce 22,300 kw.
3,870 second-feet at Rock Creek site will produce 25,000 kw.

"Therefore the kw. gain at Rock Creek over Spring Creek with 3,870 second-feet = 2,700 kw.

"The kilowatt-hour gain at Rock Creek over Spring Creek based on an average usable release from Shasta of 3,600,000 acre-feet per year and an average increase in head of 9 feet:

"3,600,000 acre-foot x 43,560 cubic feet x 62.5 pounds x 9 foot x .80 plant eff. = 2,653,000 foot-pounds per kw.-h. = 26,600,000 kw.-h.

"On page 242 of bulletin No. 26 of the State of California, 1931 report on the Sacramento River basin, the value of energy from the Spring Creek or Rock Creek plants with the Shasta reservoir operated primarily for irrigation yield is $0.00193 per kilowatt hour at the power plant.

"The Rock Creek site for the power plant, therefore, has the following annual value in excess of the annual value of a plant at the Spring Creek site:

"26,600,000 kw.-hr. x $0.00193 = $51,338."

It is well to point out that the differences in the cost of operation, amortization, interest, and other chargeable costs for either site will be small.

Spring Creek site.--The proposed installation would consist of three 35,000-horsepower, 94.7 r.p.m., Francis-type turbines operating under an approximate head of 80 feet connected to three 25,000-kv.-a. generators. The variation in head would be from a reservoir elevation of 590 down to elevation 576. The elevation of the draft-tube floor is 475. The service-bay floor was set at elevation 560 and is located on a backfill and excavated surface. No rooms were provided below elevation 560. The service gates in the intake are approximately 14- by 16.5 feet high of the fixed-wheel type while the emergency gate is about 14 feet by 19 foot high.

Rock Creek sites.--At Rock Creek the proposed power installation would be three 39,000-horsepower, 100 r.p.m., Francis-type turbines operating under an approximate head of 89 feet and connected to three 28,000-kv.-a. generators. The variation in power head is between reservoir elevation 587 down to elevation 576. The draft-tube floor is set at elevation 463. The service-bay floor is at elevation 548 set on a backfill and excavation surface with no rooms below. There is some excavation in the intake

channel to elevation 535. The service gates are 14 feet by 22 feet high while the emergency gate is 14 feet by 25 feet.

The elevations governing the draft tube, service bay, and other controlling elevations for the power plant at Rock Creek are subject to change when more authentic data are available to compute tail-water surfaces. The present elevations are based on a predicted curve of tail-water heights.

At the upper Rock Creek site the cut-off under the power intake structure will probably encounter the zone of soft, strongly weathered schist which cuts laterally across the site. Outside of some deep cuts, this should present no serious foundation trouble and in view of the deep draft-tube excavation that is required, will probably be entirely removed under the powerhouse foundation.

Fish Ladder and Traps

The fish ladder and trapping facilities are provided to allow the migratory fish (mostly salmon) to be trapped at this point and transported to spawning beds or hatchery. The general layout for fish facilities shown on drawings is simply an arbitrarily selected plan used as basis for estimated cost. Final designs, studies, and tests to be conducted in cooperation with the Bureau of Fisheries will, no doubt, require radical changes in detail plans with possibly some revisions in estimated cost. The proposed plan provides an overflow type of ladder consisting of an inclined trough with a series of pools formed by notched baffles which create low falls and allow the fish to jump from one pool to the next. The ladder has three continuous runs connected by two 180° bends which enables it to gain sufficient altitude within the limits of the spillway length. The operation requirements which would enable the traps to operate for all flows between a low of 3,000 second-feet to a maximum of 50,000 second-feet are rather severe. The slope of the ladder will probably be between the limits of 1 to 10 and 1 to 15, depending on decisions to be made. The supply for the trap and ladder is taken through an intake pipe connected to the reservoir and controlled by a gate valve. The trap at the upstream end of the ladder is similar to the one used at Rock Island Dam. The fish will be hoisted to roadway level for loading and transportation to the hatchery. The ladders and trap are of reinforced concrete construction supported by concrete columns and the adjacent walls. The location between the powerhouse and spillway places the entrance near the middle of the stream where it will be the most

attractive to the fish. It is possible that a supplemental discharge may be required at the ladder entrance to attract the fish.

Construction Program

There are two pertinent features of Keswick Dam which will have a definite bearing on the construction program; namely, trapping fish and regulation of the river.

The fish traps should be in operation when the closure is made at Shasta Dam in the spillway area which will prevent the salmon from passing that point en route to the spawning beds. The Shasta Dam construction program now indicates that trapping facilities should be completed by April 1942. The operation of the trap necessitates a weir or barrier across the river of about 20 feet in height and the ladder and trap in operation. Hoisting and loading facilities for truck transportation must also be provided. It also appears that provisions for river regulation of discharges from Shasta Dam should be completed by the fall of 1943, or the spring of 1944. This requires completion of the spillway and installation of the gates with sufficient storage capacity in the reservoir to absorb the surplus flow. It is anticipated that the Shasta power plant will meet all power demands for several years and it appears there is no economic justification for the completion of the Keswick power plant until all of the available power output at Shasta is under contract.

The river-diversion provisions must be such as not to interfere with or endanger normal railroad operations of the Southern Pacific railroad before November of 1941, or before the ownership and operation of the road passes into the control of the Government. This will be accomplished as soon as the permanent relocation of the Southern Pacific line is complete and accepted. After the fall of 1941, the cofferdams and required overflow sections of the dam must be kept low enough to pass all but extreme floods and cause a minimum amount of interference with the transportation of cement and other construction materials to Shasta Dam.

The general construction program recommended and studied for an estimate is as follows: Excavate all possible areas above water level previous to April 1941. In the spring of 1941, construct a cofferdam in the area to be occupied by the left bay of the powerhouse and intake. Connect this cofferdam to the left bank with up and downstream wing dams. With the river passing along the right bank during the low-water period of April to

November, construct the spillway apron, piers, and training walls to roadway level; complete the spillway apron and the lower part of the crest, the fish ladder and traps, and the left-abutment gravity section. For the second stage, construct cofferdams across the right side of the river which would allow construction of the power intake while the fish traps were being operated. The plan for each site used in the estimate is given in detail below.

Spring Creek site.--Excavate both abutments to water level before April 1941.

First-Stage Construction - Spillway and Fishway.

(a) Divert river along the right bank by providing a channel to pass 15,000 second-feet by means of cellular or timber crib cofferdams. Protect the railroad grade with rock-filled cribs where protection may be necessary. Connect the channel cofferdam to the left bank with an upstream cofferdam to about elevation 525 and a downstream cofferdam to about elevation 515.

(b) Unwater and excavate for spillway and fishway.

(c) Build the spillway crest to about elevation 515, complete the spillway apron and bucket and also the piers and training walls to roadway level.

(d) Construct fish ladder and traps complete ready for operation by April 1942.

(e) The first-stage construction is to be completed between April and November, during low-water stages. Remove all cofferdams for the high-water period of November to April.

Second-Stage Construction.

(a) Install highway bridge and complete access road for transportation of fish.

(b) In April 1942, construct cofferdams to right abutment from fishway, upstream cofferdam to elevation 550, and downstream cofferdam to elevation 535. The spillway will be able to pass 100,000 second-feet if railroad cut is sandbagged for high floods.

(c) Increase weir height for operation of fish traps by installing about 20 feet of structural-steel stop logs in grooves which are provided in the spillway piers.

(d) Operate the fish traps.

(e) Unwater, excavate for, and construct the power intake structure and enough of power plant to dispense with the downstream cofferdam.

(f) Remove cofferdams and pass floods through the intake structure. Unwater spillway crest by placing bulkheads across the upstream pier noses. Complete the spillway structure and install the gates and hoists. Remove the railroad tracks from the reservoir and complete work in the road-bed area after Shasta Dam is completed.

Rock Creek sites.—The construction program for Rock Creek is similar to Spring Creek except for the necessary elevations of cofferdams. The channel capacities and time elements would be the same as for Spring Creek. The first-stage upstream and channel cofferdams would be built to elevation 525. The second-stage upstream cofferdams would be constructed to elevation 550, leaving an opening for the railroad tracks. The railroad tracks would have to be left in and operation continued until Shasta Dam is complete. After the tracks are removed, the portion occupied by the road bed, access areas, and roads would be excavated and the structure completed.

Materials and Estimated Unit Prices

The unit costs used in this estimate for concrete materials were based on the assumption that aggregates could be supplied from the same source as the Shasta Dam aggregates. Concrete aggregates would be transported from some convenient point on the belt-conveyor system by trucks or by railroad from the source nearest to the Keswick site. No study was made to determine a location for an unloading yard or switch near the site as this feature will depend on the site selected. There are no improved roads to either site at the present time and it will be necessary to build several miles of improved highway for transportation of materials and for access to the dam.

Estimated prices conform to the indicated trend of increase in commodities. The concrete-material costs are similar to Shasta with approximately a 10-percent increase for cost of materials. Excavation quantities are estimated as unclassified because available data did not permit an accurate classification of excavation. The construction program which indicates that the

(d) Operate the fish traps.

(e) Unwater, excavate for, and construct the power intake structure and enough of power plant to dispense with the downstream cofferdam.

(f) Remove cofferdams and pass floods through the intake structure. Unwater spillway crest by placing bulkheads across the upstream pier noses. Complete the spillway structure and install the gates and hoists. Remove the railroad tracks from the reservoir and complete work in the road-bed area after Shasta Dam is completed.

Rock Creek sites.--The construction program for Rock Creek is similar to Spring Creek except for the necessary elevations of cofferdams. The channel capacities and time elements would be the same as for Spring Creek. The first-stage upstream and channel cofferdams would be built to elevation 525. The second-stage upstream cofferdams would be constructed to elevation 550, leaving an opening for the railroad tracks. The railroad tracks would have to be left in and operation continued until Shasta Dam is complete. After the tracks are removed, the portion occupied by the road bed, access areas, and roads would be excavated and the structure completed.

Materials and Estimated Unit Prices

The unit costs used in this estimate for concrete materials were based on the assumption that aggregates could be supplied from the same source as the Shasta Dam aggregates. Concrete aggregates would be transported from some convenient point on the belt-conveyor system by trucks or by railroad from the source nearest to the Keswick site. No study was made to determine a location for an unloading yard or switch near the site as this feature will depend on the site selected. There are no improved roads to either site at the present time and it will be necessary to build several miles of improved highway for transportation of materials and for access to the dam.

Estimated prices conform to the indicated trend of increase in commodities. The concrete-material costs are similar to Shasta with approximately a 10-percent increase for cost of materials. Excavation quantities are estimated as unclassified because available data did not permit an accurate classification of excavation. The construction program which indicates that the

major part of the work should be done during low-water periods, may result in an increase in construction bids. The metalwork and power-plant materials prices are higher than average due to the effect of a wartime market. Estimated excavation unit prices are believed to be adequate for all excavation costs and contingencies, and should cover the cost of extra facilities that might be required for the rapid removal of the material in the short time available in low-water periods.

The estimated unit costs are assumed to include sufficient allowance for required construction plant in an independent contract. However, it is believed that either one of the large contractors operating in this vicinity could, if so inclined, profitably handle this work for considerably less than estimated, probably as much as 25 percent less. Much of the available plant facilities now in use could be utilized on Keswick Dam without seriously interfering with present operations, particularly concrete aggregate and mixing-plant facilities. The short distance from Shasta Dam should permit the batching of concrete at Shasta Dam, and probably mixing with transit mixers and hauling to Keswick more economically than the work could be done with a separate concrete plant. It is believed the labor contract is low enough to bring in considerable competition from several responsible smaller contractors on railroad and highway work in this vicinity which might force the two large contracting firms to make reasonably low bids. It is also probable that some competition might be eliminated by a joint bid from the two large contracting firms.

Future Investigations

The additional foundation exploration and investigation necessary for final designs depends upon the site selected. It is believed that sufficient work has been done at the Spring Creek site and that future drilling at all sites, if required, should be confined to holes necessary for a thorough consideration of the weak rock zones and cut-off provisions for those zones and the abutments.

The foundation exploration at all sites does not need to be as extensive as that required for a high dam. The information to be obtained should provide the required depths of excavation for an adequate cut-off under the upstream face. As bearing pressures will be comparatively low, except under the pier and wall footings, no trouble should be experienced in obtaining adequate foundation at stripping depths over most of the area. Drill holes to define the depths of soft, weathered rock zones

and test pits to determine stripping and classification of excavation should be ample for design purposes.

Topography adequate for design purposes is available at all sites. Hydrographic studies will require more data within the reservoir area. A survey of the reservoir area is needed to obtain the capacity and area data and to be certain that the reservoir is sufficient for regulation purposes. The data available are sufficient for preliminary design but are not accurate enough for final design and regulation studies.

The backwater effect of Keswick Dam on Shasta Dam has not been studied in detail. The tail-water heights at Shasta Dam will be materially changed by Keswick reservoir and their effect on the power plant and spillway should be studied. The tail-water heights at Spring Creek have been rather carefully computed. At Rock Creek the tail-water heights have been based on predicted heights and should be more accurately obtained. The tail-water studies can be made from one of two sources. The most accurate would be to use the information gained from the flood of February 28, 1940, and any measured water-surface elevations taken on the falling water surface as datum points. The gaging station located about 1,000 feet downstream of the Spring Creek site has been operated by the U.S.G.S. for some time and should have accurate flow data to be used. The second method for checking Rock Creek tail-water heights and probably less accurate is to obtain cross sections on control points between the gaging station and well downstream of Rock Creek. The tail-water elevations are urgently needed for the design of the spillway, fish ladder, and power plant, and must be accurate to within reasonable limits.

Hydraulic model studies should be initiated immediately with the view of obtaining data for final spillway designs and a proper design and layout for trapping fish.

Alternate Plans

State site. The original estimate used by the State of California was based on a site located about 500 feet upstream of the site used for this estimate at Spring Creek. This site, referred to in this report as the upper Spring Creek or State site was the basis for a rough preliminary estimate. Later studies on this site based on more adequate designs proved the site too narrow for the structure under consideration. The State site was eliminated in favor of the wider canyon below.

Plan No. 3-C. Although the upper Rock Creek site was the basis for this estimate, it would apply in general to any other site selected. This study would provide a structure complete in all details except for a power plant. It would provide river regulation and fish-trapping facilities and a power intake structure which could be used for future power development. When the power plant is built at some future date, it would be necessary to reconstruct the downstream cofferdam, unwater the site, and excavate for the power plant at that time. This plan would present about $700,000 less initial cost than to build plan 3-A and enough of the powerhouse substructure to allow unwatering the power plant without the use of a downstream cofferdam. This saving is an approximate figure and could possibly be increased by using timber bulkheads in place of service gates and also eliminating various items of metalwork such as trashracks, gantry crane, etc. From this apparent saving should be subtracted the cost of a second downstream cofferdam below the power plant. Also, the interest on the investment in power features should be added to this saving if the power-plant construction is to be postponed for several years. Plan 3-C should be given careful consideration in case it is not proposed to complete the power plant in the first contract or in the near future.

Plan No. 3-B. This estimate would only provide fish-trapping facilities and a foundation complete for the spillway. It would complete enough of the spillway to start the second-stage construction. The cofferdam which would close off the right side of the river would be a semi-permanent structure of cellular construction. The weir for preventing fish from traveling upstream would be of structural-steel stop logs to elevation 535 set in grooves of the spillway piers. The roadway would be constructed across the spillway piers. The concrete in the spillway crest would be placed to elevation 515 and the top of the cofferdam to elevation 545. The fish ladder and trap is complete. No storage is allowed and by removing the temporary stop logs on the spillway, a flood of 100,000 second-feet could be passed providing the railroad grade is sandbagged. This plan was suggested as practical in case appropriations are so limited that only a portion of the structure adequate for trapping fish is to be provided. It should be borne in mind, however, that in view of the fact that no storage or regulation is available, it would be necessary to continue construction at some future date and that a semi-permanent cofferdam will be more costly than one used for only one or two seasons. The cost of this plan would probably have to be charged against migratory-fish control until the structure is carried to completion.

In connection with this plan, it is well to mention an alternate that has considerable merit. Instead of constructing an expensive semi-permanent cofferdam to be left in use for several years, the power intake structure would be constructed to about elevation 535 with enough of the walls to provide slots for timber bulkheads. This alternate to plan 3-B would provide the essential fish-trapping facilities and also complete the foundation work across the entire river. Sufficient time was not available to include an estimate for this scheme in the report but in case appropriations are limited, a study should be conducted along these lines before decisions are made regarding the extent of the initial construction.

SUPPLEMENT TO KESWICK DAM REPORT

Effect of Keswick Dam on Operations of
the Mountain Copper Company at Matheson, California
(S.P.R.R. Milepost 267.2)

1. The completed Keswick Dam will require a decision on the responsibility of the Government for the replacement of destroyed transportation facilities of the Mountain Copper Company at Matheson, about 4.3 miles upstream from the Keswick dam site and possibly the inclusion of the cost of required new facilities in the estimated cost of Keswick Dam.

2. As long as the railroad is maintained to Shasta Dam, arrangements for the transportation of the Mountain Copper Company's ore (about 75,000 tons annually) to Redding can be made. However, after the abandonment and submergence of the railroad between Keswick and Shasta Dams, some other arrangement for transportation of the copper ore will be necessary.

3. While there is a moral or equitable responsibility for the replacement of the transportation facilities, Government attorneys question the legal responsibility for replacement under the transportation regulations of the Interstate Commerce Commission.

4. An investigation of this matter was made by Special Agent Cassius C. Smith of the Division of Investigations, Department of the Interior who, in his report of June 1, 1937, estimated the cost of required tramway replacement facilities at $160,742.

5. It is believed that further investigations should be made to determine the practicability of other methods of transportation than the proposed aerial tramway, with a view to a more detailed analysis of damages, and a possible lump-sum settlement with the Mountain Copper Company, if any is required.

(C O P Y)

Denver, Colorado, February 13, 1940.

MEMORANDUM TO DESIGNING DIVISION
(J. R. Riter)

Subject: Hydraulic data for use in the preparation of estimates for the Keswick afterbay - Central Valley project.

1. Reference is made to letter from the acting chief engineer to the supervising engineer at Sacramento requesting additional data to be used in the preparation of estimates for the Keswick afterbay.

2. In this connection, reference is also made to the attached memorandum of December 6, 1937, suggesting a high-water line of 590 feet for the Keswick afterbay.

3. The following additional hydraulic data are recommended:

(a) Power plant. This should be designed for a hydraulic capacity of 13,000 second-feet and electrical capacity of about 75,000 kilowatts.

(b) Spillway capacity. The spillway should be of the gate type to minimize the interference with the Shasta power plant. A capacity of 250,000 second-feet without encroachment above the flow line elevation of 590 feet should be provided.

(c) Outlet capacity for irrigation. This capacity should be 20,000 second-feet. The outlets should be so arranged that regulation can be effected to the nearest 100 second-feet. In view of the relatively low head it is presumed that partial opening of gates will be permitted.

- - -

J. R. Riter.

(C O P Y)

Denver, Colorado, December 6, 1937.

MEMORANDUM TO DESIGNING SECTION
(E. B. Debler)

Subject: Effect of Keswick afterbay on tailwater elevations at Shasta power plant.

1. Drawing 214-D-472 revised "Kennett Dam Tailwater Curve" August 31, 1937 is based on actual observations up to 85,000 second-feet and reflects the relation between discharge and tailwater at the Shasta power plant with present downstream conditions as follows:

Discharge	W. S. Elev. Feet
0	575
5,000	580
10,000	584
*14,000	586
250,000	632.5

* Hydraulic capacity of power plant with all 5 units installed.

2. Ultimately it is contemplated that an afterbay will be provided by construction of a dam at the Keswick site to smooth out the diurnal fluctuations in stream flow caused by operations of the Shasta power plant and to develop the power head (about 85 feet) available between the Shasta Dam and the Keswick dam site.

3. The maximum amount of afterbay storage required for the regulation of Shasta releases during any one day is 7,000 acre-feet. This will result from a uniform release of 7,000 second-feet at Keswick (14,000 acre-feet per day) and a variable release from Shasta power plant as follows:

12 hours at 14,000 s.f.
12 hours no release.

4. The following area capacity table for the Keswick afterbay is determined by planimetering from the topographic map furnished by the project office:

Elev. Feet	Area Acres	Capacity A.F.
510	0	0
520	63	310
540	153	2,470
560	297	6,970
580	479	14,730
600	658	26,100

5. Considering the practicable limit of head variations at the proposed Keswick power plant and the encroachment on the Shasta tailwater elevation, it is believed that the required 7,000 acre-feet of afterbay storage should be secured between elevations 576 and 590 of the Keswick reservoir.

6. Under those conditions, the tailwater elevations at the Shasta power plant will vary, depending upon the water surface elevation of the Keswick reservoir as follows:

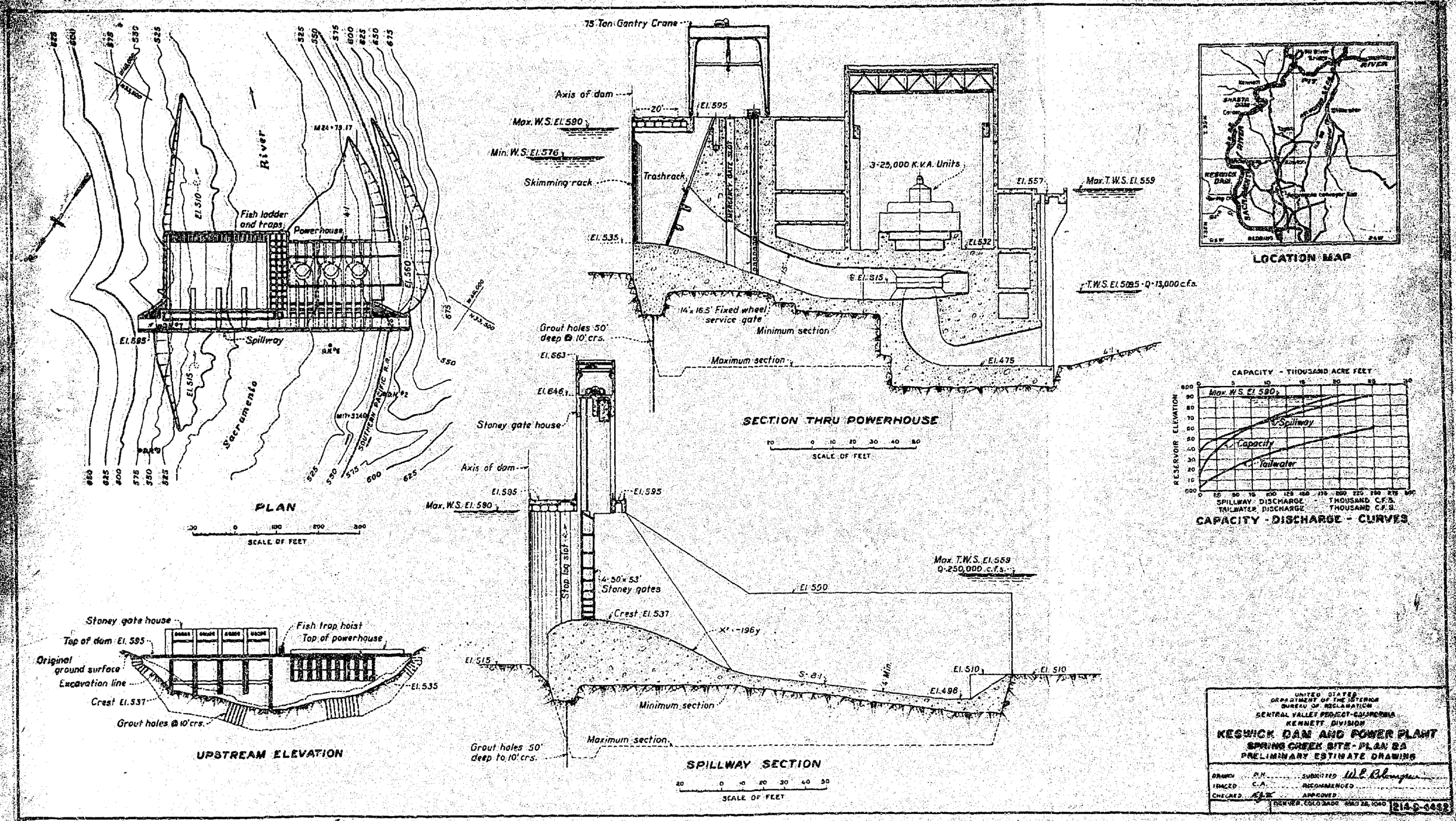
With 14,000 s.f. release at Shasta Dam - from 592 to 586 feet.

With no release at Shasta Dam - from 590 to 576 feet.

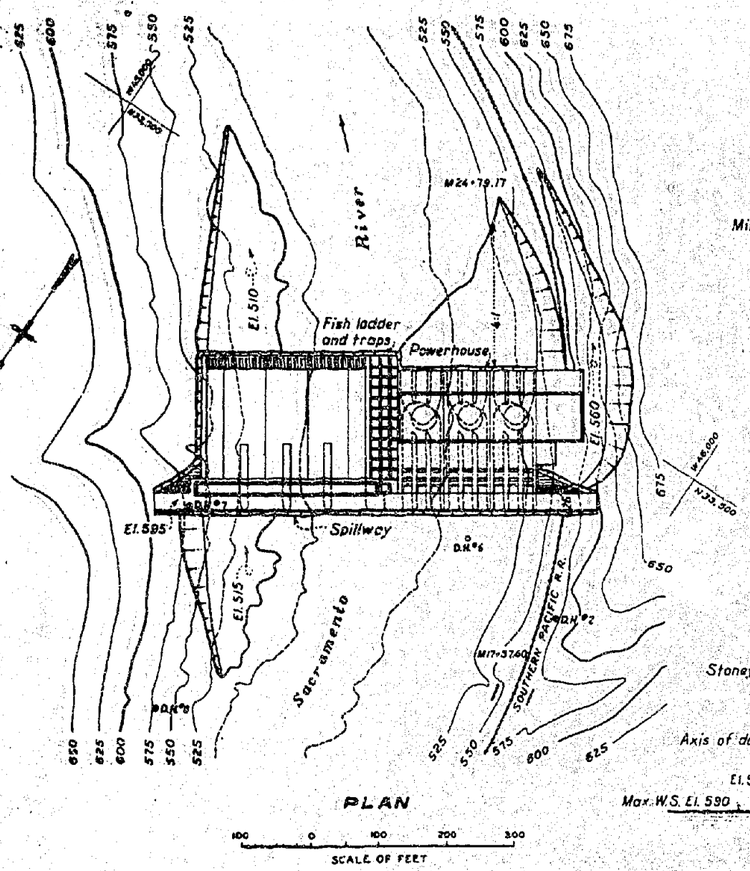
For high flood discharges the Keswick afterbay will have no appreciable effect on the tailwater elevations at the Shasta power plant.

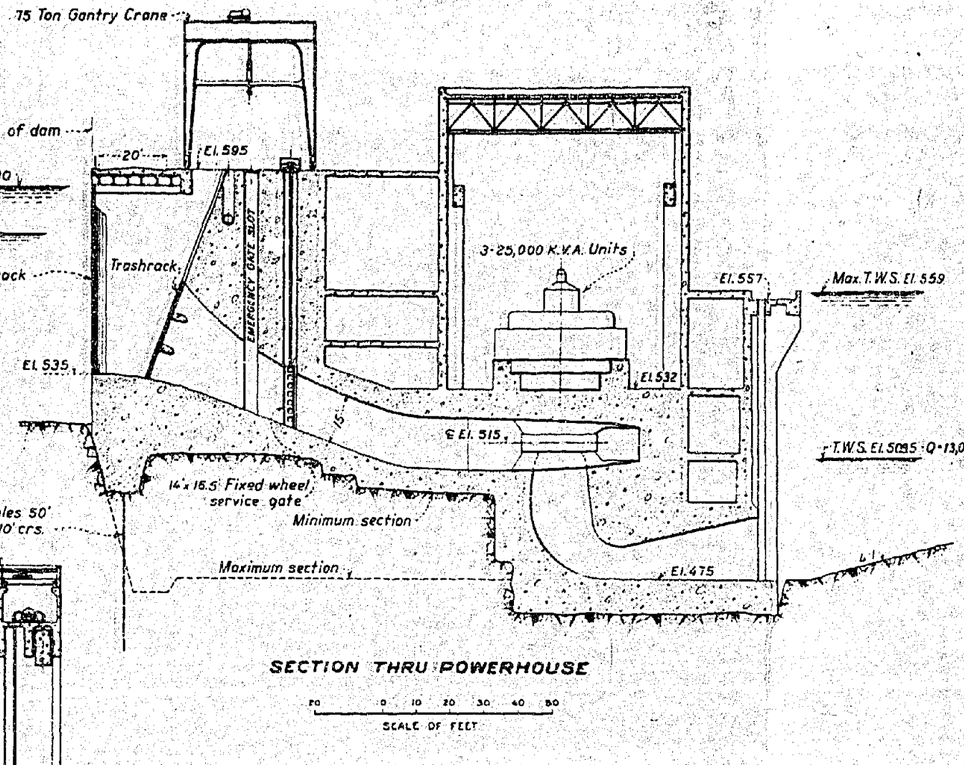
- - -

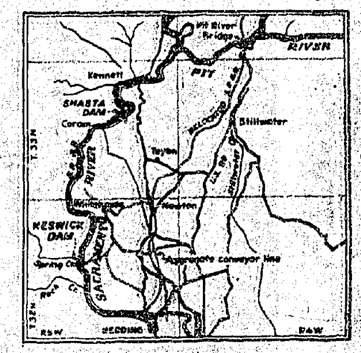
E. B. Debler.



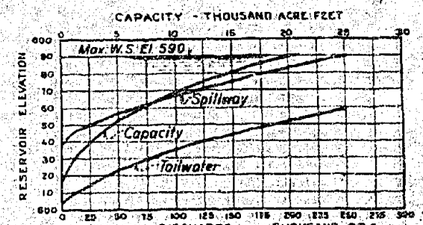
PLAN
SCALE OF FEET
Sacramento River
Fish ladder and traps
Powerhouse
Spillway
El. 510
El. 515
El. 560
El. 595
SOUTHERN PACIFIC R.R.
75 Ton Gantry Crane
Axis of dam
Max. W.S. El. 590
Min. W.S. El. 576
Skimming rack
Trashrack
El. 595
3-25,000 K.V.A. Units
El. 557
Max. T.W.S. El. 559
El. 535
El. 532
El. 515
T.W.S. El. 509.5 - Q-13,000 c.f.s.
14' x 16.5' Fixed wheel service gate
Minimum section
Maximum section
El. 475
Grout holes 50' deep @ 10' crs.
SECTION THRU POWERHOUSE
SCALE OF FEET
LOCATION MAP
CAPACITY - THOUSAND ACRE FEET
RESERVOIR ELEVATION
Max. W.S. El. 590
Spillway
Capacity
Tailwater
SPILLWAY DISCHARGE - THOUSAND C.F.S.
TAILWATER DISCHARGE - THOUSAND C.F.S.
CAPACITY - DISCHARGE - CURVES
Stoney gate house
Top of dam El. 595
Original ground surface
Excavation line
Crest El. 537
Grout holes @ 10' crs.
Fish trap hoist
Top of powerhouse
El. 535
UPSTREAM ELEVATION
El. 663
El. 646
Stoney gate house
Axis of dam
El. 595
Max. W.S. El. 590
Stop log slot
4-50' x 53' Stoney gates
Crest El. 537
Max. T.W.S. El. 559
Q-250,000 c.f.s.
El. 550
El. 515
El. 510
El. 498
Minimum section
Maximum section
Grout holes 50' deep to 10' crs.
SPILLWAY SECTION
SCALE OF FEET
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT-CALIFORNIA
KENNETT DIVISION
KESWICK DAM AND POWER PLANT
SPRING CREEK SITE - PLAN 2A
PRELIMINARY ESTIMATE DRAWING
DRAWN P.H.
TRACED C.A.
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
214-D-6452



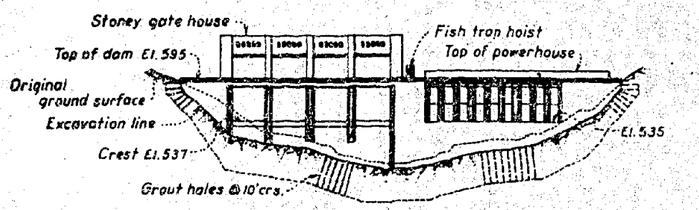




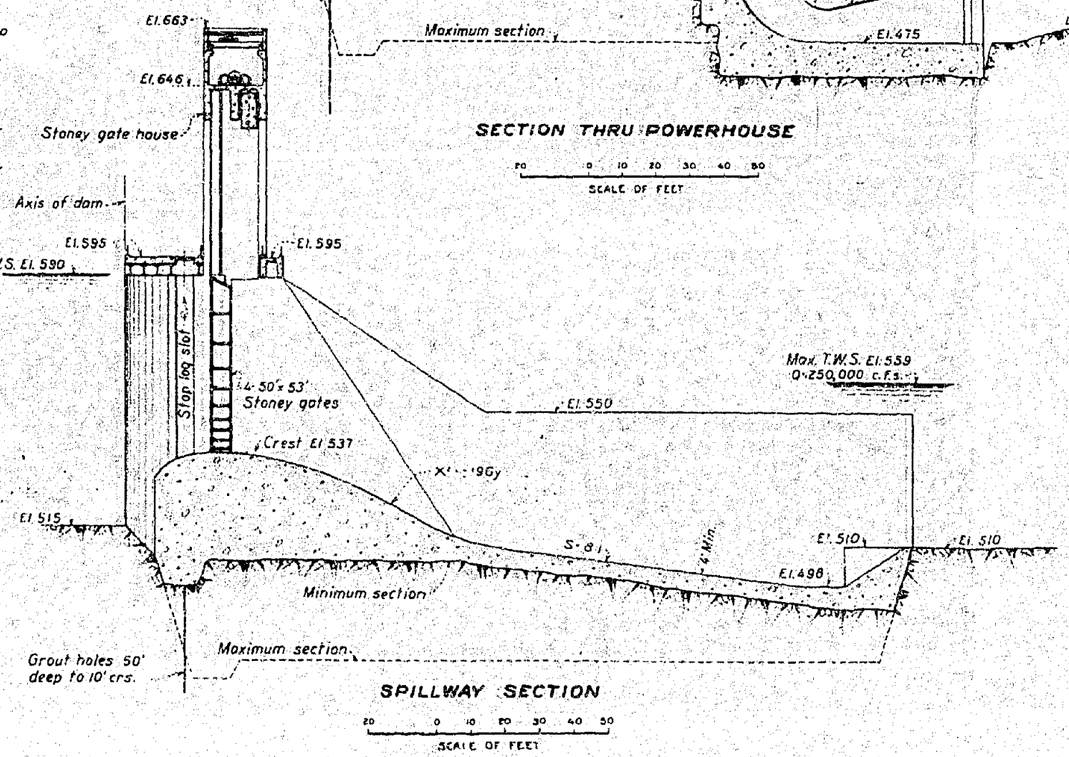
LOCATION MAP



CAPACITY - DISCHARGE - CURVES



UPSTREAM ELEVATION



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT-CALIFORNIA
KENNETT DIVISION

KESWICK DAM AND POWER PLANT
SPRING CREEK SITE - PLAN 2A
PRELIMINARY ESTIMATE DRAWING

DRAWN P.H. SUBMITTED W. E. Blomgren
TRACED C.A. RECOMMENDED
CHECKED APPROVED
DENVER, COLORADO MAR 24, 1940 214-D-4462

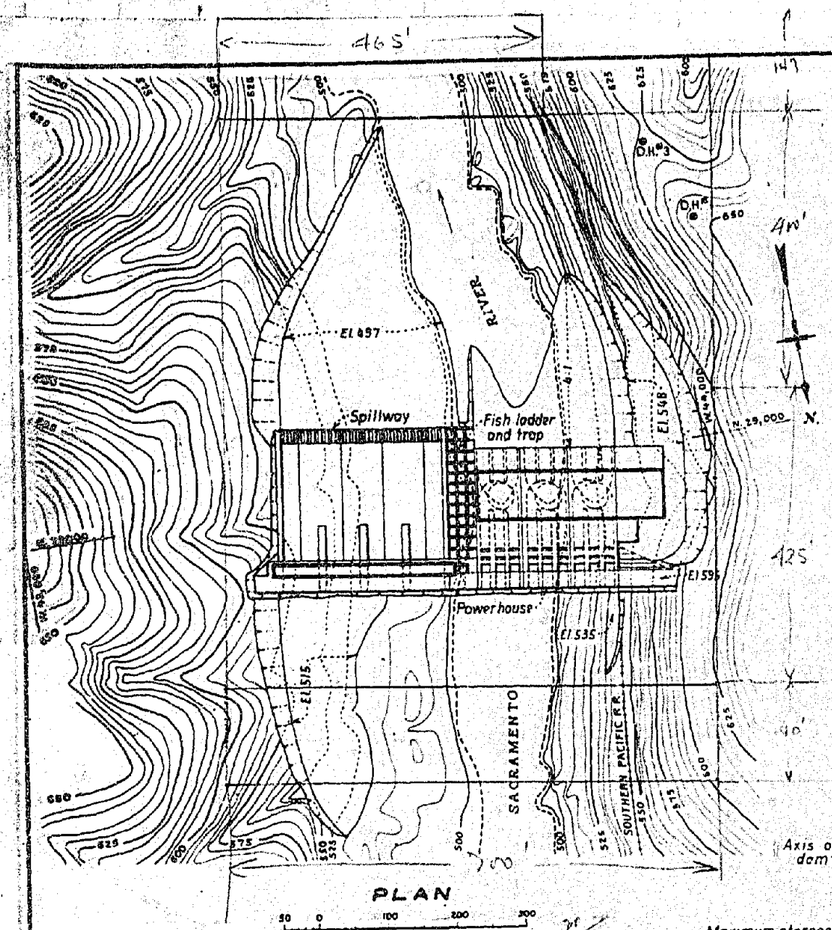
Top of dam elev. 595.0
Maximum W.S. elev. 590.0
Normal W.S. elev. 590.0
Maximum height of dam 120 ft.
Concrete dam
Reference drawing No. 214-D-4462.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT - CALIFORNIA
KESWICK DAM
Preliminary Estimate

March 26, 1940.
Storage capacity 20,000 A.F.
Spillway capacity 250,000 S.F.
Power outlet cap. 13,000 S.F.
Site - Spring Creek - Plan 2A.

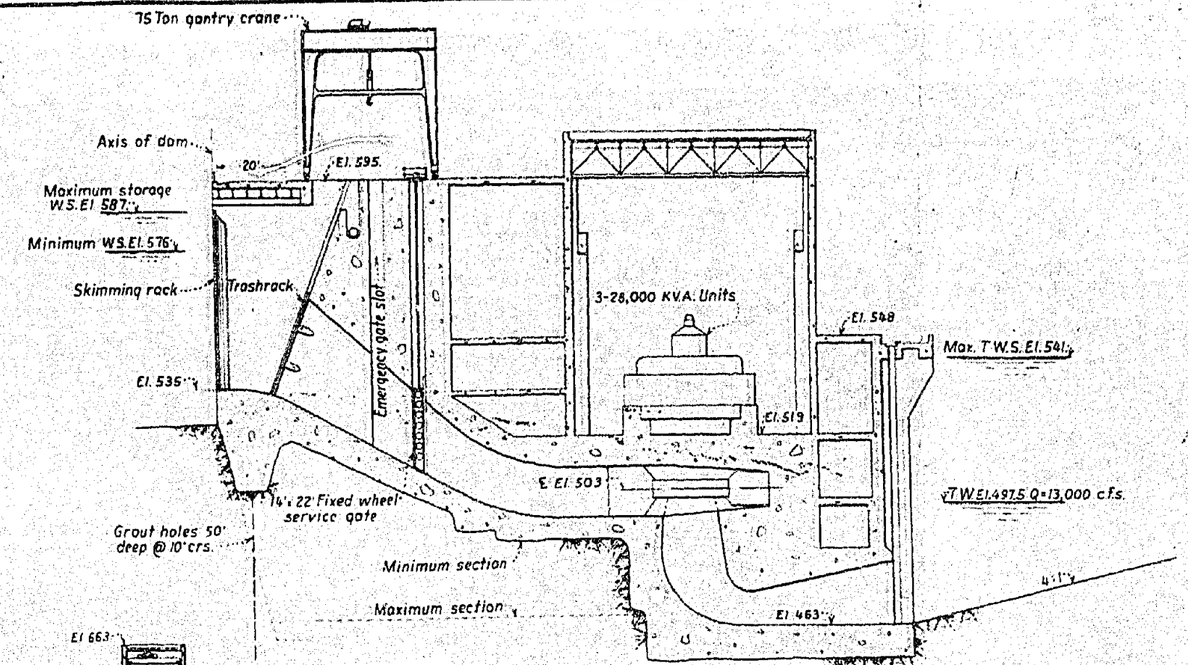
ITEM NO.	ITEM	QUANTITY		MATERIAL AND LABOR FURNISHED BY THE CONTRACTOR		MATERIAL FURNISHED BY THE GOVERNMENT		SUMMARY	
		AMOUNT	UNIT	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST
	Diversion and care of river during construction and unwatering foundation	Lump Sum		L.S.	$ 340,000			L.S.	$ 340,000
	Excavation, unclassified:								
	Dam and power-plant foundation	109,000	cy	$3.25	354,250			$3.25	354,250
	Access area for power plant	32,000	cy	3.25	104,000			3.25	104,000
	Spillway channel	21,000	cy	3.25	68,250			3.25	68,250
	Power outlet channel	31,000	cy	3.25	100,750			3.25	100,750
	Embankment:								
	Backfill about structures	6,000	cy	0.60	3,600			0.60	3,600
	Grouting:								
	Drilling grout holes not more than 25 ft. deep	700	lf	1.50	1,050			1.50	1,050
	Drilling grout holes 26 to 50 feet deep	2,000	lf	2.00	4,000			2.00	4,000
	Pressure grouting dam foundation	2,700	cf	1.00	2,700	$0.65	$ 1,755	1.65	4,455
	Grout pipe and fittings	10,000	lb	0.12	1,200	0.16	1,600	0.28	2,800
	Drainage:								
	Drilling drainage holes not more than 25 ft deep	1,700	lf	2.00	3,400			2.00	3,400
	Drain pipe and fittings	50,000	lb	0.12	6,000	0.16	8,000	0.28	14,000
	5-inch porous concrete drain tile in dam	2,200	lf	1.00	2,200	0.27	594	1.27	2,794
	12-inch split sewer-pipe drains	1,700	lf	2.00	3,400	0.60	1,020	2.60	4,420
	Concrete:								
	Nonoverflow sections	18,000	cy	4.00	72,000	4.00	72,000	8.00	144,000
	Spillway crest and apron	45,000	cy	6.50	292,500	4.50	202,500	11.00	495,000
	Power intake base	19,000	cy	8.00	152,000	4.50	85,500	12.50	237,500
	Spillway piers and training walls	10,000	cy	8.50	85,000	4.75	47,500	13.25	132,500
	Power intake structure	19,500	cy	10.50	204,750	4.50	87,750	15.00	292,500
	Trashrack beams	120	cy	25.00	3,000	4.75	570	29.75	3,570
	Spillway bucket sill	1,600	cy	8.50	13,600	4.75	7,600	13.25	21,200
	Spillway and power intake bridges	440	cy	25.00	11,000	4.75	2,090	29.75	13,090
	Spillway gate hoist superstructure	2,200	cy	25.00	55,000	5.00	11,000	30.00	66,000
	Spillway gate counterweights	430	cy	15.00	6,450	4.50	1,935	19.50	8,385
	Fish ladder and control trap	1,100	cy	25.00	27,500	5.00	5,500	30.00	33,000
	Metalwork:								
	Reinforcement bars	1,960,000	lb	0.02	39,200	0.035	68,600	0.055	107,800
	Trashrack metalwork	210,000	lb	0.02	4,200	0.13	27,300	0.15	31,500
	Skimming rack metalwork	170,000	lb	0.03	5,100	0.13	22,100	0.16	27,200
	Structural steel for bridges	761,000	lb	0.02	15,220	0.055	41,855	0.075	57,075
	Spillway gates and frames	2,170,000	lb	0.03	65,100	0.135	292,950	0.165	358,050
	Spillway gate hoists and control mechanisms	720,000	lb	0.035	25,200	0.30	216,000	0.335	241,200
	Power outlet gates and frames	1,165,000	lb	0.03	34,950	0.11	128,150	0.14	163,100
	Traveling and gantry cranes and rails	190,000	lb	0.03	5,700	0.18	34,200	0.21	39,900
	Bridge railing	81,000	lb	0.10	8,100	0.20	16,200	0.30	24,300
	Pipe handrailing	10,000	lb	0.10	1,000	0.20	2,000	0.30	3,000
	Metal stairways and walkways	16,000	lb	0.04	640	0.15	2,400	0.19	3,040
	30-inch outlet pipe for fish trap	6,000	lb	0.03	180	0.12	720	0.15	900
	30-inch gate valve for fish trap	6,000	lb	0.02	120	0.20	1,200	0.22	1,320
	Miscellaneous fish-trap metalwork	200,000	lb	0.04	8,000	0.12	24,000	0.16	32,000
	Elevator and hoist hoists for fish trap	10,000	lb	0.04	400	0.30	3,000	0.34	3,400
	Miscellaneous metalwork	10,000	lb	0.10	1,000	0.12	1,200	0.22	2,200
	Metal sealing strips	1,000	lf	0.70	700	0.25	250	0.95	950
	Electrical conductors and conduits	Lump Sum		L.S.	3,000	L.S.	5,000	L.S.	8,000
	SUBTOTAL				$ 2,135,410		$1,424,039		$3,559,449
	Contingencies +15%								533,917
	Lands and improvements								20,000
	Highway and railroad relocation								50,000
	TOTAL ESTIMATED FIELD COST								$4,163,366
	Engineering and inspection +6%								249,802
	Superintendence and accounts +1½%								62,450
	General expense +2½%								104,084
	TOTAL ESTIMATED COST (exclusive of power plant)								$4,580,702
	POWER PLANT and TRANSMISSION LINES (exclusive of power-plant excavation) see estimate No. 214-D-4440								$6,944,467
	TOTAL ESTIMATED COST - RESERVOIR, DAM, POWER PLANT, and TRANSMISSION LINES								$11,525,169

214-D-4437



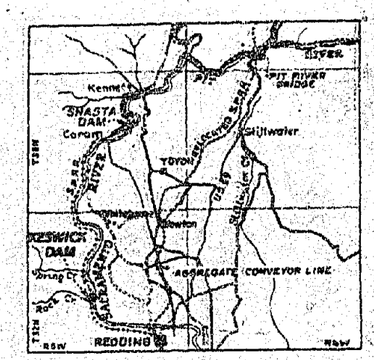
PLAN

SCALE OF FEET

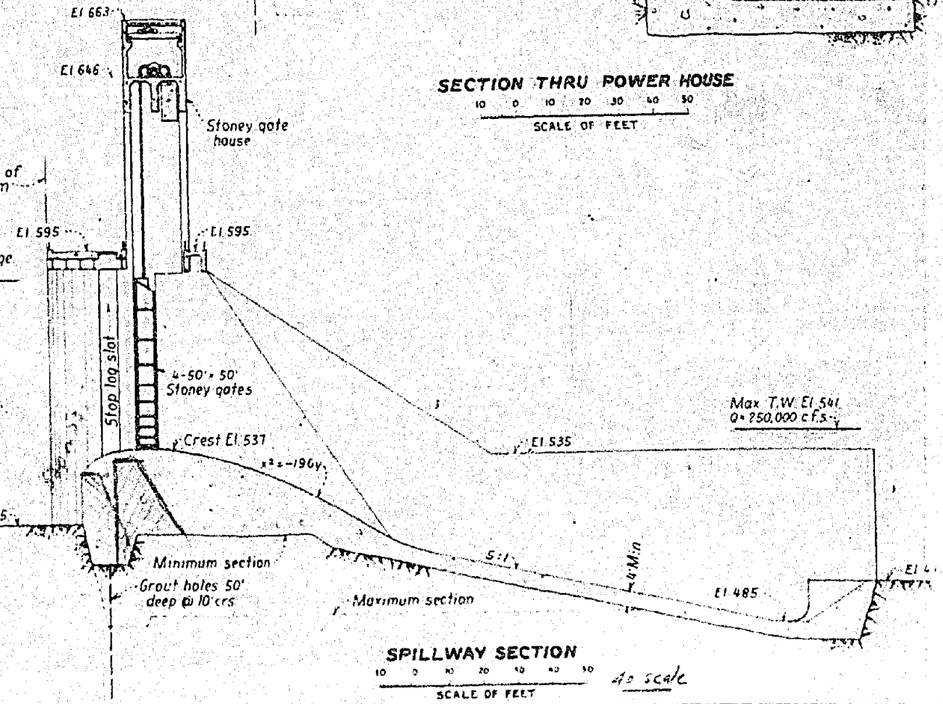


SECTION THRU POWER HOUSE

SCALE OF FEET



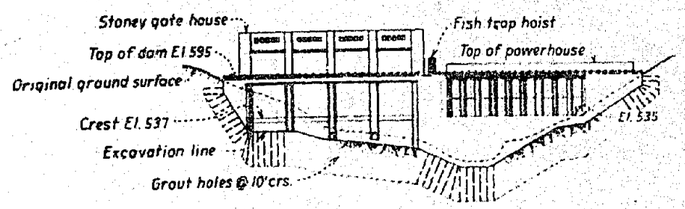
LOCATION MAP



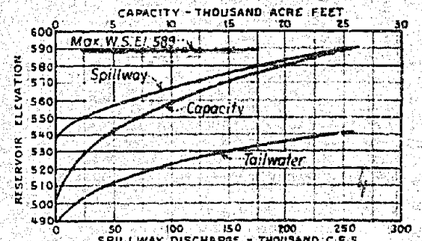
SPILLWAY SECTION

SCALE OF FEET

As scale



UPSTREAM ELEVATION



CAPACITY - DISCHARGE - CURVES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT - CALIFORNIA
KENNETT DIVISION

KESWICK DAM AND POWER PLANT
ROCK CREEK SITE - PLAN 3A
PRELIMINARY ESTIMATE DRAWING

DRAWN	P.H.	SUBMITTED	W. E. Blanquin
TRACED	E.W.C.	RECOMMENDED	
CHECKED		APPROVED	

DENVER, COLORADO, MAY 24, 1960 — 214-D-4463

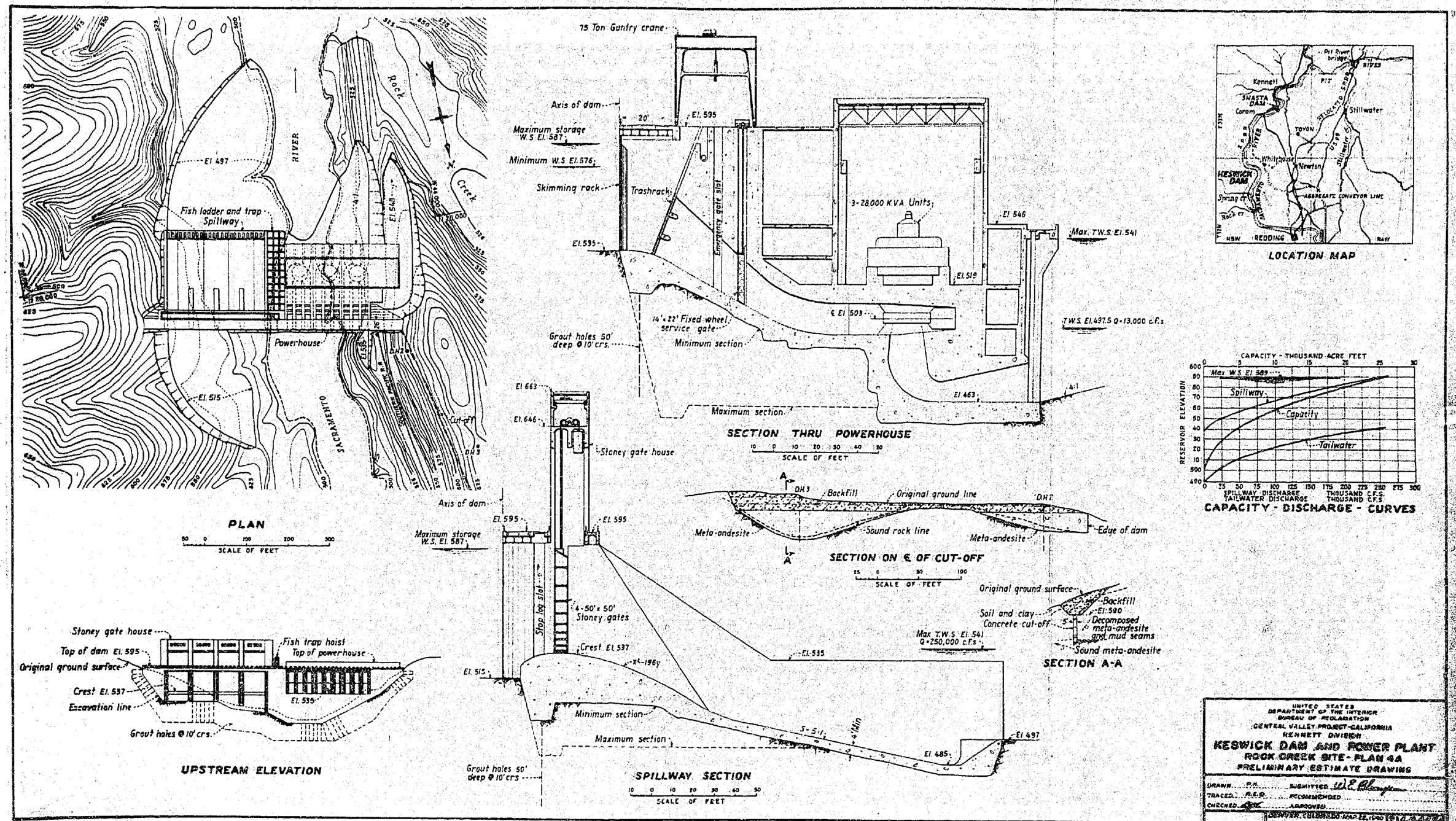
Top of dam elev. 595.0
Maximum W.S. elev. 587.0
Normal W.S. elev. 587.0
Maximum height of dam 120 feet
Concrete dam
Reference drawing No. 214-D-4463

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT - CALIFORNIA
KESWICK DAM
Preliminary Estimate

March 26, 1940.
Storage capacity 24,000 A.F.
Spillway capacity 250,000 S.F.
Power outlet cap. 13,000 S.F.
Site - Rock Creek - Plan No. 3A.

ITEM NO.	ITEM	QUANTITY		MATERIAL AND LABOR FURNISHED BY THE CONTRACTOR		MATERIAL FURNISHED BY THE GOVERNMENT		SUMMARY	
		AMOUNT	UNIT	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST
	Diversion and care of river during construction and unwatering foundation	Lump Sum		L.S.	$ 235,000			L.S.	$ 235,000
	Excavation, unclassified:								
	Dam and power-plant foundation	140,000	cy	$3.25	455,000			$3.25	455,000
	Access area for power plant	22,000	cy	3.25	71,500			3.25	7[illegible],500
	Spillway channel	78,000	cy	3.25	253,500			3.25	2[illegible],500
	Power outlet channel	31,000	cy	3.25	100,750			3.25	100,750
	Embankment:								
	Backfill about structures	3,000	cy	0.60	1,800			0.60	1,800
	Grouting:								
	Drilling grout holes not more than 25 ft. deep	700	lf	1.50	1,050			1.50	1,050
	Drilling grout holes 26 to 50 feet deep	2,000	lf	2.00	4,000			2.00	4,000
	Pressure grouting dam foundation	2,700	cf	1.00	2,700	$0.65	$ 1,755	1.65	4,455
	Grout pipe and fittings	10,000	lb	0.12	1,200	0.16	1,600	0.28	2,800
	Drainage:								
	Drilling drainage holes not more than 25 ft. deep	1,700	lf	2.00	3,400			2.00	3,400
	Drain pipe and fittings	50,000	lb	0.12	6,000	0.16	8,000	0.28	14,000
	5-inch porous concrete drain tile in dam	2,200	lf	1.00	2,200	0.27	594	1.27	2,794
	12-inch split sewer-pipe drains	1,700	lf	2.00	3,400	0.60	1,020	2.60	4,420
	Concrete:								
	Nonoverflow sections	18,500	cy	4.00	74,000	4.00	74,000	8.00	148,000
	Spillway crest and apron	31,000	cy	6.50	201,500	4.50	139,500	11.00	341,000
	Power intake base	19,500	cy	8.00	156,000	4.50	87,750	12.50	243,750
	Spillway piers and training walls	10,000	cy	8.50	85,000	4.75	47,500	13.25	132,500
	Power intake structure	20,900	cy	10.50	219,450	4.50	94,050	15.00	313,500
	Trashrack beams	120	cy	25.00	3,000	4.75	570	29.75	3,570
	Spillway bucket sill	1,600	cy	8.50	13,600	4.75	7,600	13.25	21,200
	Spillway and power intake bridges	440	cy	25.00	11,000	4.75	2,090	29.75	13,090
	Spillway gate hoist superstructure	2,200	cy	25.00	55,000	5.00	11,000	30.00	66,000
	Spillway gate counterweights	430	cy	15.00	6,450	4.50	1,935	19.50	8,385
	Fish ladder and control trap	1,100	cy	25.00	27,500	5.00	5,500	30.00	33,000
	Metalwork:								
	Reinforcement bars	2,002,000	lb	0.02	40,040	0.035	70,070	0.055	110,110
	Trashrack metalwork	210,000	lb	0.02	4,200	0.13	27,300	0.15	31,500
	Skimming rack metalwork	170,000	lb	0.03	5,100	0.13	22,100	0.16	27,200
	Structural steel for bridges	761,000	lb	0.02	15,220	0.055	41,855	0.075	57,075
	Spillway gates and frames	2,060,000	lb	0.03	61,800	0.135	278,100	0.165	339,900
	Spillway gate hoists and control mechanisms	680,000	lb	0.035	23,800	0.30	204,000	0.335	227,800
	Power outlet gates and frames	1,410,000	lb	0.03	42,300	0.11	155,100	0.14	197,400
	Traveling and gantry cranes and rails	190,000	lb	0.03	5,700	0.18	34,200	0.21	39,900
	Bridge railing	81,000	lb	0.10	8,100	0.20	16,200	0.30	24,300
	Pipe handrailing	10,000	lb	0.10	1,000	0.20	2,000	0.30	3,000
	Metal stairways and walkways	16,000	lb	0.04	640	0.15	2,400	0.19	3,040
	30-inch outlet pipe for fish trap	6,000	lb	0.03	180	0.12	720	0.15	900
	30-inch gate valve for fish trap	6,000	lb	0.02	120	0.20	1,200	0.22	1,320
	Miscellaneous fish-trap metalwork	200,000	lb	0.04	8,000	0.12	24,000	0.16	32,000
	Elevator and brail hoists for fish trap	10,000	lb	0.04	400	0.30	3,000	0.34	3,400
	Miscellaneous metalwork	10,000	lb	0.10	1,000	0.12	1,200	0.22	2,200
	Metal sealing strips	1,000	lf	0.70	700	0.25	250	0.95	950
	Electrical conductors and conduits	Lump Sum		L.S.	3,000	L.S.	5,000	L.S.	8,000
	SUBTOTAL				$2,215,300		$1,373,159		$ 3,588,459
	Contingencies +15%								538,269
	Lands and improvements								20,000
	Highway and railroad relocation								50,000
	TOTAL ESTIMATED FIELD COST								$ 4,196,728
	Engineering and inspection +6%								251,804
	Superintendence and accounts +1½%								62,953
	General expense +2½%								104,918
	TOTAL ESTIMATED COST (exclusive of power plant)								$ 4,616,401
	POWER PLANT and TRANSMISSION LINES (exclusive of power-plant excavation) see estimate No. 214-D-4440								$ 6,945,467
	TOTAL ESTIMATED COST - RESERVOIR, DAM, POWER PLANT, and TRANSMISSION LINES								$11,561,868

214-D-4436


PLAN
SCALE OF FEET
RIVER
SACRAMENTO
Rock
Creek
El 497
Fish ladder and trap
Spillway
Powerhouse
El. 515
El. 540
Cut-off
Axis of dam
Maximum storage
W.S. El. 587
SECTION THRU POWERHOUSE
SCALE OF FEET
75 Ton Gantry crane
Axis of dam
Maximum storage
W.S. El. 587
Minimum W.S. El. 576
Skimming rack
Trashrack
Emergency gate slot
El. 595
El. 535
3-28,000 K.V.A. Units
El. 546
Max. T.W.S. El. 541
El. 519
℄ El 503
T.W.S. El. 497.5 Q=13,000 c.f.s.
14'x22' Fixed wheel
service gate
Minimum section
Grout holes 50'
deep @ 10' crs.
El 463
Maximum section
LOCATION MAP
Pit River bridge
Kennett
SHASTA DAM
Coram
Stillwater
TOYON
Whitehouse
Newton
KESWICK DAM
Spring cr.
Rock cr.
AGGREGATE CONVEYOR LINE
NSW
REDDING
RAVI
CAPACITY - THOUSAND ACRE FEET
Max W.S. El 589
Spillway
Capacity
Tailwater
RESERVOIR ELEVATION
SPILLWAY DISCHARGE THOUSAND C.F.S.
TAILWATER DISCHARGE THOUSAND C.F.S.
CAPACITY - DISCHARGE - CURVES
El 663
El. 646
Stoney gate house
Axis of dam
Maximum storage
W.S. El. 587
El. 595
Stop log slot
4-50'x 50'
Stoney gates
Crest El. 537
El. 515
Minimum section
Maximum section
Grout holes 50'
deep @ 10' crs
SPILLWAY SECTION
SCALE OF FEET
Backfill
Original ground line
Meta-andesite
Sound rock line
Edge of dam
SECTION ON ℄ OF CUT-OFF
SCALE OF FEET
Original ground surface
Backfill
El. 590
Soil and clay
Concrete cut-off
Decomposed
meta-andesite
and mud seams
Sound meta-andesite
SECTION A-A
Max T.W.S. El. 541
Q=250,000 c.f.s.
El. 535
El. 497
El. 485
Stoney gate house
Top of dam El. 595
Original ground surface
Crest El. 537
Excavation line
Fish trap hoist
Top of powerhouse
El. 535
Grout holes @ 10' crs.
UPSTREAM ELEVATION
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT-CALIFORNIA
KENNETT DIVISION
KESWICK DAM AND POWER PLANT
ROCK CREEK SITE - PLAN 4A
PRELIMINARY ESTIMATE DRAWING
DRAWN
TRACED
CHECKED
SUBMITTED
RECOMMENDED
APPROVED

Top of dam elev. 595.0
Maximum W.S. elev. 587.0
Normal W.S. elev. 587.0
Maximum height of dam 120 feet
Concrete dam
Reference drawing No. 214-D-4464

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT - CALIFORNIA
KESWICK DAM
Preliminary Estimate

March 26, 1940.
Storage capacity 24,000 A.F.
Spillway capacity 250,000 S.F.
Power outlet cap. 13,000 S.F.
Site - Rock Creek -Plan No. 4A.

ITEM NO.	ITEM	QUANTITY		MATERIAL AND LABOR FURNISHED BY THE CONTRACTOR		MATERIAL FURNISHED BY THE GOVERNMENT		SUMMARY	
		AMOUNT	UNIT	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST
	Diversion and care of river during construction and unwatering foundation	Lump Sum		L.S.	$ 235,000			L.S.	$ 235,000
	Excavation, unclassified:								
	Dam and power-plant foundation	147,000	cy	$3.25	477,750			$3.25	477,750
	Access area for power plant	21,000	cy	3.25	68,250			3.25	68,250
	Spillway channel	98,000	cy	3.25	318,500			3.25	318,500
	Power outlet channel	31,000	cy	3.25	100,750			3.25	100,750
	Cut-off wall extension	17,000	cy	3.25	55,250			3.25	55,250
	Embankment:								
	Backfill about structures	3,000	cy	0.60	1,800			0.60	1,800
	Grouting:								
	Drilling grout holes not more than 25 ft. deep	700	lf	1.50	1,050			1.50	1,050
	Drilling grout holes 26 to 50 feet deep	2,000	lf	2.00	4,000			2.00	4,000
	Pressure grouting dam foundation	2,700	cf	1.00	2,700	$0.65	$ 1,755	1.65	4,455
	Grout pipe and fittings	10,000	lb	0.12	1,200	0.16	1,600	0.28	2,800
	Drainage:								
	Drilling drainage holes not more than 25 ft. deep	1,700	lf	2.00	3,400			2.00	3,400
	Drain pipe and fittings	50,000	lb	0.12	6,000	0.16	8,000	0.28	14,000
	5-inch porous concrete drain tile in dam	2,200	lf	1.00	2,200	0.27	594	1.27	2,794
	12-inch split sewer pipe drains	1,700	lf	2.00	3,400	0.60	1,020	2.60	4,420
	Concrete:								
	Nonoverflow sections	18,500	cy	4.00	74,000	4.00	74,000	8.00	148,000
	Spillway crest and apron	30,200	cy	6.50	196,300	4.50	135,900	11.00	332,200
	Power intake base	20,000	cy	8.00	160,000	4.50	90,000	12.50	250,000
	Spillway piers and training walls	10,000	cy	8.50	85,000	4.75	47,500	13.25	132,500
	Power intake structure	20,900	cy	10.50	219,450	4.50	94,050	15.00	313,500
	Trashrack beams	120	cy	25.00	3,000	4.75	570	29.75	3,570
	Spillway bucket sill	1,600	cy	8.50	13,600	4.75	7,600	13.25	21,200
	Spillway and power intake bridges	440	cy	25.00	11,000	4.75	2,090	29.75	13,090
	Spillway gate hoist superstructure	2,200	cy	25.00	55,000	5.00	11,000	30.00	66,000
	Spillway gate counterweights	430	cy	15.00	6,450	4.50	1,935	19.50	8,385
	Fish ladder and control trap	1,100	cy	25.00	27,500	5.00	5,500	30.00	33,000
	Cut-off wall extension	3,000	cy	6.00	18,000	4.00	12,000	10.00	30,000
	Metalwork:								
	Reinforcement bars	2,002,000	lb	0.07	40,040	0.035	70,070	0.055	110,110
	Trashrack metalwork	210,000	lb	0.02	4,200	0.13	27,300	0.15	31,500
	Skimming rack metalwork	170,000	lb	0.03	5,100	0.13	22,100	0.16	27,200
	Structural steel for bridges	761,000	lb	0.02	15,220	0.055	41,855	0.075	57,075
	Spillway gates and frames	2,060,000	lb	0.03	61,800	0.135	278,100	0.165	339,900
	Spillway gate hoists and control mechanisms	680,000	lb	0.035	23,800	0.30	204,000	0.335	227,800
	Power outlet gates and frames	1,410,000	lb	0.03	42,300	0.11	155,100	0.14	197,400
	Traveling and gantry cranes and rails	190,000	lb	0.03	5,700	0.18	34,200	0.21	39,900
	Bridge railing	81,000	lb	0.10	8,100	0.20	16,200	0.30	24,300
	Pipe handrailing	10,000	lb	0.10	1,000	0.20	2,000	0.30	3,000
	Metal stairways and walkways	16,000	lb	0.04	640	0.15	2,400	0.19	3,040
	30-inch outlet pipe for fish trap	6,000	lb	0.03	180	0.12	720	0.15	900
	30-inch gate valve for fish trap	6,000	lb	0.02	120	0.20	1,200	0.22	1,320
	Miscellaneous fish-trap metalwork	200,000	lb	0.04	8,000	0.12	24,000	0.16	32,000
	Elevator and brail hoists for fish trap	10,000	lb	0.04	400	0.30	3,000	0.34	3,400
	Miscellaneous metalwork	10,000	lb	0.10	1,000	0.12	1,200	0.22	2,200
	Metal sealing strips	1,000	lf	0.70	700	0.25	250	0.95	950
	Electrical conductors and conduits	Lump Sum		L.S.	3,000	L.S.	5,000	L.S.	8,000
	SUBTOTAL				$ 2,371,850		$1,383,809		$ 3,755,659
	Contingencies +15%								563,349
	Lands and improvements								20,000
	Highway and railroad relocation								50,000
	TOTAL ESTIMATED FIELD COST								$ 4,389,008
	Engineering and inspection +6%								263,340
	Superintendence and accounts +1½%								65,836
	General expense +2½%								109,725
	TOTAL ESTIMATED COST (exclusive of power plant)								$ 4,827,908
	POWER PLANT and TRANSMISSION LINES (exclusive of power-plant excavation) see estimate No. 214-D-4440								$ 6,945,467
	TOTAL ESTIMATED COST - RESERVOIR, DAM, POWER PLANT, and TRANSMISSION LINES								$11,773,375

214-D-4438

SPRING CREEK SITE
Plan No. 2A
25,000 kv.-a.
35,000 horsepower
94.7 r.p.m.
80-foot head

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT - CALIFORNIA
KESWICK DAM
Preliminary Estimate - Power Plant and Transmission Lines

March 26, 1940
ROCK CREEK SITE
Plans Nos. 3A and 4A
28,000 kv.-a.
39,000 horsepower
100 r.p.m. - 89-foot head

ITEM NO.	ITEM	QUANTITY		MATERIAL AND LABOR FURNISHED BY THE CONTRACTOR		MATERIAL FURNISHED BY THE GOVERNMENT		SUMMARY	
		AMOUNT	UNIT	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST
	Concrete:								
	Substructure - 1st stage	8,632	cy	$25.00	$ 215,800	$3.70	$ 31,938	$28.70	$ 247,738
	Substructure - 2nd stage	30,841	cy	15.00	462,615	3.70	114,112	18.70	576,727
	Superstructure - 1st stage	13,189	cy	35.00	461,615	3.70	48,799	38.70	510,414
	Terrazzo floor	20,732	sf	2.50	51,830	0.30	6,220	2.80	58,050
	SUBTOTAL				$1,191,860		$ 201,069		$ 1,392,929
	Steel:								
	Roof steel	550,000	lb	0.015	8,250	0.05	27,500	0.065	35,750
	Reinforcing steel	3,952,000	lb	0.02	79,040	0.035	138,320	0.055	217,360
	Draft-tube gates	27,200	lb	0.015	408	0.10	2,720	0.115	3,128
	Draft-tube gate frames	63,300	lb	0.04	2,532	0.10	6,330	0.14	8,862
	Miscellaneous metalwork	33,000	lb	0.10	3,300	0.12	3,960	0.22	7,260
	Track rails	83,000	lb	0.02	1,660	0.05	4,150	0.07	5,810
	SUBTOTAL				$ 95,190		$ 182,980		$ 278,170
	Hydraulic equipment:								
	Turbines 39,000-hp.; 100-r.p.m., H = 89 ft.	3	ea	10,800	32,400	245000	735,000	255800	767,400
	Governor and piping	3	ea	600	1,800	17,800	53,400	18,400	55,200
	SUBTOTAL				$ 34,200		$ 788,400		$ 822,600
	Electrical equipment:								
	Generators 28,000-kv.-a.; 6.9-kv.	3	ea	19,600	58,800	340000	1,020,000	359600	1,078,800
	Gen. leads 1ø	700	lf	20	14,000	270	189,000	290	203,000
	Transformers, 10,000-kv.-a., 6.9/220-kv.	10	ea	1,600	16,000	54,540	543,400	55,940	559,400
	Transformers, 500-kv.-a., 6.9/115-230	7	ea	50	350	5,378	37,646	5,428	37,996
	Disc. sw. 7,500-volt, 400-amp.	15	ea	3	45	18.60	279	21.60	324
	Exc. cub. and volt reg.	3	ea	575	1,725	13,700	41,100	14,275	42,825
	Main swbd.	Lump Sum			1,875		62,000		63,875
	Station serv.	Lump Sum			4,800		62,000		66,800
	Station serv. cable and cond.	Lump Sum			3,800		9,600		13,400
	Control " " "	Lump Sum			3,800		8,000		11,800
	Lighting cable and cond.	Lump Sum			2,800		6,400		9,200
	Lighting transformers, 75-kv.-a.	5	ea	10	50	1,320	6,600	1,330	6,650
	Lighting fixtures, cabinets, etc.	Lump Sum			2,250		14,250		16,500
	Storage battery and charging equip.	Lump Sum			800		17,200		18,000
	Miscellaneous elec. equipment	Lump Sum			11,000		50,000		61,000
	SUBTOTAL				$ 122,095		$2,067,475		$ 2,189,570
	Mechanical equipment:								
	Crane 180-ton	1	ea		7,000		55,000		62,000
	Pumps and eductors	10,000	lb	0.05	500	0.30	3,000	0.35	3,500
	Water, air, oil piping and valves	Lump Sum			65,000		131,000		196,000
	Oil tanks	28,000	lb	0.02	560	0.10	2,800	0.12	3,360
	Draft-tube gantry	Lump Sum			600		6,000		6,600
	Transfer car	Lump Sum			300		4,500		4,800
	Machine-shop equipment	Lump Sum			1,000		50,000		51,000
	Miscellaneous mech. equipment	Lump Sum			7,500		25,000		32,500
	SUBTOTAL				$ 82,460		$ 277,300		$ 359,760
	Switchyard:								
	Excavation and grading	7,500	cy	3.00	22,500			3.00	22,500
	Concrete foundations	1,125	cy	20.00	22,500	3.00	3,375	23.00	25,875
	Steel reinforcing	112,500	lb	0.02	2,250	0.035	3,938	0.055	6,188
	Steel structural galvanized	430,000	lb	0.02	8,600	0.08	34,400	0.10	43,000
	Disc. switch S.P.S.T. 220-kv. T.P.S.T.	3	ea	400	1,200	8,000	24,000	8,400	25,200
	O.C.B. 220-kv. 3P.	3	ea	1,000	3,000	65,000	195,000	66,000	198,000
	Miscellaneous swyd. equipment	Lump Sum			6,000		26,000		32,000
	SUBTOTAL				$ 86,050		$ 286,713		$ 372,763
	TOTAL				$1,591,855		$3,803,937		$ 5,395,792
	Contingencies 15%				238,778		570,591		809,369
	ESTIMATED FIELD COST				$1,830,633		$4,374,528		$ 6,205,161
	Overhead +10%								620,516
	TOTAL ESTIMATED COST (POWER PLANT exclusive of excavation)								$ 6,825,677
	TRANSMISSION LINES								
	Construction and station serv. 6.9-kv.	9	mi					2,000	$ 18,000
	Trans. to Shasta Swyd.	9	mi					9,000	81,000
	TOTAL								$ 99,000
	Contingencies 10%								9,900
	ESTIMATED FIELD COST								$ 108,900
	Overhead 10%								10,890
	TOTAL ESTIMATED COST - TRANSMISSION LINES								$ 119,790

214-D-4440

D.C.M. 3-13-40

Top of dam elev. 595.0
Maximum W.S. elev. 545.0
W.S. top of temporary weir elev. 535.0
Maximum height of dam 120 feet
Partial construction of concrete dam and cofferdam adequate for trapping fish

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT - CALIFORNIA
KESWICK DAM
Preliminary Estimate

March 26, 1940
Storage capacity - None
Flood capacity 100,000 S.F.
Power outlet capacity - None
Site - Rock Creek - Plan No. 3B.

ITEM NO.	ITEM	QUANTITY		MATERIAL AND LABOR FURNISHED BY THE CONTRACTOR		MATERIAL FURNISHED BY THE GOVERNMENT		SUMMARY	
		AMOUNT	UNIT	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST
	Diversion and care of river during construction and unwatering foundation	Lump Sum		L.S.	$ 170,000			L.S.	$ 170,000
	Excavation, unclassified:								
	Dam foundation	89,000	cy	3.25	289,250			$ 3.25	289,250
	Spillway channel	78,000	cy	3.25	253,500			3.25	253,500
	Embankment:								
	Backfill about structures	2,500	cy	0.60	1,500			0.60	1,500
	Grouting:								
	Drilling grout holes not more than 25 ft. deep	1,250	lf	1.50	1,875			1.50	1,875
	Drilling grout holes 26 to 50 feet deep	330	lf	2.00	660			2.00	660
	Pressure grouting dam foundation	1,600	cf	1.00	1,600	$ 0.65	$ 1,040	1.65	2,640
	Grout pipe and fittings	5,300	lb	0.12	636	0.16	848	0.28	1,484
	Drainage:								
	Drilling drainage holes not more than 25 ft deep	930	lf	2.00	1,860			2.00	1,860
	Drain pipe and fittings	28,250	lf	0.12	3,390	0.16	4,520	0.28	7,910
	5-inch porous concrete drain tile in dam	2,200	lf	1.00	2,200	0.27	594	1.27	2,794
	12-inch split sewer-pipe drains	1,120	lf	2.00	2,240	0.60	672	2.60	2,912
	Concrete:								
	Nonoverflow section	12,000	cy	4.00	48,000	4.00	48,000	8.00	96,000
	Spillway crest and apron	20,200	cy	6.50	131,300	4.50	90,900	11.00	222,200
	Spillway piers and training walls	11,360	cy	8.50	96,560	4.75	53,960	13.25	150,520
	Spillway bucket sill	1,600	cy	8.50	13,600	4.75	7,600	13.25	21,200
	Spillway bridges	270	cy	25.00	6,750	4.75	1,282	29.75	8,032
	Fish ladder and control trap	1,100	cy	25.00	27,500	5.00	5,500	30.00	33,000
	Metalwork:								
	Reinforcement bars	1,007,500	lb	0.02	20,150	0.035	35,262	0.055	55,412
	Structural steel for bridges	469,000	lb	0.02	9,380	0.055	25,795	0.075	35,175
	Bridge railing	40,000	lb	0.10	4,000	0.20	8,000	0.30	12,000
	Pipe handrailing	10,000	lb	0.10	1,000	0.20	2,000	0.30	3,000
	Metal stairways and walkways	1,000	lb	0.04	40	0.15	150	0.19	190
	30-inch outlet pipe for fish trap	6,000	lb	0.03	180	0.12	720	0.15	900
	30-inch gate valve for fish trap	6,000	lb	0.02	120	0.20	1,200	0.22	1,320
	Miscellaneous fish-trap metalwork	200,000	lb	0.04	8,000	0.12	24,000	0.16	32,000
	Elevator and brail hoists for fish trap	10,000	lb	0.04	400	0.30	3,000	0.34	3,400
	Miscellaneous metalwork	2,000	lb	0.10	200	0.12	240	0.22	440
	Metal sealing strips	500	lf	0.70	350	0.25	125	0.95	475
	Electrical conductors and conduits	Lump Sum		L.S.	2,000	L.S.	4,500	L.S.	6,500
	SUBTOTAL				$ 1,098,241		$ 319,908		$ 1,418,149
	Contingencies +15%								212,722
	Lands and improvements								20,000
	Highway relocation								50,000
	TOTAL ESTIMATED FIELD COST								$ 1,700,871
	Engineering and inspection +6%								102,052
	Superintendence and accounts +1½%								25,513
	General expense +2½%								42,522
	TOTAL ESTIMATED COST - RESERVOIR and partially constructed DAM adequate for trapping fish.								$ 1,870,958

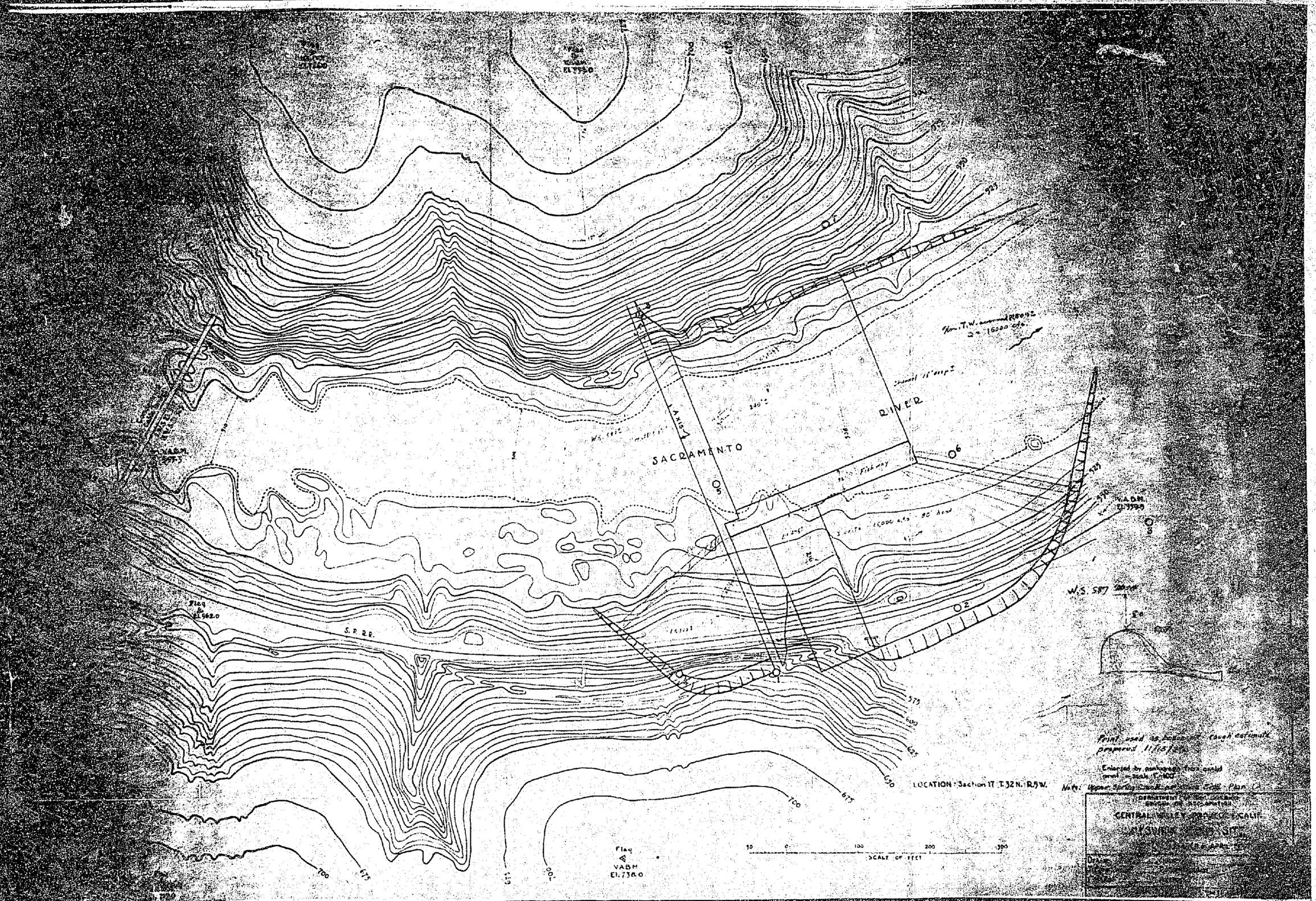
214-D-4441

Top of dam elev. 595.0
Maximum W.S. elev. 587.0
Normal W.S. elev. 587.0
Maximum height of dam 120 feet
Concrete dam - No power plant.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT - CALIFORNIA
KESWICK DAM
Preliminary Estimate

March 26, 1940.
Storage capacity 24,000 A.F.
Spillway capacity 250,000 S.F.
Power outlet capacity - None
Site - Rock Creek - Plan No. 3C.

ITEM NO.	ITEM	QUANTITY		MATERIAL AND LABOR FURNISHED BY THE CONTRACTOR		MATERIAL FURNISHED BY THE GOVERNMENT		SUMMARY	
		AMOUNT	UNIT	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST
	Diversion and care of river during construction and unwatering foundation	Lump Sum		L.S.	$ 240,000			L.S.	$ 240,000
	Excavation, unclassified:								
	Dam and power-intake foundation	104,000	cy	$3.25	338,000			$3.25	338,000
	Spillway and power inlet channels	80,000	cy	3.25	260,000			3.25	260,000
	Embankment:								
	Backfill about structures	3,000	cy	0.60	1,800			0.60	1,800
	Grouting:								
	Drilling grout holes not more than 25 feet deep	700	lf	1.50	1,050			1.50	1,050
	Drilling grout holes 26 to 50 feet deep	2,000	lf	2.00	4,000			2.00	4,000
	Pressure grouting dam foundation	2,700	lf	1.00	2,700	$0.65	$ 1,755	1.65	4,455
	Grout pipe and fittings	10,000	lb	0.12	1,200	0.16	1,600	0.28	2,800
	Drainage:								
	Drilling drainage holes not more than 25 ft. deep	1,700	lf	2.00	3,400			2.00	3,400
	Drain pipe and fittings	50,000	lb	0.12	6,000	0.16	8,000	0.28	14,000
	6-inch porous concrete drain tile in dam	2,200	lf	1.00	2,200	0.27	594	1.27	2,794
	12-inch split sewer-pipe drains	1,700	lf	2.00	3,400	0.60	1,020	2.60	4,420
	Concrete:								
	Nonoverflow sections	18,500	cy	4.00	74,000	4.00	74,000	8.00	148,000
	Spillway crest and apron	32,000	cy	6.50	208,000	4.50	144,000	11.00	352,000
	Power intake base	19,500	cy	8.00	156,000	4.50	87,750	12.50	243,750
	Spillway piers and training walls	10,000	cy	8.50	85,000	4.75	47,500	13.25	132,500
	Power intake structure	20,900	cy	10.50	219,450	4.50	94,050	15.00	313,500
	Trashrack beams	120	cy	25.00	3,000	4.75	570	29.75	3,570
	Spillway bucket sill	1,600	cy	8.50	13,600	4.75	7,600	13.25	21,200
	Spillway and power intake bridges	440	cy	25.00	11,000	4.75	2,090	29.75	13,090
	Spillway gate hoist superstructure	2,200	cy	25.00	55,000	5.00	11,000	30.00	66,000
	Spillway gate counterweights	430	cy	15.00	6,450	4.50	1,935	19.50	8,385
	Fish ladder and control trap	1,100	cy	25.00	27,500	5.00	5,500	30.00	33,000
	Metalwork:								
	Reinforcement bars	2,002,000	lb	0.02	40,040	0.035	70,070	0.055	110,110
	Trashrack metalwork	210,000	lb	0.02	4,200	0.13	27,300	0.15	31,500
	Structural steel for bridges	761,000	lb	0.02	15,220	0.055	41,855	0.075	57,075
	Skimming rack metalwork	170,000	lb	0.03	5,100	0.13	22,100	0.16	27,200
	Spillway gates and frames	2,060,000	lb	0.03	61,800	0.135	278,100	0.165	339,900
	Spillway gate hoists and control mechanisms	680,000	lb	0.035	23,800	0.30	204,000	0.335	227,800
	Power outlet gates and frames	1,410,000	lb	0.03	42,300	0.11	155,100	0.14	197,400
	Traveling and gantry cranes and rails	190,000	lb	0.03	5,700	0.18	34,200	0.21	39,900
	Bridge railing	81,000	lb	0.10	8,100	0.20	16,200	0.30	24,300
	Pipe handrailing	10,000	lb	0.10	1,000	0.20	2,000	0.30	3,000
	Metal stairs and walkways	16,000	lb	0.04	640	0.15	2,400	0.19	3,040
	30-inch outlet pipe for fish trap	6,000	lb	0.03	180	0.12	720	0.15	900
	30-inch gate valve for fish trap	6,000	lb	0.02	120	0.20	1,200	0.22	1,320
	Miscellaneous fish-trap metalwork	200,000	lb	0.04	8,000	0.18	24,000	0.18	32,000
	Elevator and brail hoists for fish trap	10,000	lb	0.04	400	0.30	3,000	0.34	3,400
	Miscellaneous metalwork	10,000	lb	0.10	1,000	0.12	1,200	0.22	2,200
	Metal sealing strips	1,000	lf	0.70	700	0.25	250	0.95	950
	Electrical conductors and conduits	Lump Sum		L.S.	3,000	L.S.	5,000	L.S.	8,000
	SUBTOTAL				$ 1,944,050		$1,377,659		$ 3,321,709
	Contingencies +15%								498,256
	Lands and improvements								20,000
	Highway and railroad relocation								50,000
	TOTAL ESTIMATED FIELD COST								$ 3,889,965
	Engineering and inspection +7%								$ 272,298
	Superintendence and accounts +1½%								58,348
	General expense +2½%								97,248
	TOTAL ESTIMATED COST - RESERVOIR, DAM, AND POWER INTAKE STRUCTURE								$4,318,861
									$14,0.4462


SACRAMENTO
RIVER
Levee
Fishway
S.P. R.R.
W.S. 587
Flag
VABM
El. 736.0
Flag
El. 962.0
VABM
El. 779.9
LOCATION: Section 17 T.32N. R.5W.
SCALE OF FEET
CENTRAL VALLEY PROJECT, CALIF.