SUMMARY REPORT
on the

Tri-Dam Project

STANISLAUS RIVER, CALIFORNIA

JANUARY, 1959

TUDOR - GOODENOUGH ENGINEERS

TUDOR - GOODENOUGH ENGINEERS

TRI - DAM PROJECT

SAN FRANCISCO OFFICE
595 MISSION STREET

PROJECT OFFICE
STRAWBERRY, CALIFORNIA

January 30, 1959

The Joint Boards of Directors of
the Oakdale Irrigation District and
the South San Joaquin Irrigation District

Gentlemen:

The Final Report of Construction required by our contract of March 25, 1955, was completed and submitted in August, 1958. That report, consisting of some 500 pages, was prepared for reference purposes and is now in the permanent files of the Tri-Dam Project.

Submitted herewith is a SUMMARY REPORT - INVESTIGATION AND CONSTRUCTION of the TRI-DAM PROJECT which is a brief history of the problems encountered in planning, financing, and construction of the project.

We wish to express our appreciation for the opportunity of having participated in the accomplishment of this noteworthy project.

Very truly yours,

TUDOR - GOODENOUGH ENGINEERS

Ralph A. Tudor

B. W. Goodenough

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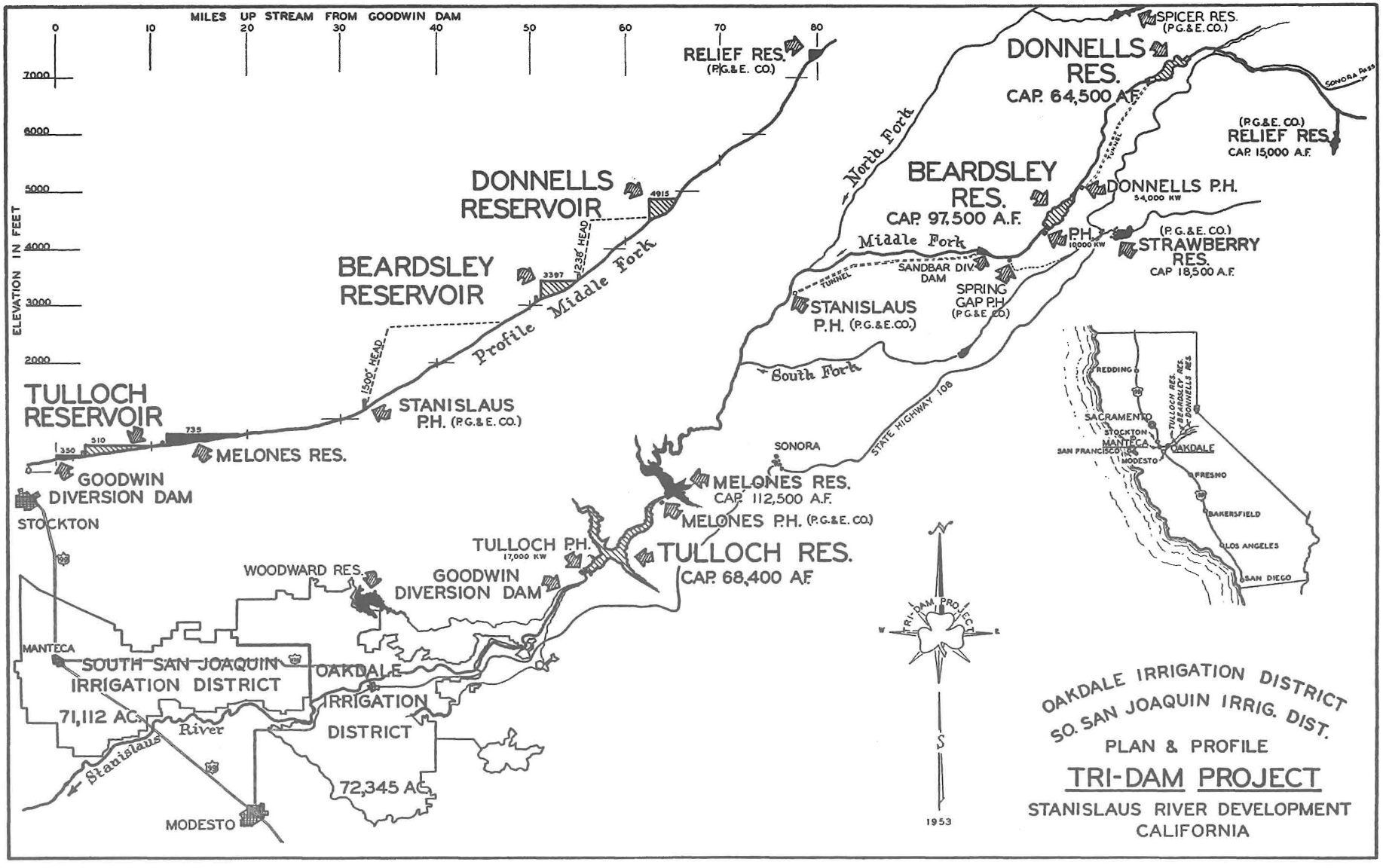
MILES UP STREAM FROM GOODWIN DAM
0
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70
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ELEVATION IN FEET
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6000
5000
4000
3000
2000
RELIEF RES.
(P.G.&E. CO.)
DONNELLS RESERVOIR
4915
BEARDSLEY RESERVOIR
3397
2236' HEAD
1500' HEAD
Profile Middle Fork
TULLOCH RESERVOIR
735
510
350
STANISLAUS P.H. (P.G.&E.CO.)
MELONES RES.
GOODWIN DIVERSION DAM
STOCKTON
SPICER RES.
(P.G.&E. CO.)
DONNELLS RES.
CAP. 64,500 A.F.
SONORA PASS
(P.G.&E. CO.)
RELIEF RES.
CAP. 15,000 A.F.
North Fork
BEARDSLEY RES.
CAP. 97,500 A.F.
DONNELLS P.H.
54,000 KW
TUNNEL
Middle Fork
P.H.
10000 KW
(P.G.&E. CO.)
STRAWBERRY RES.
CAP. 18,500 A.F.
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SPRING GAP P.H.
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STANISLAUS P.H. (P.G.&E.CO.)
South Fork
STATE HIGHWAY 108
SONORA
MELONES RES.
CAP. 112,500 A.F.
MELONES P.H. (P.G.&E. CO.)
TULLOCH P.H.
17,000 KW
TULLOCH RES.
CAP. 68,400 A.F.
WOODWARD RES.
GOODWIN DIVERSION DAM
MANTECA
SOUTH SAN JOAQUIN IRRIGATION DISTRICT
71,112 AC.
OAKDALE IRRIGATION DISTRICT
72,345 AC.
Stanislaus River
MODESTO
REDDING
SACRAMENTO
STOCKTON
MANTECA
SAN FRANCISCO
MODESTO
OAKDALE
FRESNO
BAKERSFIELD
LOS ANGELES
SAN DIEGO
TULLOCH RES.
BEARDSLEY RES.
DONNELLS RES.
TRI-DAM PROJECT
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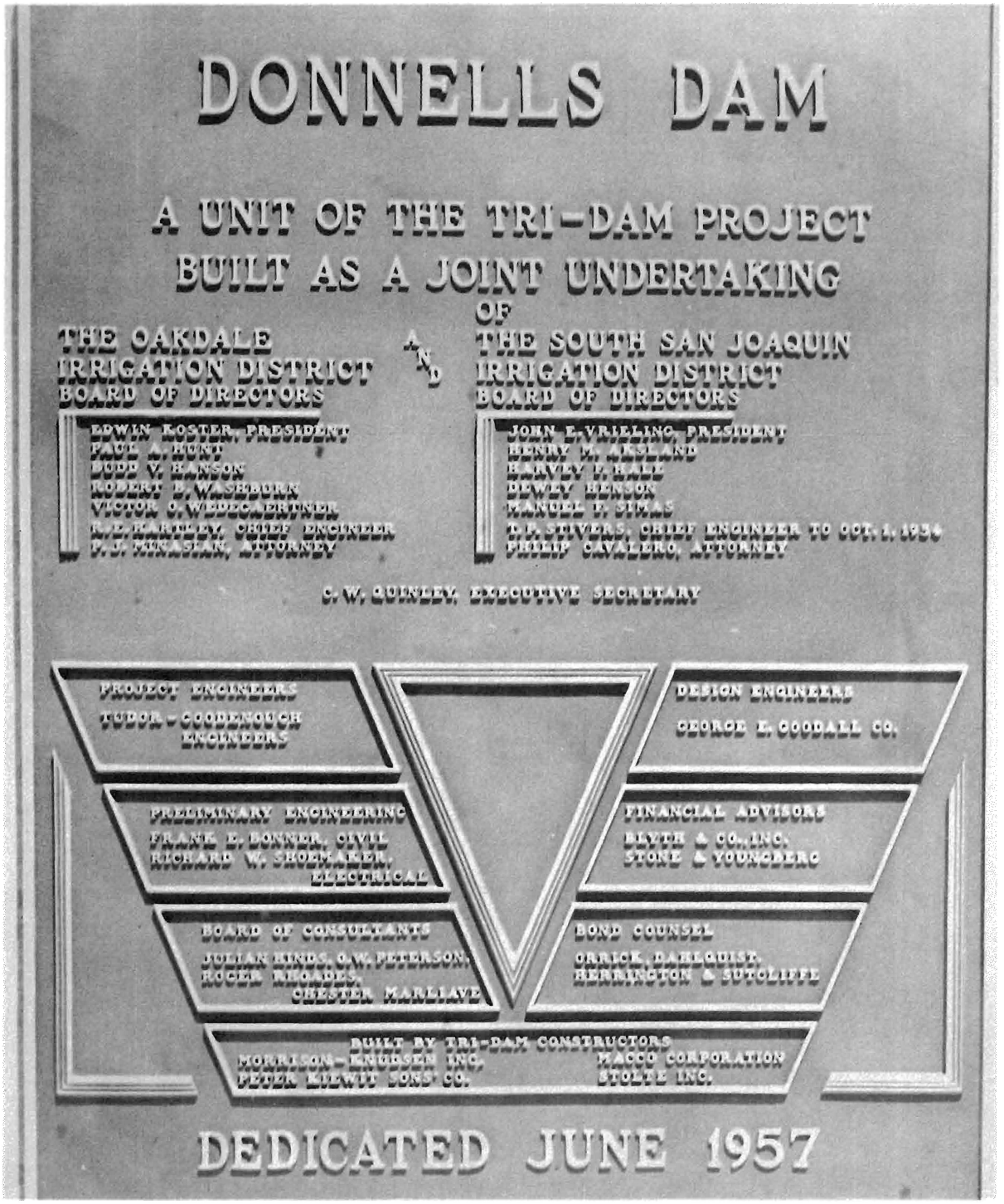
1953
OAKDALE IRRIGATION DISTRICT
SO. SAN JOAQUIN IRRIG. DIST.
PLAN & PROFILE
TRI-DAM PROJECT
STANISLAUS RIVER DEVELOPMENT
CALIFORNIA



ONE OF PLAQUES INSTALLED AT DEDICATION
(Photo by Allen Holbrook, OID)

FOREWORD

The recently completed Tri-Dam Project is an outstanding example of the "do it yourself" principle which has long been a part of the American heritage, but which has too often faded in the recent era of dependence on Government spending. As the name implies, this Project involved the construction of three major dams for the principal purpose of providing a supplemental water supply for the lands of two irrigation districts. Power generation is the secondary purpose of the project but an important one since it provides all of the revenue required to repay the capital investment as well as maintenance and operation costs.

The Tri-Dam development is owned by the Oakdale and South San Joaquin Irrigation Districts and is located on the Stanislaus River in California. The successful physical completion of the Tri-Dam Project marks the end of nearly ten years of intensive effort on the part of the Districts and culminates twenty-five years of study and consideration of ways and means to secure an ample and dependable water supply for the thirsty farm lands in the two Districts.

The history of this project since its inception constitutes a tribute to the Board of Directors of each District and to their staff of engineers, lawyers and secretaries, the financial advisors, the Board of Consulting Engineers and the designers who furnished technical advice, the Engineers and staff who supervised the construction work, and the contractors who actually performed the construction.

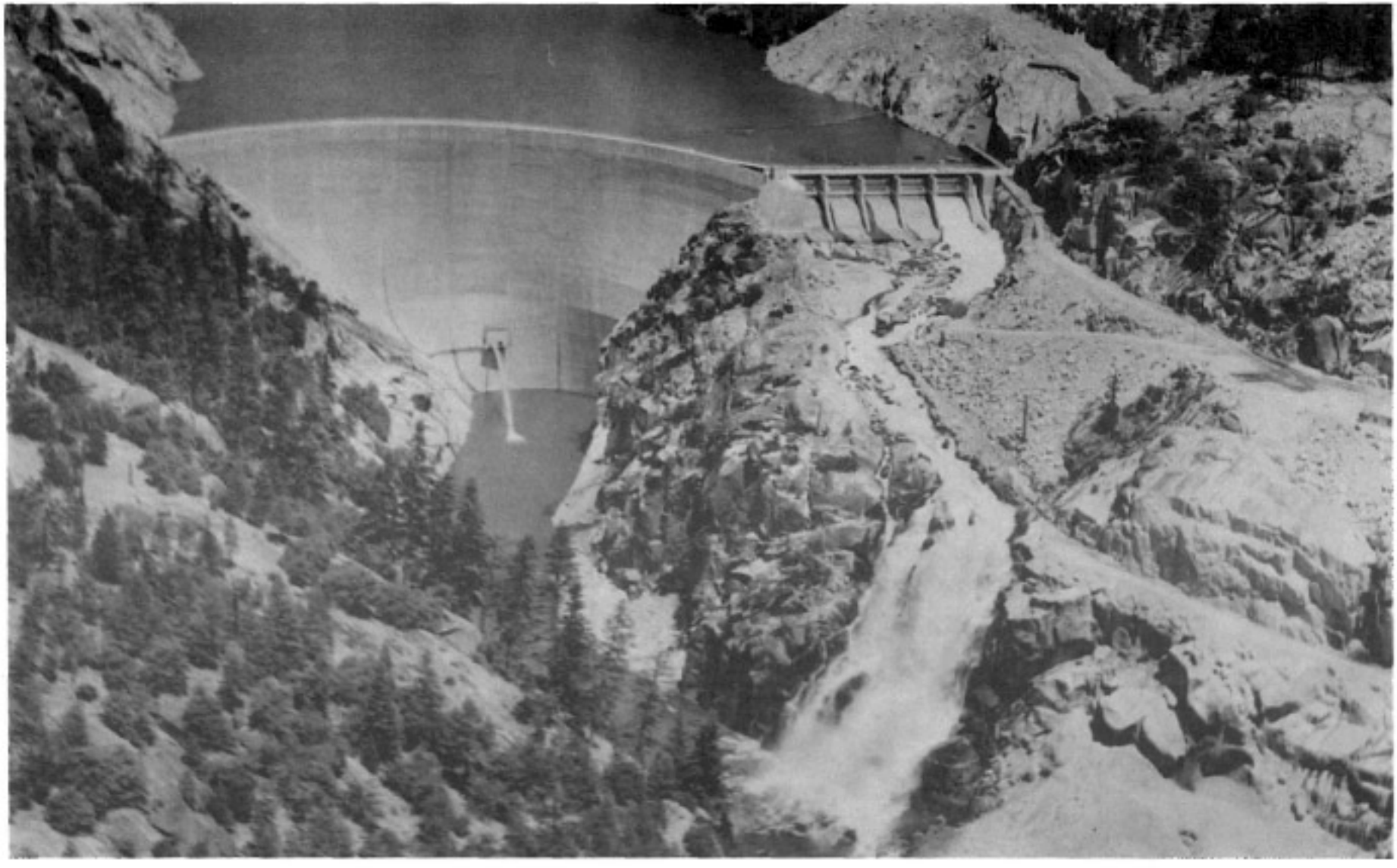
The Boards of Directors should be especially commended for their courageous and steadfast effort over the years to bring the project to completion, in the face of many complex and difficult problems. Also in the recognition to those who had an important part in the Tri-Dam Project, the role of the Pacific Gas and Electric Company should not be overlooked. Without their cooperation in the purchase of the hydro-electric power it would have been much more difficult to finance the project and thus correct

the periodic and serious irrigation water shortage that existed prior to construction of the Tri-Dam Project.

It should be fully recognized that this effort was made and resulted in successful completion of this large project without Federal or State financial assistance of any kind.

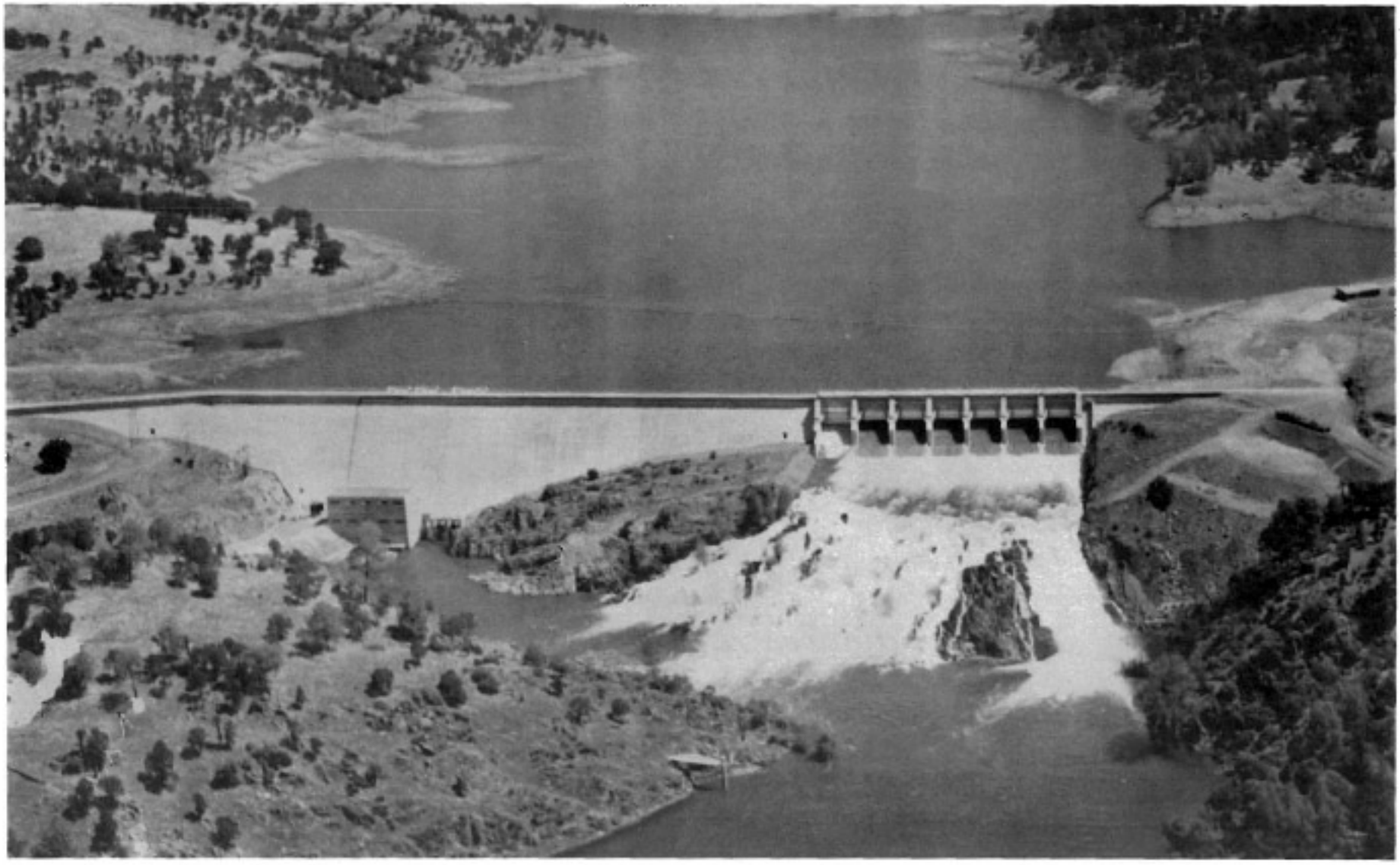
The Tri-Dam development is thus a symbol of what can be achieved by diligent and cooperative effort on the part of all concerned to solve a local problem of irrigation water shortage.

Following hereinafter are aerial views of the completed three dams, Donnells, Beardsley and Tulloch.



DONNELLS DAM, July 2, 1958
(Photo by Bob Hooe, Sonora)

BEARDSLEY DAM, May 16, 1958
(Photo by Bob Hoge, Sonora)



TULLOCH DAM, May 16, 1958
(Photo by Bob Hooe, Sonora)

SECTION I - INVESTIGATION

CHAPTER 1

THE CONSTRUCTING AGENCIES

A. Oakdale Irrigation District

This District, which is an agency of the State of California, is located principally in Stanislaus County with the City of Oakdale, which is headquarters, in the approximate center of the District. Its lands lie on either side of the Stanislaus River and have a gross area of 72,345 acres of which 61,666 acres are irrigable. About half of the irrigated area is in the river valley proper with the other half in the rolling plains adjacent to the Sierra foothills. The estimated population of the District is 17,000, of which about 56% is rural. The assessed valuation of the lands of the Districts is in the neighborhood of $7,000,000. This figure is much less than the true value of the land.

The principal crop of the District of late years has been ladino clover used for fattening livestock prior to marketing which, with dairying, comprise the most important industry of the District.

The affairs of the District are administered by a Board of Directors, consisting of five members who are elected for a term of four years by the qualified electors of the District. Since elections are held each two years, a part of the Board of Directors are retained in office and continuity of policy and administration is assured. Officials of the District include: The Board of Directors, Secretary-Assessor-Collector, and Treasurer.

After the District was organized in 1909, general obligation bonds were issued when needed to make necessary improvements and there was no trouble in meeting

operational costs and bond retirement schedules until the depression period of the 1930's when it became necessary to obtain a Reconstruction Finance Corporation loan. Since obtaining this loan in 1934, the District has been able to meet its financial obligations and has been on a sound financial basis.

B. South San Joaquin Irrigation District

This District, which is also an agency of the State of California, was organized in 1909 and is located in San Joaquin County on the north bank of the Stanislaus River immediately west of the Oakdale Irrigation District. The City of Manteca, which is headquarters, lies near the westerly edge of the District. The District, almost entirely in the river valley, has a gross area of 71,112 acres of which approximately 67,000 acres is irrigable. The estimated population is 23,000 of which 60% is rural. The lands of the District had an assessed valuation of approximately $8,500,000 which is much less than the true value of the land. A wide variety of field, tree and vine crops are grown in this District. In addition, dairying and stock feeding are important industries.

Administration of the District is accomplished by officials similar to those previously described for the Oakdale District. The South San Joaquin Irrigation District has had a similar financial history to the Oakdale District and secured a Reconstruction Finance Corporation Loan in 1935 to assist in redemption of its then current indebtedness at a discount of approximately 30%. This was in accordance with a plan of reorganization filed with the U. S. District Court under the Municipal Bankruptcy Act. Since that time, the District has been able to meet all its financial obligations and the construction of the Tri-Dam Project placed no additional burden in assessments against the land.

CHAPTER 2

EARLY DEVELOPMENT OF STANISLAUS RIVER

A. By the Irrigation Districts

Earliest development of water resources in this vicinity started soon after the gold rush days when several different companies were formed for the purpose of distributing water for mining and irrigation purposes. The predecessor of the Oakdale and South San Joaquin Irrigation Districts was a company controlled by the Tulloch family, who, in 1858, constructed a diversion dam immediately downstream from the present Tulloch Dam and distributed water by ditch to the Knights Ferry region. Their system was later extended to serve several thousand acres, reaching as far downstream as Manteca.

ORIGINAL TULLOCH DAM
(Photo by Allen Holbrook, OID)

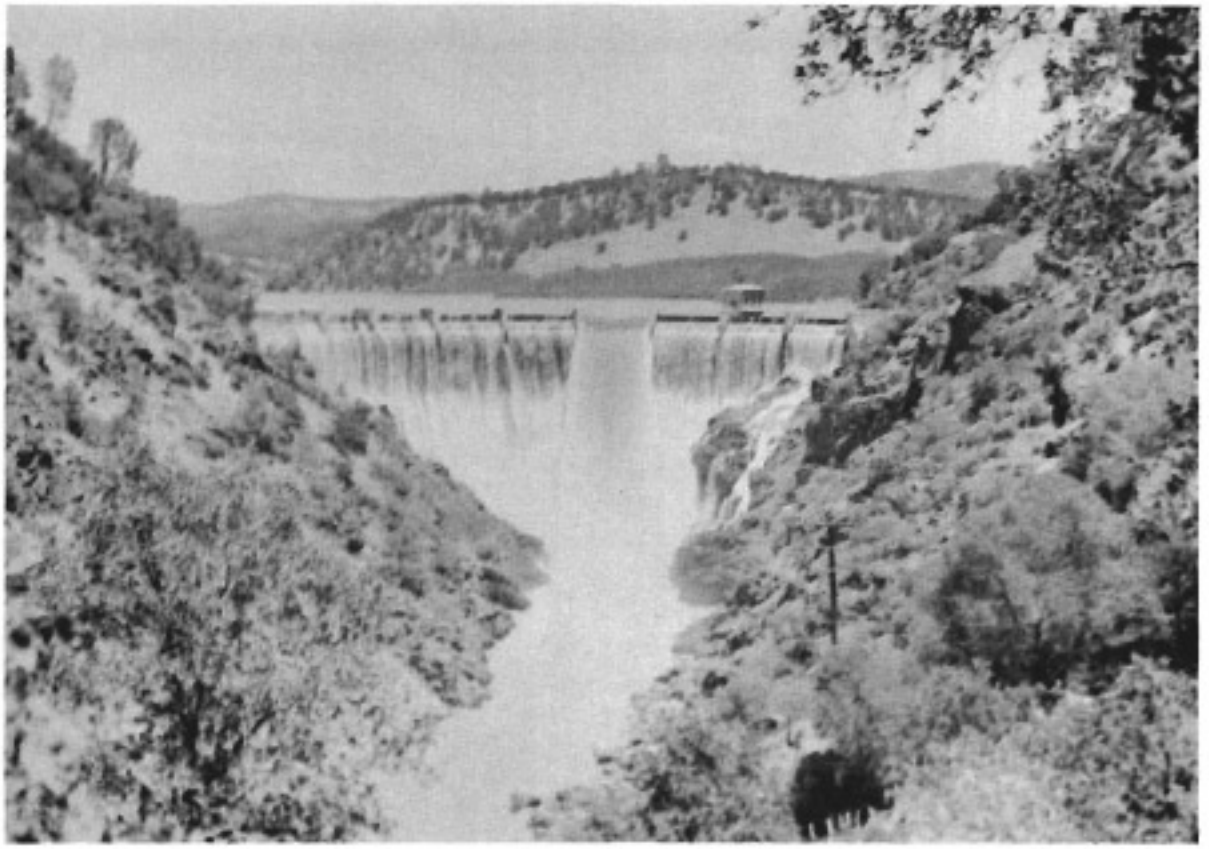
In connection with the activity of the Tulloch family, Mr. David Tulloch, a son of the original developer, came to the new Tulloch Dam at the time of its completion in 1957 with the time book which had been used to record the wages due the employees on the original dam built in 1858. A number of the employees of The Arundel Corporation and L. E. Dixon Company signed blank pages in that book, and likewise, Mr. Neville Long, the Resident Engineer, and B. W. Goodenough, Project Engineer, for Tudor-Goodenough Engineers. It was Mr. Tulloch's intention to preserve this book for its historical value.

Since the original development was a run-of-the-river supply, the service was not satisfactory, and this resulted in agitation for improvement and the two Districts were formed. The South San Joaquin Irrigation District was organized in May and the Oakdale Irrigation District in November of 1909. In 1910, they purchased jointly the old Tulloch Irrigation System facilities and water rights, based on claims dating back to 1853 which were adjudicated in 1922. This and appropriation rights acquired later provided each District with total water rights of 908.3 cubic feet per second. In 1912-1913, the Districts constructed the Goodwin Diversion Dam which diverts the water from the Stanislaus River into the Districts' canal systems. The Oakdale District has a canal on the south or left bank and there is a main canal on the north bank which is used jointly for approximately 3 miles after which the water is divided to serve the separate needs of the two Districts.

The South San Joaquin District developed more rapidly than did the Oakdale District and in 1918 it constructed the Woodward reservoir, an off-stream storage, to provide 36,000 acre feet of stored water. This water is accumulated during the winter months by diversion from the river at Goodwin Dam and dispersed throughout the summer.

B. By the Irrigation Districts and the Pacific Gas and Electric Company

In 1925 and 1926 the Districts again combined resources to construct the Melones Dam, which provided a gross storage of 112,500 acre feet of water. On January 2, 1925, the Districts and the Pacific Gas and Electric Company signed a contract which provided for the construction of the dam by the Districts and construction of the power facilities by the Pacific Gas and Electric Company. This contract set forth the cooperative principal that, during the irrigation season, the water rights of the Districts would take precedence over the power demands, whereas in the winter season, the power needs would govern. This development provided each District with 51,250 acre feet of stored water and this quantity was to prove sufficient for the South San Joaquin District until the early 1940's. Oakdale, on the other hand, encountered an increased demand for water with the development of ladino clover as a basic crop in the early 1930's and its share of Melones storage was periodically inadequate in that decade.



MELONES DAM
(Photo by Allen Holbrook, OID)

C. By the Pacific Gas and Electric Company

The Pacific Gas and Electric Company and its predecessor, the Sierra and San Francisco Power Co. built power generating facilities on the Stanislaus River and its tributaries as early as 1908. These facilities included the Spring Gap Powerplant, the Stanislaus Powerplant and the Melones Powerplant. The latter was constructed under the terms of the cooperative agreement with the Districts as previously described. The Pacific Gas and Electric Company, in order to improve hydro-electric power production during low-flow periods, constructed Strawberry Dam on the South Fork, Relief Dam on the Middle Fork, and Spicers, Silver Valley, Union and Utica Dams on the North Fork of the Stanislaus. It also constructed Lyons Dam on the South Fork to store water for domestic and farm use and produce power at Phoenix Plant near Sonora.

The water storage afforded by the Districts' Tri-Dam Project made the production of power at the Company's Stanislaus and Melones plants much more dependable during the summer and autumn months and therefore increased the value of these plants.

CHAPTER 3

SELECTION OF TRI-DAM PROJECT

A. Investigation by Oakdale Irrigation District Prior to January 13, 1948

During the preliminary stages of development of the Melones Project, the Beardsley reservoir site was considered as an alternate. The first surveys of the Beardsley site were made by R. E. Hartley, Chief Engineer, in 1924, but development of Beardsley was dropped in 1925 when the Melones site was selected. Beardsley was

BEARDSLEY DAM SITE
(Photo by Allen Holbrook, OID)

again considered in 1938 and the Oakdale District proceeded to draw up plans and endeavored to finance its construction. Power revenues from the Beardsley site were sufficient to pay only 60% of its cost and attempts were made to obtain status as a PWA project to overcome the deficit. However, this proved to be infeasible and the project was dropped at that time. In 1939 Oakdale cooperated with the U.S. Corps

of Engineers in investigating the Oakdale site above Knights Ferry but this site was insufficient in capacity to provide the flood control storage required by the Corps of Engineers.

Oakdale became actively interested in the Tulloch site in 1940 and had made considerable progress in the studies when the 2nd World War deferred such development. The Columbia site, immediately downstream of the junction from the South Fork with the main stem of the Stanislaus River, was another site which was actively studied by the Oakdale District. This site was eventually abandoned as the Tri-Dam Project was developed.

Continued increase in agricultural activity in the Oakdale area accentuated the need for a supplemental water supply to fully satisfy the requirements for irrigation and at the close of the war the Oakdale District moved again to solve this problem. The Melones Project Agreement between the Oakdale and South San Joaquin Districts included a provision that in the event either District desired to further develop the Stanislaus River, the other District would have the right to join in such further development, if it so desired. If it did not so desire, the District interested in further development could then proceed independently.

Therefore, in 1948 the Oakdale District informed the South San Joaquin District of its intent to develop supplemental storage and requested a decision from the South San Joaquin District as to whether or not it would join with Oakdale District in such a development. The South San Joaquin Irrigation District responded in the affirmative and by a joint resolution of each Board of Directors, dated January 13, 1948, both Districts agreed to share equally in the cost of the investigations required and also in the benefits to be obtained.

B. Development of Tri-Dam Project

1. Selection of Tri-Dam Project by Joint Staff and Consultants

Following the decision of the Districts to proceed with further development on the Stanislaus River a joint staff was formed which consisted of the following:

P. J. Minasian	Attorney	Oakdale Irrigation District
R. E. Hartley	Chief Engineer	" " "
C. W. Quinley	Secretary	" " "
Philip Cavalero	Attorney	South San Joaquin Irrigation District
T. P. Stivers	Chief Engineer	" " " " "
S. L. Steele	Secretary	" " " " "

This staff proceeded with the studies and investigations required to make a final selection of the features of the proposed development and to prepare a report of its engineering and financial feasibility.

Prior to the Joint Resolution of January 13, 1948, the Oakdale District had retained:

Chester Marliave	Consulting Geologist
R. W. Shoemaker	Consulting Electrical Engineer
George Goodall	Consulting Civil Engineer
Frank E. Bonner	Consulting Civil Engineer

This group of Consultants was approved by the Joint Resolution of January 13, 1948, and continued to function in the final selection of a feasible project.

After a great deal of study, it was decided that the most feasible project on the Stanislaus River would consist of:

Donnells Dam: A thin arch concrete dam, approximately 300 feet in height above stream bed, with a concrete gravity plug section in the buried gorge known to exist for approximately 190 feet below the stream bed. A spillway to be located in a

natural saddle on the left abutment with the ogee crest surmounted by five 35 foot by 19 foot high tainter gates. The reservoir created by this dam to impound 64,500 acre feet of water.

Donnells Tunnel and Power Plant: A horseshoe-shaped tunnel, approximately 12 feet by 13 feet and 7.2 miles in length to carry the water from Donnells Dam to a point opposite the Hells Half Acre Bridge where a steel penstock, 81 inches in diameter, would carry the water to a power plant located at the edge of the river and just upstream from the reservoir to be created by Beardsley Dam. The power generating unit to be a single, vertical shaft, six-jet impulse type turbine designed to operate under an average net head of 1,238 feet, with a generator capable of generating 54,000 K.W. of electric power.

Beardsley Dam: A rolled earth-fill type structure 285 feet high above stream bed with a clay or silt core, reinforced with sand, gravel and cobbles and faced with rock. The spillway to be a concrete structure on the right bank of the river, with the crest surmounted by four 40 foot by 30 foot high tainter gates. The reservoir to impound 97,500 acre feet of water.

Beardsley Power Plant: This plant to be served with water carried in a 96 inch diameter steel penstock in a horseshoe-shaped tunnel 15.5 feet in diameter, under the right abutment of the earth dam. The plant to be located immediately downstream from the dam on the right bank of the river and the power generating unit to consist of a single Francis type turbine and generator, capable of producing 10,000 K.W. at a maximum head of 258 feet.

Beardsley Afterbay: Required to create a reservoir of 250 acre feet minimum capacity to equalize the variable discharges expected from the Beardsley Plant. This afterbay dam to be located about one mile downstream of the Beardsley Dam and

about two miles upstream of the Pacific Gas and Electric Company's diversion structure for its existing Stanislaus Power Plant. The dam to be a timber and rock-filled crib type structure, with provision made to regulate the discharge through a 72 inch diameter pipe encased in the crib, by remote control from the Beardsley Plant.

Tulloch Dam: A concrete gravity dam approximately 200 feet in height above stream bed to create a reservoir of 68,400 acre feet capacity, with maximum water surface to be at Elevation 510 in order to avoid interference with the existing Pacific Gas and Electric Company's Melones Power Plant. Tulloch Dam water levels to be controlled by two low-level bypass conduits and by a concrete spillway, on the left side of the dam, with the ogee crest surmounted by seven 40 foot by 30 foot high tainter gates.

Tulloch Power Plant: This plant to be located at the toe of the dam on the right bank of the river and receive water through two 114 inch diameter penstocks embedded in the dam. Power generation to be by two vertical Francis type turbines designed for a combined capacity of 17,000 K.W. at a maximum head of 153 feet.

Tulloch Afterbay Dam: A regulation reservoir of 500 acre feet capacity to be created by enlargement of the existing Goodwin Dam. This to be accomplished by raising this twin arch concrete structure seven feet, with necessary modifications to the intake structures for the irrigation canals of the Districts.

Upon conclusion of this study it was the opinion of the Joint Staff and their Consultants that construction of the Tri-Dam project by the Joint Districts would result in:

(a) Sufficient supplemental water storage, in combination with the existing Melones Reservoir storage, to assure a full gravity supply of 570,000 acre feet of water annually which would probably be available during 19 out of 25 years.

(b) Holdover storage from the reservoirs would considerably reduce the shortage of water during the critically low water years, which historically have occurred about 6 out of 25 years.

(c) Sufficient revenue from sale of the hydro-electric energy to be generated in the Tri-Dam Project Power Plants which when combined with revenue from additional falling water available to the existing plants of the Pacific Gas and Electric Company at Stanislaus and Melones, would finance the construction of the project solely from power revenues without imposing any new taxes or assessments on the properties of the District land owners.

2. Negotiations with Pacific Gas and Electric Company

The question of public distribution of power by the Districts had been the subject of considerable discussion, especially among the land owners in the Oakdale District, for some time prior to 1948. It had been determined that there was insufficient market within the confines of the Districts to absorb the peak capacity of the plants, and for low-flow periods it would be necessary to have stand-by generation by facilities such as a steam plant. To provide for local distribution, it would be necessary to either purchase the Pacific Gas and Electric Company's transmission system or else construct duplicate facilities. Either of these alternates involved such expense as to make the financing of the project impossible, if dependent on direct retail sale of power.

The United States Bureau of Reclamation was contacted in regard to inclusion of the entire power output and/or the surplus into the Central Valley system. However, that Agency could not purchase power from such a source because they were permitted by law to sell only the power produced on their own construction projects.

In September, 1949, the Consulting Electrical Engineer, Richard W. Shoemaker, reported conclusions which can be summarized as follows:

(a) It would be to the best interest of the Districts to endeavor to secure a firm contract for sale of power and energy to a responsible organization which would enable the Districts to construct, operate and own the Donnells, Beardsley, and Tulloch Dams and associated power plants.

(b) Due to the fact that the Pacific Gas and Electric Company already had two power plants on the Stanislaus River (Stanislaus and Melones) that would benefit by these developments, this concern appeared to be the logical one to purchase the power output.

(c) With money available at 3% or less, the project as proposed could be made to pay its way and still give a reasonable cash profit to the Districts.

(d) The project as outlined could provide a substantial increase in the yearly amount of water available to the Districts for irrigation.

(e) It would not be economically feasible for the Districts to consider the sale of power through a local distribution system.

These conclusions were concurred in by the Joint Staff and approved by the Joint Boards of Directors. Accordingly, negotiations were started with the Pacific Gas and Electric Company for the sale of the Hydro-electric power. These negotiations were unavoidably lengthy and tedious, but with the background of the Melones Project Contract entered into in 1925 and the very satisfactory relationship between the Joint Districts and the Pacific Gas and Electric Company during the 25 years of its operation, the negotiations were successfully consummated on July 9, 1952 by the signing of the Tri-Dam Project Contract.

Principally, this contract provides:

(a) For the construction by the Districts of the dams and power plants listed previously.

(b) For construction of the required power transmission facilities by the Pacific Gas and Electric Company.

(c) For delivery of the power, generated at the Tri-Dam Project, to the Company on the high tension side of the transformer banks.

(d) For power payments to be made by Pacific Gas and Electric Company, at a guaranteed annual rate of $2,506,000 with an escalation clause to protect against increase in operation and maintenance costs. Payments of this amount, commencing after the plants have been declared "Fully Operable" as defined in the project contract, will be made for a total period of 46 years to December 15, 2004.

3. Water Rights, Federal Licenses and Bond Election

During the negotiations with the Pacific Gas and Electric Company, the Districts moved to secure the necessary water rights for the Tri-Dam Project from the State of California. It was found that Tuolumne County Water District No. 2 and Calaveras County Water District had certain filings which were affected by the filings of the Oakdale and South San Joaquin Districts and thus protests were entered. After extensive negotiation, an agreement was signed on June 27, 1951 which settled the differences with Tuolumne County Water District No. 2. On July 3, 1951 a similar agreement settled the differences with Calaveras County Water District. Thereupon, the State of California issued the necessary water rights for storage and power generation by the Tri-Dam Project.

Application was made to the Federal Power Commission for the necessary Federal licenses to construct the project. After some revision of the original applications, License No. 2005 to cover the Donnells and Beardsley units was issued on May 1, 1950, and License No. 2067 to cover the Tulloch and Goodwin Dam Units was issued on October 1, 1951.

After conclusion of these agreements and securing of the necessary water rights and licenses, the Joint Districts made application to the California Districts Securities Commission for authority to hold elections to authorize each of the Districts to issue $26,000,000 of revenue bonds, secured by the revenue from the sale of power which is assured by the Tri-Dam Project Contract with the Pacific Gas and Electric Company. This approval was secured on October 27, 1952 and elections were held in each District during November and December, 1952. The revenue bond issues were approved by the voters of each District by large majorities and the Tri-Dam Project thus passed from a "negotiation stage" to a "preliminary design stage".

CHAPTER 4

PRELIMINARY TO CONSTRUCTION

A. History Prior to Bid Opening of April 16, 1953

Following the Bond Authorization Elections, the Joint Districts decided to assign the work of preparing contract plans and specifications for bidding purposes to:

1. George E. Goodall Company for:
    a. Donnells Dam and Spillway
    b. Revisions to Goodwin Dam
2. International Engineering Company for:
    a. Donnells Tunnel
    b. Donnells Power Plant
    c. Beardsley Dam, Power Plant and Afterbay
    d. Tulloch Dam and Power Plant

It was planned that the Districts would receive bids on several separate schedules of work, in accordance with normal practice, as follows:

Schedule I. Donnells Dam

Schedule II. Donnells Tunnel

Schedule III. Donnells Power Plant

Schedule IV. Beardsley Dam, Power Plant and Afterbay

Schedule V. Tulloch Dam and Power Plant

Schedule VI. Goodwin Dam Revisions

In addition to the above six schedules, the designers prepared equipment specifications covering the major machinery items needed to complete the job and proposed to award separate supply contracts for the procurement, with the general contractor to be responsible for installation. The time for completion was fixed at three

years from start of construction for all units of the work. This period of time was set because it was then the maximum period permitted by the California Water Code for the payment of interest during construction from bond funds.

With their own forces under R. E. Hartley, the Districts made topographical surveys at the site of each structure and carried on extensive drilling and material testing work at the dam sites. Simultaneously the Districts employed Charles O. Greenwood, Jr. to perform triangulations and level control surveys, as required, to accurately locate the various structures and elements of the Tri-Dam Project.

The Joint Staff realized that access to the difficult and remote Donnells Dam site was an important matter, both during investigations prior to construction, and permanently thereafter. Therefore, on recommendation of the Staff, the Joint Boards organized a force of equipment and men for construction of a permanent road to Donnells Dam. Under direction of R. E. Hartley, the crew worked intensively during 1952 and by fall had constructed a permanent road nearly 3 miles in length from the state highway to the cliffs above the dam site and a pioneer jeep trail from the cliffs to the dam site.

ACCESS ROAD INTO DONNELLS DAM SITE
(Photo by Allen Holbrook, OID)

During this period, it was necessary to prepare applications to the Supervisor of Dams, Division of Water Resources, State of California, for permission to construct the dams. Before such permits were granted, it was necessary for the State Supervisor to review the physical conditions at the sites and the preliminary designs prepared by the Districts, to make certain that all requirements for public safety were being met.

The Joint Staff, with the approval of the Joint Boards, engaged Blyth and Co., Inc., as financial advisors and Orrick, Dahlquist, Herrington and Sutcliffe as bond counsel. Both of these firms assisted in the final negotiations of the Tri-Dam Project Contract with the Pacific Gas and Electric Company and worked with the Joint Staff, their consultants and designers as the contract plans and specifications were in preparation.

In 1952 a revised Organization Plan was prepared and approved by the Joint Boards of Directors which provided for the following:

1. An Executive Engineer to be responsible for coordination of designers, negotiations with federal and state agencies and others as required and to be the liaison between the Construction Engineer and the Joint Boards of Directors.

   T. P. Stivers was appointed to this position and acted in this capacity until October 1954.

2. An Executive Secretary to be responsible for all funds, accounts and minutes of the actions of the Joint Boards of Directors.

   C. W. Quinley was appointed to this position and has acted continuously in this capacity.

3. A Field Engineer to be responsible for performance of the clearing work in the reservoirs and other similar work as required for completion of the Project.

   R. E. Hartley was appointed to this position and so acted until August 1953.

4. A Construction Engineer to be in charge of inspection and supervision of the contractors' work in construction of the Project.

This position was not filled until March 26, 1953 when B. W. Goodenough was selected by the Joint Staff with approval of the Joint Boards of Directors.

While the plans and specifications were being prepared, a notice was sent to interested bidders on September 30, 1952 inviting them to inspect the sites of the various structures before winter snows blocked access to the sites. Invitation to the bidders was published on January 30, 1953. Bids for the construction work were opened on April 16, 1953 and bids for furnishing of the major accessory machinery were opened at various later dates.

B. History During Period of April 16, 1953 and December 1, 1954

The opening of construction bids on April 16, 1953 attracted wide attention. Nearly 300 people were present and 12 bids were received for some or all of the schedules.

The low bids received were as follows:

General-Pacific-Shea-Kaiser		
Schedule I	Donnells Dam	$8,669,733.02
Schedule II	Donnells Tunnel	7,525,885.00
Schedule III	Donnells Power Plant	1,322,986.00
Winston-Johnson		
Schedule IV	Beardsley Dam, Power Plant and Afterbay	7,926,673.00
Macco-Morrison-River		
Schedule V	Tulloch Dam and Power Plant	6,557,202.25
John C. Gist Co.		
Schedule VI	Goodwin Dam Revisions	218,680.00

This bidding had been on the unit price-quantity basis and, as such, the bids were based on the quantities estimated by the designers. In the event the quantities of work actually performed differed from those shown in the bidding schedule, the Districts were obligated to pay the Contractor for such quantities of work at the unit price bid therefore, whether greater or smaller than the bid schedule estimates. This form of construction bidding is extremely flexible and is the form commonly used in construction work of the type involved in the Tri-Dam Project. However, the bid amounts are affected by the accuracy with which the designers estimate the bid schedule quantities. If these estimates vary from the final quantities, the final costs will reflect these changes. This method affords the owner no assurance against possible increases in final cost above the amounts bid.

Since the construction bids listed above were considered to be very favorable, the Joint Boards of Directors desired to accept them and issue the required Notices to Proceed to the contractors. It was necessary, however, to complete the sale of the revenue bonds and thus obtain construction funds, before such notices could be issued.

However, early in 1953, the market for revenue bonds was seriously depressed. As a result, Blyth & Co., Inc., acting as financial advisors, wrote letters on April 7 and 17, 1953 informing the Districts that, in their opinion, the Tri-Dam Project Revenue Bonds should not be offered for sale at that time. These letters pointed out that the interest rates then available would at best only support the sale of part of the authorized amount of bonds, and the bids contained inadequate guarantees to the bond buyer that the project would be completed and earn the required revenue to repay the buyer. In their opinion, there was a strong possibility no bids would be received if the bonds were offered for sale at that time.

Many meetings were held between the contractors who had submitted the low bids, and the District Staff and Directors, in an attempt to work out some form of guarantee

of final cost to the Districts which would satisfy the financial advisors and be fair to the low bidders who had not contemplated assumption of any such guarantee. The contractors were cooperative and worked seriously towards a solution of the problem but in the end, all concerned had to admit the problem could not be solved to the satisfaction of the financial advisors with equity to the bidders. Therefore, the Joint Boards of Directors were reluctantly forced to reject all construction bids in June, 1953 and abandon plans for the sale of the bonds at that time.

Some further attempts to solve the problem were made during July and August, but all of these were unsuccessful. H. W. Stronck of San Mateo was engaged for possible presentation of the problem to the Reconstruction Finance Corporation, but the lending authority of that agency was discontinued and this effort was abandoned. A number of meetings were held with officials of the Pacific Gas and Electric Company but no solution to the problem was obtained.

In August, 1953 the South San Joaquin Irrigation District decided that their financial condition would not permit further expenditures for the Tri-Dam Project at that time. As a result of this action, T. P. Stivers returned solely to his work as Chief Engineer for the South San Joaquin District, R. E. Hartley and C. W. Quinley to their work with the Oakdale District and the services of B. W. Goodenough as Construction Engineer for the Tri-Dam Project were terminated. However, the Oakdale Irrigation District decided that Mr. Goodenough's services should be retained and arranged with him to act as a Consultant to their District on Tri-Dam Project problems, which employment continued until November, 1954.

A bill was prepared for introduction into the Congress of the United States in January, 1954 which was to provide a reserve fund for the construction of the Tri-Dam Project. Recognition was given to the policy of the Congress of the United States

in furnishing interest-free funds for the development of irrigation projects, which is the basis of Bureau of Reclamation financing of such projects. A computation of the irrigation benefit afforded by construction of the Tri-Dam Project to the lands of the Oakdale and South San Joaquin Districts was made in accordance with U. S. Bureau of Reclamation rules, and the amount of $10,370,000 was determined to be a proper measure of such irrigation benefit. The bill provided for payment of such benefits as the Chief of Engineers U. S. Army Corps of Engineers determined to be proper for the flood control afforded by the Tri-Dam Project. Also, the Tri-Dam Project Bill, as presented to Congress, provided for a review of the project by the Secretary of Interior and if favorable an interest-free reserve credit of $10,370,000 would be requested by appropriation from the Congress, to be used only after all funds from the public sale of Tri-Dam Project Revenue Bonds had been exhausted. If the Districts used all or any part of this reserve credit, the amount so drawn was to be repaid to the United States in future years from District revenues, other than those to be pledged in support of the revenue bonds. This bill was in full accord with the policies of the Administration and received its support. It was introduced into the House by Congressman Leroy Johnson of Stockton and into the Senate by Senator Thomas Kuchel.

Hearings were held before the sub-committees of both houses during the summer of 1954 and the bill recommended for Congressional approval by large majorities. However, the hearings were held so late in the session that the Rules Committees could not place the Tri-Dam Bill on the calendar for debate and vote by the full houses. An attempt was made to place the bill on the Consent Calendar of both houses, but if only one member objects this cannot be done and as at least one in each house did so object it could not be included. Thus the effort to obtain Federal assistance failed.

Following the unsuccessful attempt to secure Federal assistance, the Joint Boards

of Directors authorized T. P. Stivers and B. W. Goodenough to act jointly in an attempt to establish a plan of procedure which might result in solution to the problems preventing construction of the Tri-Dam Project.

During the early summer of 1954, Mr. Stivers had studied the effect of delaying the construction of Tulloch Dam and Power Plant, and whether such a program might aid in expediting the start of construction of the Donnells and Beardsley Units. Later that summer, Mr. Goodenough made a similar but independent study and both wrote reports to the Joint Boards of Directors on that subject. While the conclusions in these reports differed somewhat, both agreed it was probable that a plan to defer construction of Tulloch Dam and Power Plant could make it possible for the Districts to proceed with construction of the other elements of the Project. Accordingly, a letter was sent to the Pacific Gas and Electric Company requesting a division of the Tri-Dam Project Contract Revenues between the Donnells, Beardsley and Tulloch Plants.

The Pacific Gas and Electric Company responded to this request and advised that the revenues payable for the power from the Donnells and Beardsley Plants were so related to the earnings derived from improvement of the Stanislaus and Melones Plants that no such separation could be made. However, they agreed to study separation of the Tulloch Plant from the combined Donnells and Beardsley Plants, thenceforth known as the Upper Works.

On October 1, 1954, T. P. Stivers resigned to become Executive Secretary of the California Districts Securities Commission. Mr. Goodenough was instructed to conduct future negotiations with the Pacific Gas and Electric Company and with such others as he deemed necessary to solve the problems confronting the Districts and enable the construction of the Project to proceed.

Effective December 1, 1954 the South San Joaquin Irrigation District by Board

resolution again cooperated with the Oakdale District in the payment of Mr. Goodenough's salary as Consulting Engineer for the Districts on Tri-Dam problems.

After some study, the Pacific Gas and Electric Company agreed by letter dated December 7, 1954, that the revenue from the Tulloch Plant could be separated and the Company proposed:

1. Payment of $951,000 semi-annually for the power to be generated directly in Donnells and Beardsley Plants, together with the improvement obtained at the Stanislaus and Melones Plants of the Company.

2. Payment of $151,000 semi-annually for the power to be generated at the Tulloch plant.

This proposal by the Company allocated a larger amount of revenue to Tulloch than had been estimated by Mr. Goodenough and Mr. Stivers. The problem relating to the Upper Works was therefore still severe.

In 1953, the Pacific Gas and Electric Company had made application to the Federal Power Commission for an extension of the Stanislaus License from December 15, 1985 to April 30, 2000 and of the Melones License from June 15, 1977 to April 30, 2000. Because of opposition to these extensions by the U. S. Fish and Wild Life Service the Commission had never acted on these applications. Therefore, the financial advisors could not agree that the revenues resulting from Tri-Dam Project benefits to these plants after 1985 and 1977 could be considered in support of the Tri-Dam Bonds, unless the applications for extension were formally approved. Furthermore, a total of nearly five years had elapsed since the District licenses for the Tri-Dam Project had been granted, reducing by that amount the period of earnings of the Project and a consequent loss in revenues for support of the Bonds.

C. History from December 1, 1954 to April 21, 1955

A major improvement in the ability of the Districts to sell their bonds could be made if all of the Federal Power Commission licenses involved could be brought to the same termination date, and the total period extended to recover the time lost in planning and unsuccessful efforts to finance the project.

As such a move involved both Pacific Gas and Electric Company and District licenses, Mr. Goodenough proposed a trip to the Federal Power Commission offices in Washington in company with representatives of the Company, in an attempt to reach a solution of the license problem. Both the Districts and the Company agreed and on December 16, 1954, Mr. Goodenough in the company of Mr. Fred Searls and Mr. Henry Lutge of the Pacific Gas and Electric Company met with Mr. John Mason and Mr. Russell Farley of the Federal Power Commission. At this meeting, it developed that the matter of the fish water releases at San Bar Dam had been agreeably settled between the Company and the Fish and Wild Life Service. Therefore, there was a general discussion of a possible solution to the problem of bringing all licenses to a common date, preferably December 31, 2004, and the improved ability of the Districts to sell revenue bonds if these changes could be made. Following this meeting, the Districts prepared an application on December 31, 1954 for a "Change in the Effective Dates" of Licenses 2005 and 2067 and the Company made a revised application for the Stanislaus and Melones Permits to effectively end on December 31, 2004. On February 16, 1955 the Federal Power Commission approved these applications and on February 21, 1955 issued orders which brought all licenses to the same expiration date. This was a major accomplishment in the solution of the problems of the Tri-Dam Project, as it greatly improved the ability to support the sale of bonds.

Simultaneously with the negotiations with the Pacific Gas and Electric Company and the Federal Power Commission, the Attorneys for the Joint Districts had assisted in

preparation of Assembly Bill No. 652, in the Legislature of the State of California, to increase the permissible period for the payment of interest during construction from 3 years to 4 years. This bill was passed by both houses and signed by the Governor on January 28, 1955.

It appeared probable that the revisions in licenses would be approved by the Federal Power Commission, and Mr. Goodenough proposed that a Board of Consulting Engineers be appointed, prior to formal approval, to consider the various problems confronting the Districts in their attempt to get the Project into the construction stage. This proposal was approved by the two Boards on December 21, 1954 and the following were subsequently appointed to serve:

O. W. Peterson, former Chief Construction Engineer for the Pacific Gas and Electric Company.

Julian Hinds, Chief Engineer and Manager of the United Water Conservation District and formerly Chief Engineer of the Los Angeles Metropolitan Water District.

Ralph A. Tudor, Senior Partner of Tudor Engineering Company and former Under Secretary of the Department of Interior.

Roger F. Rhoades, Consulting Geologist and former Chief Geologist of the United States Bureau of Reclamation.

This Board of Consulting Engineers met in San Francisoo on January 17 and 18, 1955 to consider the questions presented to them by Mr. Goodenough as the representative of the Joint Districts. On February 10, 1955, they submitted their findings, which can be briefly stated as follows:

1. The investigation of the subsurface conditions at the dam sites and tunnels was generally adequate, but recommended some additional drilling for checking purposes at Donnells Dam.

2. Recommended a change in the provisions of the specifications governing the

lump-sum bid for removal of the river bed debris in the buried channel at Donnells Dam.

3. Commented on the possible damage from earthquake and stated that in their opinion there was no hazard of such damage.

4. Recommended that insurance be obtained to protect the Districts and the Bond purchasers, in the event a water shortage existed in the year the construction of the Project was completed, which would prevent the Project from becoming "Fully Operable" as defined in the contract with the Pacific Gas and Electric Company.

5. Approved the change in the construction schedule from 2-1/2 years or 3 construction seasons to 3-1/2 years or 4 construction seasons.

6. Reviewed the proposed "Guarantee of Completion" to be afforded by adding Section 22 to the General Provisions of the Specifications.

   In this section, it was proposed to:

   (a) State the exact amount of money guaranteed to be available for payment of contractor's earnings.

   (b) Make payment to the contractor for the quantities of work actually performed at the unit prices contained in the bidding schedule, until the total earnings reached the amount so guaranteed.

   (c) Require that the contractor guarantee to complete the work regardless of developments during construction, at a final cost, to the Districts, not in excess of the amount of money stated and guaranteed to be available for contractor's earnings.

The Board of Consultants commented that although unique these provisions were fair and would assure completion of the work within the funds available.

7. Approved the provision that the General Contractor furnish and install the power generation and other permanent equipment.

8. Reviewed the quantities contained in the Bidding Schedule and, with several changes, believed them to be adequate and realistic.

9. Reviewed the Districts' estimate of costs and bonding capacity, stating it was their opinion the funds available would be adequate.

Everyone concerned agreed the report by the Board of Consulting Engineers was very favorable and as it seemed to be probable that the Federal Power Commission would act favorably on the applications before them, a period of intense activity followed.

The matter of securing a suitable insurance policy, to protect the Districts against a deficient water supply in the year the project could otherwise become "Operable", was a matter of great importance. After discussion with Miller and Ames, Insurance Brokers of San Francisco, they engaged Mac Silvert to make a detailed study of the stream flow records and to make a report for presentation to the insurance companies. Mr. Silvert was assisted in this work by Henry Trainer of Miller and Ames and R. E. Hartley of the Oakdale District. Based on this report, Miller and Ames were able to arrange a policy acceptable to all concerned at a cost of $129,630.00 payable only if the project went into the construction stage.

The changes in the specification provisions, recommended by the Board of Consulting Engineers, were made by the design engineers and the attorneys. Jointly with the financial advisors, bond counsel and attorneys for the Districts, a final draft of Section 22 - Finances and Guarantee of Completion was carefully prepared and revised until everyone concerned was in agreement that the necessary Guarantee of Completion was afforded to the bond purchaser.

The financial advisors, Blyth and Co., Inc., were of the opinion that it was desirable to place the engineering management, inspection and supervision of the Tri-Dam Project in the charge of a firm of engineers and thus provide for the continuity of engineering management throughout the construction period. As a result, Tudor-Goodenough Engineers was formed as a joint venture association of Tudor Engineering Company of San Francisco and B. W. Goodenough. After some negotiation with the Districts, a contract was approved on March 25, 1955, for Tudor-Goodenough Engineers to act as the Engineers in the performance of the management, inspection and supervision of the Project, with the requirement that the Engineers would provide the services of B. W. Goodenough as Project Engineer.

Completing the provision for the engineering work that would be required if the project went into the construction stage, the Districts entered into an agreement with R. E. Hartley and John B. Duff to perform the survey work as required for construction of the various features of the Project.

Following completion of this work and approval of the revised specifications by the Joint Boards of Directors, an Invitation to Bid was issued. This called for construction bids for the Donnells and Beardsley Units to be received at Oakdale, California on April 21, 1955. On that date, only one bid was submitted. That bid contained conditions which were not in conformity with the terms stipulated in the call for bids as the total amount of the bid, based on estimated quantities of work, was $32,940,290 with a stipulation that a maximum of $33,690,000 of funds be provided, in conflict with the specification provision for $31,840,000 to be available and guaranteed as the maximum cost to the Districts. The bidder apparently felt that there was possibility of over-runs on estimated quantities, particularly with regard to tunnel lining, dam excavation and construction, and consequently stipulated that the maximum sum to be paid under the contract be increased. After study by the attorneys and

engineers, it was decided that the bid must be rejected by the Joint Boards of Directors.

After the rejection of this bid, discussions were held with contractors and further steps were taken which in the opinion of the Districts' engineers would assure receipt of construction bids within the limits of the funds to be made available.

D. The Final Plan

To overcome the objections of contractors, several material changes were made in a second call for construction bids, to be received on May 23, 1955. These changes included a provision that bids would be received only on the Beardsley and Donnells Units combined instead of separately as provided under the previous call.

The guaranteed amount from proceeds of sale of the Bonds to become available for payment to the contractor was increased from the previous maximum of $31,840,000 to $32,840,000. The Districts again reserved the right to reject any bids if the sum of the unit prices exceeded $32,840,000.

As an incentive to the contractor to complete the work prior to the latest date fixed for completion (December 15, 1958), the call for bids provided that the contractor would receive all sums which might become payable for power produced prior to December 15, 1958, under the Tri-Dam Project Contract with the Pacific Gas and Electric Company. Under this arrangement, if for example both units were completed and operable by December 15, 1958, the contractor would be entitled to receive two payments of $951,000 each which would become due to the Districts from Pacific Gas and Electric Company on June 15 and December 15, 1958, respectively.

1. Second Bid Opening on May 23, 1955

Following the disappointing events of April 21, 1955, there was considerable anxiety as to what would develop when the appointed hour arrived for the second opening of construction bids in 1955. However, on May 23 two good proposals were received and they were as follows:

Bidder	Amount
The Arundel Corporation, L. E. Dixon Co. and Guy F. Atkinson Co.	$31,217,613.50
Morrison-Knudsen Co., Inc., Peter Kiewit Sons Co., Macco Corporation & Stolte, Inc. (Later known as Tri-Dam Constructors)	$31,199,850.00

These were exceptionally close bids for construction work of this type and magnitude, as the difference was only $17,763.50. They were very satisfactory from the standpoint of the Districts as the low bid was $1,640,150.00 below the sum guaranteed to be available for construction payments and a reserve contingency fund of that amount was thus created to protect against increases in the quantities of work necessary to complete the Project.

2. Bond Sale on May 25, 1955

Following the receipt of acceptable construction bids on May 23, 1955, only a satisfactory proposal for the purchase of the Revenue Bonds for the Upper Works, totaling $41,500,000 was needed to allow construction of the Project to proceed. This was scheduled for May 25, 1955, and on that date three bids, as follows, were received:

Bidder	Coupon Rate	Premium Offered	Effective Interest Rate
F. S. Smithers & Co. and Salomon Bros. & Hutzler	3.05	$166,000.00	3.041836%
Allen, Walston & Co.	3.05	109,686.00	3.044608%
Blyth & Co., Inc.	3.10	250,000.00	3.08777%

When credit for the premium was taken, the effective interest rate under the F. S. Smithers & Co. and Salomon Bros. & Hutzler proposal was lowest and the bonds were sold to them. In the offering to the public, the bonds were

sold at $101.27 to yield 3% and the entire issue was sold promptly.

With these actions, the construction of the Upper Works of the Tri-Dam Project was at long last ready to proceed.

3. Financing of Tulloch Unit

(a) Preparatory

By resolution dated July 28, 1955, the Joint Boards of Directors instructed the Engineers to review the financial situation of the Tri-Dam Project and determine whether in their opinion construction of Tulloch Unit could be started. This study indicated that there was now sufficient money in the bond authorization of $52,000,000 to complete the entire Tri-Dam Project. The Engineers accordingly recommended that bids for construction of the Tulloch Unit be advertised for opening on October 25, 1955, and if these bids were favorable, the remaining outhorized amount of $10,500,000 of bonds be offered for sale. This recommendation was concurred in by the Board of Engineering Consultants and approved by the Joint Boards on August 12, 1955.

It was necessary to revise the plans and specifications previously prepared by International Engineering Company to provide for a 40-foot shift in the location of Tulloch Dam, as proposed by the State Supervisor of Dams, and to provide for payment of power revenues to the contractor, should he complete the plant in operable status prior to March 15, 1958. The sum of $8,800,000 was stated in the specifications as the minimum guaranteed amount of money available for this work, but that an additional amount, up to a maximum of $1,230,000, might or might not be available when the final costs of the Upper Works were determined. The contractor was required to guarantee that he would complete the work for $8,800,000

if that were the only money available and for such amount over that figure as was available from any savings that might be realized on the Upper Works construction. This advertisement also included the work of raising Goodwin Dam to form an afterbay for the Tulloch Power Plant.

(b) Construction Bids

Three bids were received on Obtober 25, as follows:

Bidder	Amount
The Arundel Corporation and L. E. Dixon Co.	$8,291,428.00
Guy F. Atkinson Co.	8,578,814.20
Tri-Dam Constructors (Contractors on Upper Works)	9,272,600.25

Since the low bid was well under the ceiling of $8,800,000 set by the specifications, the Joint Boards immediately advertised for the sale of the remaining block of bonds, with bids to be opened on November 30.

(c) Bond Sale on November 30, 1955

The following firms offered to buy the $10,500,000 bond issue:

Bidder	Coupon Rate	Premium Offered	Effective Interest Rate
F. S. Smithers & Co. and Salomon Bros. & Hutzler	3.05%	$38,850.00	3.042448%
Blyth & Co., Inc.	3.05%	13,652.00	3.0473%
Halsey-Stuart & Co., Smith-Barney & Co., and White-Weld & Co.	3.10%	34,965.00	3.093204%
Ira Haupt Co.	3.10%	31,395.00	3.093897%

The bid of F. S. Smithers & Co., and Salomon Bros. & Hutzler was the most favorable as it afforded the lowest net interest rate and their offer

was accepted by the Joint Boards. It is to be noted that this was the same group that was low bidder on the bond sale for the Upper Works at the same coupon interest rate.

After approval of the Tulloch bids by the Districts Securities Commission, final award of the Tulloch work was made to The Arundel Corportation and L. E. Dixon Co., thus clearing the last hurdle in converting the entire Tri-Dam Project from a dream to the reality of construction.

SECTION II - CONSTRUCTION

CHAPTER 5

CONSTRUCTION OF DONNELLS UNIT

As noted in Chapter 4, the combination of Morrison-Knudsen Co., Inc., Peter Kiewits Sons Co., Macco Corporation, and Stolte, Inc. was awarded the contract for the construction of Donnells and Beardsley Units and operated under the name of Tri-Dam Constructors. Due to internal policy in the organization of the sponsoring contractor, the work was conducted as two separate jobs with one for the Donnells Unit and the other for the Beardsley Unit. The Donnells work was performed under the sponsorship of the Dam Division of the Boise Office of Morrison-Knudsen Co., Inc., while the Beardsley work was performed under the Los Angeles Division of the same company. Only in the matter of employing workers and in labor relations were there common interests and common employees. While this split of work probably served to the advantage of the contractor, it made the administration of the work more difficult for the Project Engineer.

A. Preparatory Work

The contract between the Districts and Tri-Dam Constructors was signed on May 31, 1955 and actual work was started immediately. A site for the construction camp of the Donnells Unit was selected along the Hells Half Acre Road near the downstream portal of the Donnells tunnel. A construction road which the Districts had carried part way down the cliffs at the dam site was improved and extended and work areas developed for shops, machinery yards and the like. At the same time, the Contractor boldly decided to link all parts of the job together by building an eight-mile construction road along the canyon wall from the construction camp on the Hells Half Acre Road to the Donnells dam site. This road, known as the 4700 road because it generally

4700 ROAD INTO DONNELLS DAM
(Photo by Allen Holbrook, OID)

followed that elevation, voided the need to use the District located road down over the cliffs, and the latter was used only during the early construction period. At the same time, the contractor proceeded with design and construction of the aggregate production and concrete plant at the dam site, which were used to furnish concrete for all parts of the job. Construction of the tunnel was initiated from adits off the 4700 road and preparation for construction of the power house was started.

Close access to the actual site of the dam was difficult and it was October, 1955 before the contractor was able to start excavation for the dam and construction of a diversion tunnel through the right abutment. Once started, this tunnel was driven for a total length of 1,500 feet and completed by November 22, 1955. Excavation in the river bottom was initiated at the same time and was carried on without undue interruption during the ensuing winter months. Prior investigations had disclosed that the

river had once eroded a deep gorge in the solid granite at Donnells dam site, which was backfilled with sand, gravel and rock. One of the first operations was to drill additional core holes to more exactly determine the probable extent and depth at the buried gorge.

DONNELLS DAM SITE - BEFORE CONSTRUCTION
(Photo by Allen Holbrook, OID)

B. The Dam

The specifications required the contractor to excavate for the dam starting at the top and working down. However, he proposed a change in this program which was approved by the Project Engineer and the Board of Consultants as it saved the Districts money and helped to speed up the work. The design for the dam involved placing a gravity plug section in the narrow buried river gorge to a predetermined height and placing the arch dam above this. The revised plan proposed by the contractor was to excavate the river bed material first to bedrock and to then place the concrete to the

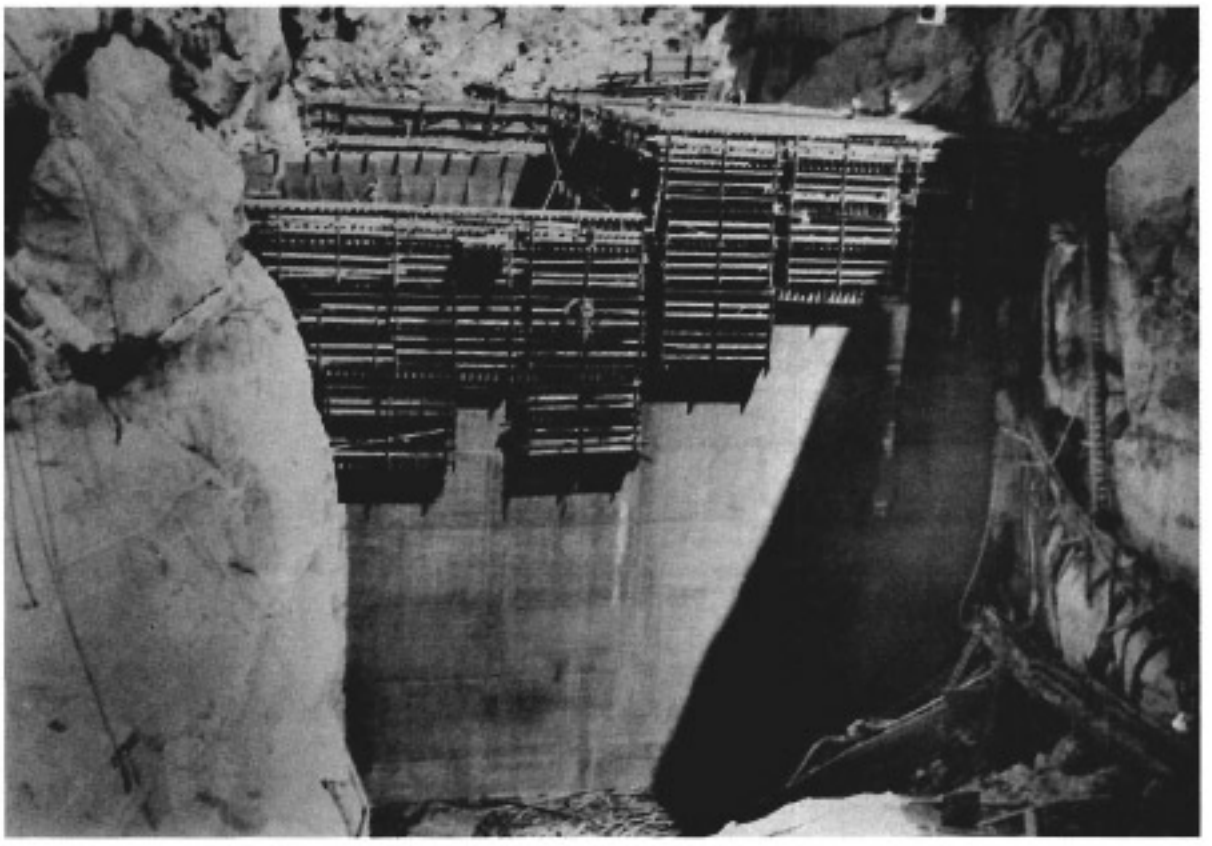
top of the plug section, protect this concrete adequately, and then proceed with the excavation of the canyon walls for the arch dam. Accordingly, the contractor proceeded with this plan and first excavated in the river bottom. This excavation was very tedious and expensive. Working room was limited, and as the excavation approached the full depth of 190 feet below original river bed, a great amount of rehandling and hoisting was required to remove the debris. Material encountered was a conglomerate mixture of sand and gravel surrounding large boulders, which had apparently broken off the canyon walls over the centuries and become lodged in the gorge. This material was found to be very dense and watertight, which obviated the heavy pumping which had been expected. This very water tightness, however, made the debris much more difficult to dig than had been expected. Work on this excavation continued throughout the winter of 1955-1956. It was only interrupted by a flood in December, 1955 when cessation of work for several weeks was forced, primarily because the storms accompanying the flood had washed out several sections of the access road. The excavation was completed on July 9, 1956, and on that same date the first concrete was placed in the plug section at Donnells Dam.

EXCAVATION OF GORGE - DONNELLS DAM
(Photo by Allen Holbrook, OID)

In the latter part of 1955, the contractor had completed his plans for the aggregate plant and had started assembly of the concrete plant. After several initial trial runs, the aggregate processing plant, which produced coarse aggregate and sands of stipulated gradation by crushing and grinding the local rock, was ready to process the materials. The concrete mixing plant, which was ready to produce the first concrete by the middle of June, 1956, was an automatic plant with two mixers of four cubic yard capacity. These mixers discharged into buckets on a railroad car, which moved

over a transfer track to points where the buckets were picked up by a 25-ton cableway which spanned the work area. The head tower, on the south bank of the river, traveled in an arc, while a stationary anchor embedded in the north canyon wall formed the tail anchorage. The first concrete was placed in the spillway area. However, when excavation of the river bottom was completed, the plug section of the dam was placed as rapidly as possible. Work on the spillway was deferred until completion of the plug section and resumed while the excavation for the arch section was underway.

The plug was raised from a bottom elevation of 4434 feet to its upper level of 4600 feet in 39 calendar days, starting July 9, 1956. This fast progress was possible because the specifications permitted this section of the dam to be placed in 10-foot lifts, with a waiting period of 72 hours between lifts. The contractor arranged his



CONCRETE PLUG - UNDER CONSTRUCTION - DONNELLS DAM
(Photo by Allen Holbrook, OID)

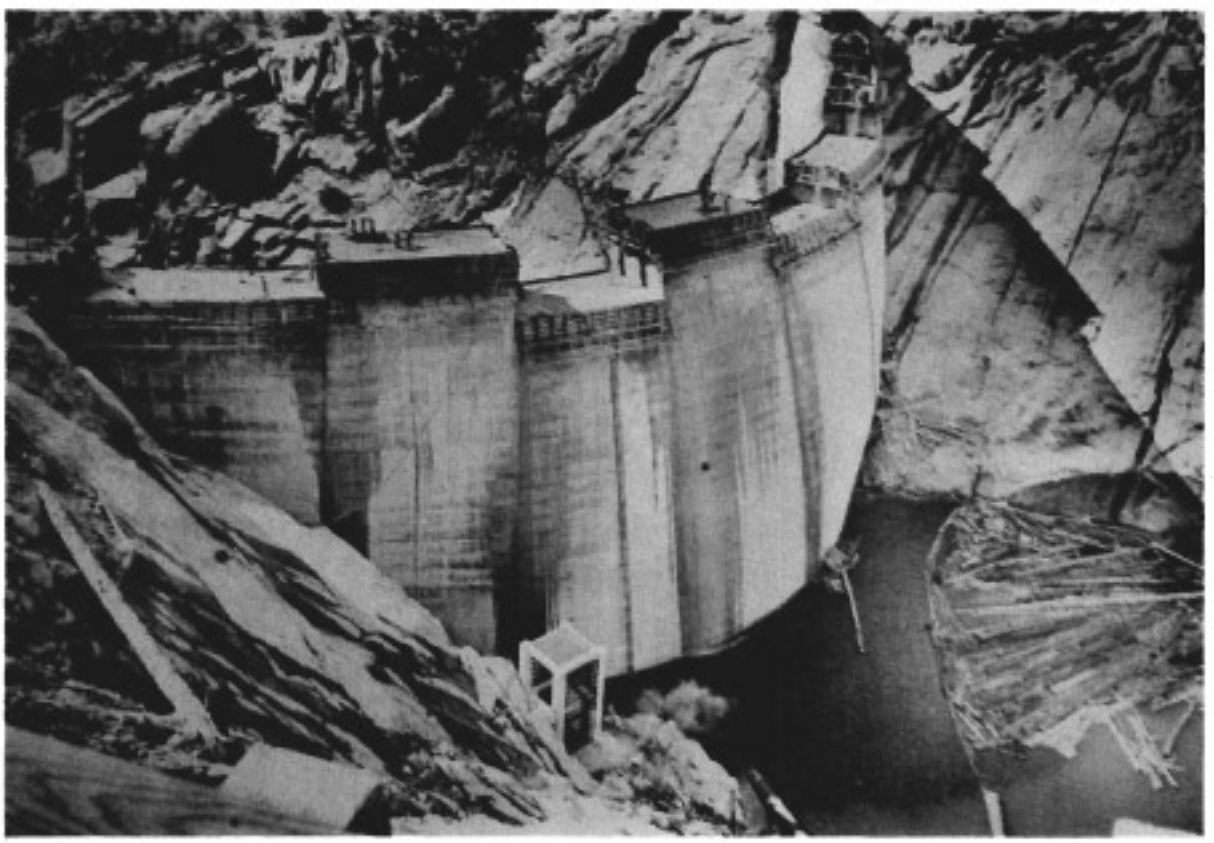
work on a 24-hour basis and started the next pour at the exact moment that the waiting period was up.

Concurrently with this work and as a result of a directive of the State Supervisor of Dams, the left abutment of the plug section was reinforced. This involved excavation of a shaft across a prominent joint in the canyon wall and backfilling it with concrete.

EXCAVATION FOR RIGHT ABUTMENT - DONNELLS DAM
(Photo by Bob Hooe, Sonora)

This work was completed on August 25, 1956. Immediately thereafter, the plug section of the dam was protected by covering with logs and excavation of the canyon walls for the arch dam was started on both abutments. This excavation work was completed in early October of 1956. It should be mentioned here that the contractor was extremely cooperative with the Project Engineer in maintaining rigid control over his drilling and blasting practices during the performance of this excavation, with the result that this work has been acclaimed as an excellent example of good excavation workmanship.

The first lift of concrete in the arch section of the dam was placed on October 15, 1956 and the work moved steadily forward to the last bucket of concrete which was placed in the dam on May 15, 1957. The contractor operated on a 24-hour, 7-day week schedule and placed the next lift as soon as the stipulated time interval between lifts had elapsed. This concrete was placed to a total height of 317 feet above



DONNELLS ARCH DAM DURING CONSTRUCTION
(Photo by Bob Hooe, Sonora)

the top of the plug in just seven months, and although the total volume of concrete placed in that period is in no way a record, the height placed in that short period is noteworthy.

The spillway concrete, which was placed only when there were no dam pours scheduled, was completed shortly after completion of the dam. By the middle of June, 1957, the dam and spillway was complete except for removal of construction plant, and water was stored behind the dam to the maximum elevation of 4916 during that month. A total of 204,838 cubic yards of concrete was placed in the main dam and spillway.

Although the actual construction of the dam is described in a few short paragraphs in this report and was completed in two years' time, it should be realized that that period was a time of intensive effort on the part of all concerned in its construction. The survey work required for layout was very complicated because of the design. There were no straight lines or surfaces in any plane and this required intricate computations in the office prior to actual field layout. Due to the thinness of the structure, which was 41.4 feet thick at the base and 10 feet thick at the top, it was exceedingly important that it be certain the full width was placed and that the concrete be of high quality, which required rigid control in the inspection of the concrete. Simultaneously with the placement of the concrete, the contractor was carrying on many other items of accessory work, including setting of the tainter gates and the grouting of the foundation rock, which was performed immediately ahead of the concrete placement. This provided an impervious curtain, extending into bedrock for a distance of about 40 feet, to prevent water in the minute cracks in the rock from exerting hydrostatic pressure on the base of the dam.

The dam was completed in two and one-half working seasons rather than the four provided for in the contract. This record was only possible because the contractor

carefully prepared for 24-hour operations and to work through the winter regardless of weather. The contractor had very little trouble with the problem of snow removal and in obtaining employees who were willing to work despite weather conditions, and this is a high recommendation in itself for his preparations. It is possible that without this adequate preparation, he would have been forced to suspend operations many times in each winter. Although it might appear that the specifications permitted an undue amount of construction time, it must be remembered that extremely severe winter weather could have occurred, with serious loss of time. Under the opinions expressed by bidders in 1953, it was believed that most contractors would probably include some amount of contingent money in their bids to protect against the risk of possible penalty. Therefore, to remove this possibility, the Districts decided to extend the contract period to four seasons or three and one-half years. Actually, during the bidding in April, 1955, the extension of time not only removed any possibility of such a contingency but afforded the basis for the final solution to the problem. The bids of May were $1,490,000 lower than the bid of April, largely due to the allowance made in the final bid for possible power earnings during the construction period. This was the only way the Districts could have secured the benefit of these earnings, as the financial advisors would not include them in the assured revenues for benefit of the bond purchaser. Although it is the contractor's responsibility to decide the economics of completing as rapidly as possible, in this particular instance the Districts secured stored water at least a year ahead of time and at the lowest eventual cost possible under the circumstances.

C. The Tunnel

Donnells Tunnel extends for a distance of over 7 miles from the intake just upstream of the dam to a terminus in the hillside immediately above the power plant.

The tunnel is of horseshoe shape, 12.5 by 12.5 feet in size. The tunnel floor is paved throughout its length. It was only necessary to fully line the tunnel with concrete in isolated areas and this full lining only amounted to 6% of the entire length. The design was such that the basic tunnel shape could be driven throughout, with any required lining extending inside the excavated section. Only in special areas, such as transitions, was excavation beyond the basic limits required. The contractor therefore excavated for the basic tunnel shape which facilitated progress of the work and came back to do any extra work required. In the initial stage of the job, the contractor devoted much time to developing working areas and disposal dumps for the excavated material. He decided upon three locations from which to drive the tunnel. The first one developed was at the downstream portal of the tunnel. A second point was at Lily Creek, where the tunnel was located about 900 feet from the canyon wall. The contractor drove a branch tunnel, or adit, those 900 feet to connect with the tunnel alignment. The Lily Creek adit was approximately 2 miles upstream from the downstream portal. A third working point was about 1500 feet downstream of the intake at the dam, where an adit 300 feet in length permitted access to the tunnel alignment. The tunnel between these two adits was approximately 5-1/2 miles in length, without a turn or bend.

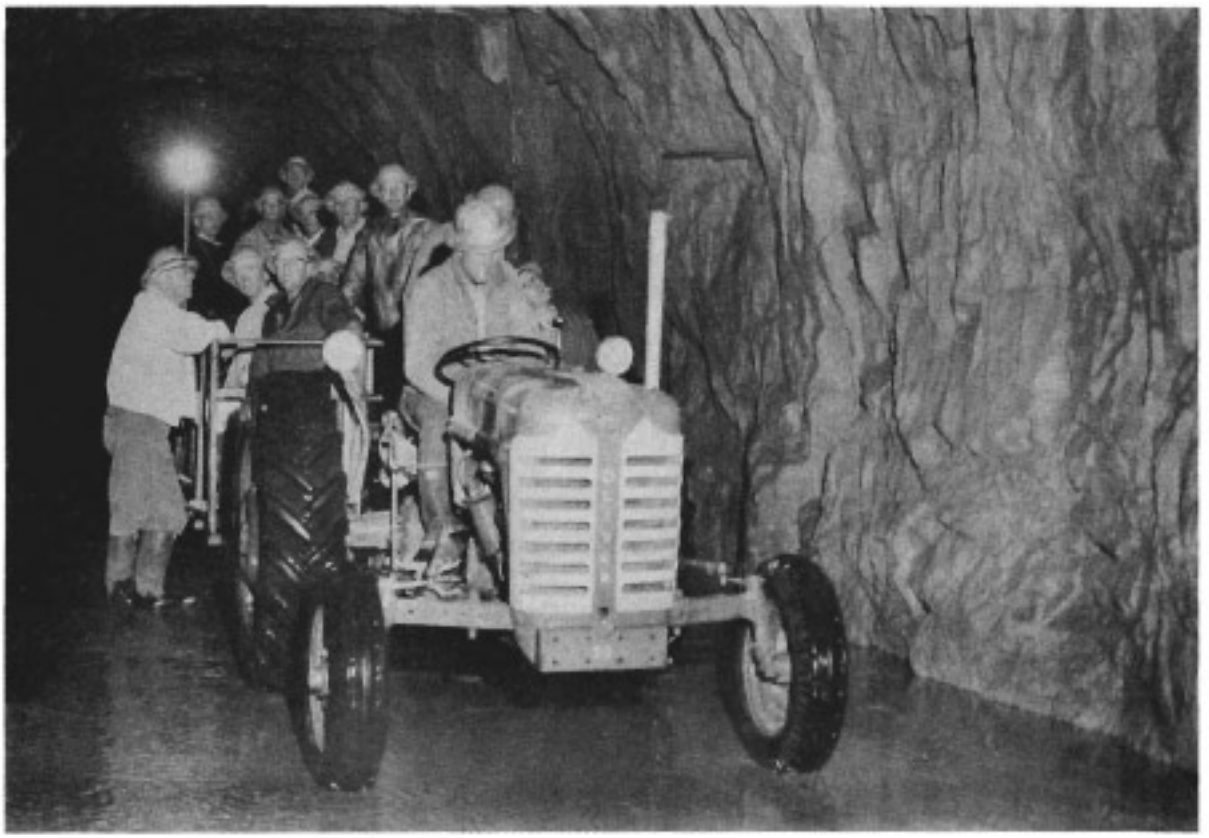
The contractor drove the tunnel from these three headings, working upstream from the downstream portal and from the adit at Lily Creek and both upstream and downstream from the adit near the dam. Initial work on excavation at the tunnel proper started on August 27, 1955 and the tunnel driving was completed on December 11, 1956.

This work was conducted on a 24-hour basis for six days per week, and required the services of about 300 specially qualified workers. The work consisted of a regular schedule of drilling, loading, detonating, mucking, and disposal of muck. Drilling was accomplished by special drills, mounted on a drill "jumbo" which was moved to

the heading on railroad track. Holes were drilled to a general depth of 12 feet in a predetermined pattern which would permit blasting of the rock to the approximate tunnel shape. Loading of the explosives was also accomplished from the "jumbo", after which it was backed away to a safe distance and the explosives discharged. Immediately thereafter, a special track-mounted loader would scoop up the blasted material and load it into muck cars, which were moved on the track by battery-powered locomotives. As the muck was loaded into these cars, the locomotives would haul the train outside of the tunnel to the disposal area where the muck was dumped. After the track crew had advanced the rail to the face of the tunnel, the cycle would be repeated. The tunnel driving averaged about 3000 feet per month throughout the period of driving, although this depended primarily upon the number of headings being worked.

After completion of the tunnel driving, the necessary concrete paving and lining were completed. The downstream leg of the tunnel was fully completed in the period from June 25, 1956 to September, 1956, the 1500 feet upstream of the upper adit in November, 1956, and in the major leg of the tunnel from December, 1956 to April, 1957. Concurrently with this latter work, the intake structure, the control structure at the upper end, the surge shaft and rock trap at the downstream end of the tunnel were completed. The intake structure required only the shaping up of the portal and the construction of a beam and column concrete support for metal trash racks. The control structure involved the excavation of a vertical shaft from the tunnel to rock surface and placing concrete lining, so as to permit sliding gates to control the flow of water. These gates are operated from a control house built atop the shaft, above the water level of the reservoir. At the downstream end, the rock trap consisted of a large excavated hole in the tunnel floor lined with concrete, which stops the travel of any fallen rock and prevents it from damaging the power plant machinery below. The surge shaft is a 22 foot diameter shaft which was excavated from the tunnel roof to ground

surface and is designed to equalize water pressures during changes of load while the plant is being operated. It was necessary to plug up the adits which had been used during construction of the tunnel and this was accomplished by means of circular steel liner plates embedded in concrete. These liners are equipped with large doors which can be opened to permit the entrance of equipment into the tunnel for purposes of inspection and maintenance.



FINAL TUNNEL INSPECTION
BY JOINT BOARDS - MAY 15, 1957 - DONNELLS
(Photo by Bob Hooe, Sonora)

D. The Penstock

A 5/8-inch thick steel liner section, 96 inches in diameter, was embedded in the tunnel for a distance of 900 feet from the downstream tunnel portal to the vicinity of the surge shaft and rock trap. This liner was secured in position by welding and then concrete was placed between the pipe and the rock to completely fill this space. At the

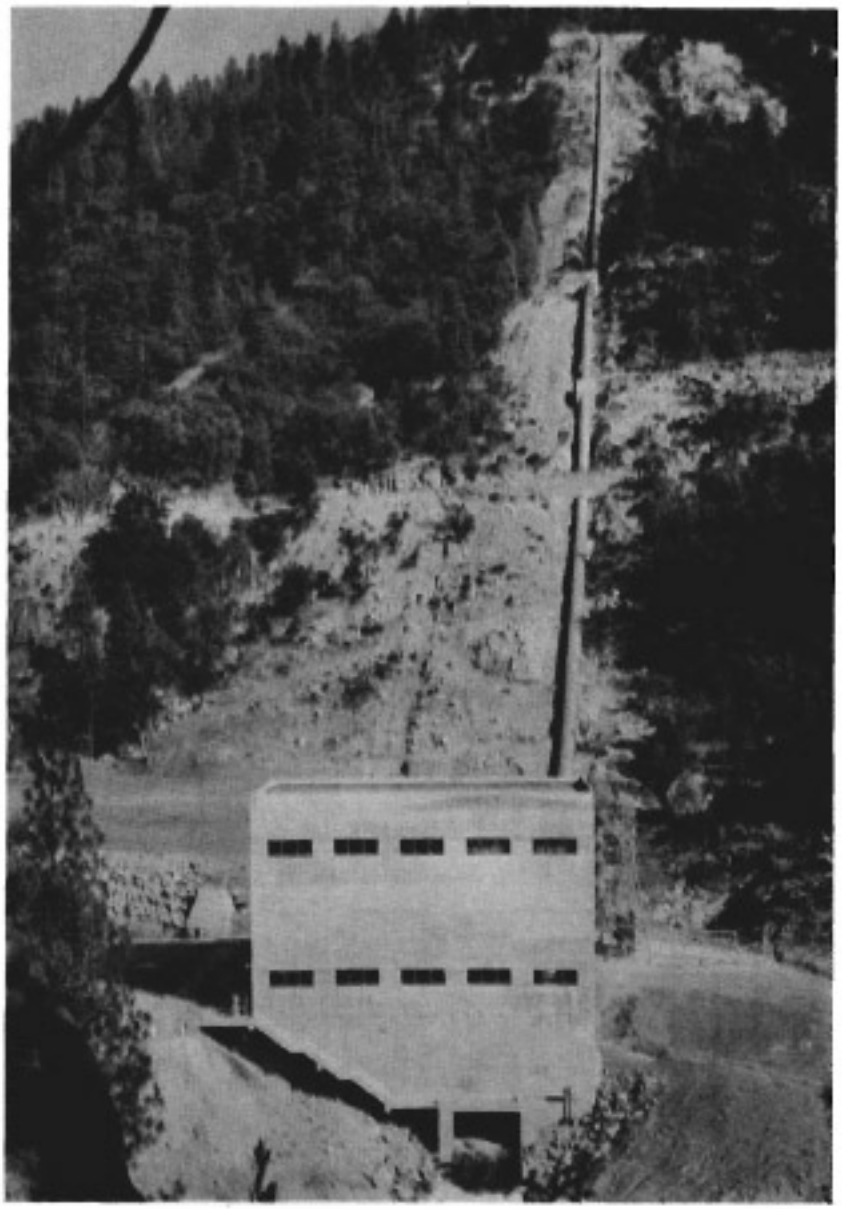
downstream portal of the tunnel, this liner connects to a 96" diameter butterfly valve, controlled from the power plant, to regulate the passage of water into the penstock proper. To carry the water from the tunnel to the power plant, it was necessary to install a steel penstock. This is 81 inches in outside diameter and is made up of steel plate welded into 40-foot long sections which were in turn connected together by Dresser-type couplings. The plate varies in thickness from 5/8 inch to 1 and 13/16 inches, depending upon the water pressure to which it is subjected, with the thicker plate being at the lower end adjacent to the power plant. The penstock is supported on concrete piers at the ends of the pipe sections. Several concrete anchors were necessary in those places where there was a distinct change in the profile of the penstock, such bends being accomplished by specially fabricated sections of pipe. In the regular sections of penstock, the Dresser coupling permitted angles up to 1 degree without special provisions.

Just upstream of the valve house, an 84-inch outlet was provided for the future use of the Tuolumne County Water District No. 2 in accordance with the provisions of the Districts' Agreement with that District.

The excavation of the penstock trench and the deeper excavation required for the piers and anchors was started in the spring of 1956, and concrete work followed that summer. The pipe installation was completed by the end of the year. Placement of the pipe on the steep hillside was a considerable problem. The contractor solved this by installing a rail on each side of the penstock trench. On this he operated a specially built gantry car, which was moved up and down the track by a hoist, and thus carried the pipe sections into position.

The work on the tunnel and penstock required meticulous survey control. On the penstock this was necessary in order to locate the piers exactly so that the pipe, which

was laid on a steep slope, would fit and be supported according to the design. In the case of the tunnel, all work had to be carried forward for long distances without opportunity for forward reference checks, and a small error could have had serious consequences and resulted in misalignment of the work. This work was exceedingly well done by the surveyors, Hartley and Duff, and the tunnel faces met almost exactly.



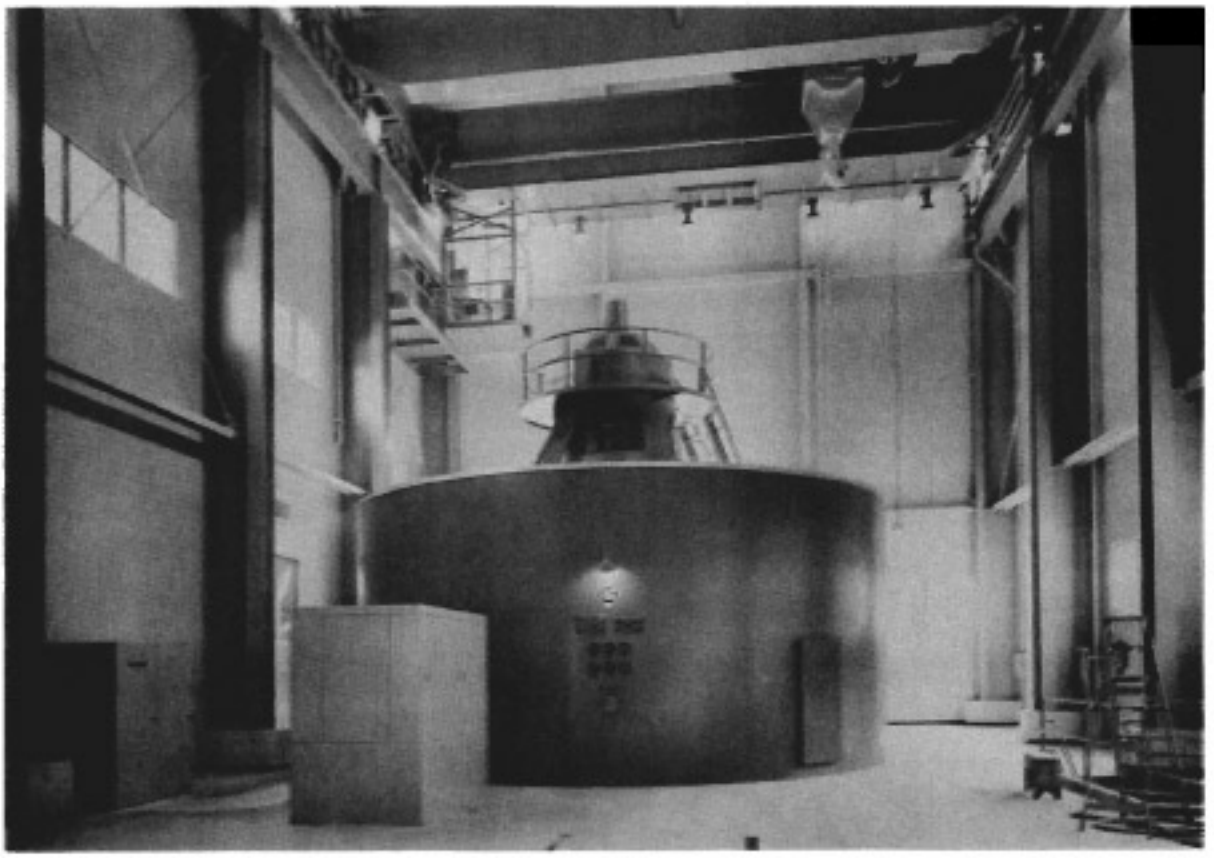
PENSTOCK AND POWERHOUSE - DONNELLS
(Photo by Allen Holbrook, OID)

E. The Power Plant

The Donnells Power House is located just above the Beardsley Reservoir and is a

reinforced concrete structure founded on rock. Excavation of the site was accomplished in late 1955 and early 1956, and concrete work started in April, 1956. The first concrete came from the Beardsley concrete plant but this was discontinued when the plant at Donnells started production in June of 1956. All concrete was then hauled about 15 miles from the Donnells Plant and was placed by means of a large stiffleg derrick, which had been erected for that purpose in the winter of 1955-56. This derrick could reach any part of the power house and was also used for handling the heavy machinery and steel materials which were a part of this job.

After the concrete was placed to the general ground level, which was the level of the generator floor, a structural steel framework was erected in October, 1956. Above that level the building is supported by the steel framework with light concrete walls secured thereto. After the completion of the concrete roof slab in January, 1957, in-



GENERATOR ROOM IN DONNELLS POWER PLANT
(Photo by Bob Hooe, Sonora)

stallation of the power generating machinery started. This work was completed except for final testing by May 26, 1957 when the unit was first turned over. The first usable power was produced on June 1, 1957. All of the major machinery furnished, including turbine, generator, transformers and switchgear, was supplied by the Allis-Chalmers Company under a subcontract with Tri-Dam Constructors. The machinery was installed without particular incident because the contractor had available first-class electrical and millwright superintendents who supervised all of this work.

A somewhat unusual provision of the Tri-Dam Project construction specifications required the contractor to furnish the permanent equipment required for the generation of power and control of the water. This was done to make certain the provisions of the specifications regarding penalty for non-completion could be enforced without question. In view of these conditions, it was mandatory that the contractor have absolute control of the procurement of the equipment to enable him to schedule its delivery in accordance with his construction program. The contractor took a like step in making an award of this work to one sub-contractor. Although he might have secured a cheaper overall bid for the machinery by allotting parts of the work to several different companies, such action would have meant a divison of responsibility which could have imperiled his completion of the work. This arrangement had a further advantage since from the operating standpoint, it was only necessary to inform Allis-Chalmers if something was wrong to obtain help. There was no need to determine what part was affecting the operation and subsequently, who was the proper person to render the help.

Immediately after the plant was placed in operation, an incident occurred which delayed final acceptance of the Upper Works when on June 4, 1957, while the plant was being tested by operating it above rated load, several of the baffle plates came loose from the needle housings of the turbine and hit the buckets of the impeller. This

caused considerable damage to thirteen of the twenty-two buckets and required a shut-down for temporary repair. Two spare buckets were installed to replace the ones damaged most severely and considerable grinding was done to smooth the remainder. The unit was placed back in service on June 15, 1957 and after careful checking it stayed in service until November when new buckets were available. Eleven buckets, which had been fabricated in the interim, were used to replace the damaged buckets which had been worked over in the field. Since completion of the installation of the new buckets, the unit has operated very satisfactorily and it was accepted by the Pacific Gas and Electric Company as meeting the conditions for full operability as of the beginning moment of January 1, 1958. This, the same acceptance date for Beardsley, meant that the Upper Works had attained the Intermediate Operable Date as defined in the Tri-Dam Project Contract with the Pacific Gas and Electric Company.

During January of 1958 the final efficiency and acceptance tests for the generators and turbine were conducted. To determine turbine efficiency, the Districts used the services and methods of Dr. Norman R. Gibson to supervise the tests. These and all other tests proved that the equipment furnished met the required guarantees and operated in the specified manner. Representatives of the Pacific Gas and Electric Company and of the Design Engineer, International Engineering Company, Inc., participated and cooperated with the Project Engineer in these tests.

F. Related Work

Very little additional work was necessary to complete the Donnells portion of the Tri-Dam Project since the specifications for Schedules I, II and III provided a very complete job in themselves. Some additional work was done by Tri-Dam Constructors, either by change order or by special purchase on the order of the Project Engineer. In the former case, this extra work is included in the final costs of those schedules.

Various change orders provided for the construction of a building used as a field office by the Project Engineer and now used by the Districts as a warehouse, the construction of a reservoir gauge, and a trail down to the valve house, all at Donnells Dam. Other change orders provided for the construction of facilities to permit the Hells Half Acre and the 4700 road to cross the penstock line, the construction of power lines and control circuits to the penstock valve house, the installation of protection and a special inspection of the surge shaft all in connection with Donnells tunnel. Finally, additional change orders provided for furnishing oils for the plant and construction of utilities for the operator's house at Donnells Power House. By a separate purchase order Tri-Dam Constructors installed a stream gauging station near the power plant.

Work done by other contractors included the clearing of the reservoir by Wixson & Crowe, Inc., which was started in the summer of 1956 and completed the following summer, and the construction of houses for the caretaker at Donnells Dam and for the attendant at Donnells Power Plant. These houses were constructed in the fall of 1957 by Moore & Johnson and by Edgar Girard, respectively.

Work done by other agencies included an attempt to construct a gauging station below Donnells Dam by the crews of the Pacific Gas and Electric Company in late 1956 and the completion of this work by crews of the United States Geological Survey in the spring of 1958. The Districts also purchased several of the contractor's houses for use by operating personnel.

CHAPTER 6

CONSTRUCTION OF BEARDSLEY

As noted in Chapter 5, the construction of the Beardsley Unit by Tri-Dam Constructors was sponsored by the Los Angeles Division of Morrison-Knudsen Co., Inc. Work on this unit was initiated immediately after award of the contract on May 31, 1955.

A. Preparatory Work

The problem of access was much less difficult at Beardsley than was the case at Donnells. This was because the Districts had in previous years constructed a jeep road down to the dam site, primarily for four-wheel drive equipment. In good weather it was possible to traverse this road with standard pickups and trucks. The contractor thus could and did take equipment into the river bottom area and start clearing work at the dam site and in the borrow area while he was constructing the permanent access road. This access road led from the Spring Gap Forest Service road to the top of the dam on the left abutment. The Contractor also built a temporary spur into the reservoir area upstream of the dam to serve his shops and warehouse.

In early July he started driving the diversion tunnel through the right abutment of the dam to permit diversion of the river during construction. Simultaneously, the contractor constructed a camp near the upper end of the access road in a relatively flat area known locally as Pedro's Corral. With the construction of these facilities and a temporary bridge across the river immediately above the dam sites, the contractor was ready to start work on the dam in August of 1955 or approximately two months after he was awarded the contract.

B. The Dam

Work on the diversion tunnel for the dam which was a 15.5 foot x 15.5 foot horse-

shoe shape, 1200 feet long and fully lined with concrete, was started on July 12, and completed on August 22, 1955. Lining of the tunnel started immediately thereafter.

There were delays in the completion of this work and a principal cause was the flood of December, 1955, which flooded the entire work area for several weeks. The tunnel lining was not completed until the latter part of February, 1956 and the river was diverted through the tunnel on February 29, 1956.

Excavation had started in the foundation of the dam in early August of 1955. At that time the river was carried through the area by means of a 72-inch diameter culvert pipe. This excavation work consisted of removing the unsuitable sands, gravels and loose rock overlying the solid rock. Rock suitable for rockfill was stockpiled for future use and unsuitable material was wasted. The contractor initiated placement of the dam embankment in the excavated areas, particularly in the upstream section of the dam, using sand, gravel and cobbles as required for that zone of the dam and rock on the upstream face. However, this work was halted before appreciable progress was made by the flood of December, 1955. While the flood waters were receding, the contractor temporarily moved his excavating equipment to the right abutment and started work in excavating for the spillway. This was only a stop-gap measure until the river could be diverted through the tunnel, after which excavation was resumed in the river bottom and on the abutments. This work was completed in April of 1956. Immediately thereafter, placement of the various materials required in the several zones of the dam was started and excavation work in the spillway was resumed.

During the fall and winter of 1955-56, an extensive investigation in the borrow area was directed to determine the exact location of the most suitable materials available for the embankment. An extensive drilling investigation was also made during this time to determine the exact amount and quality of rock available from the required

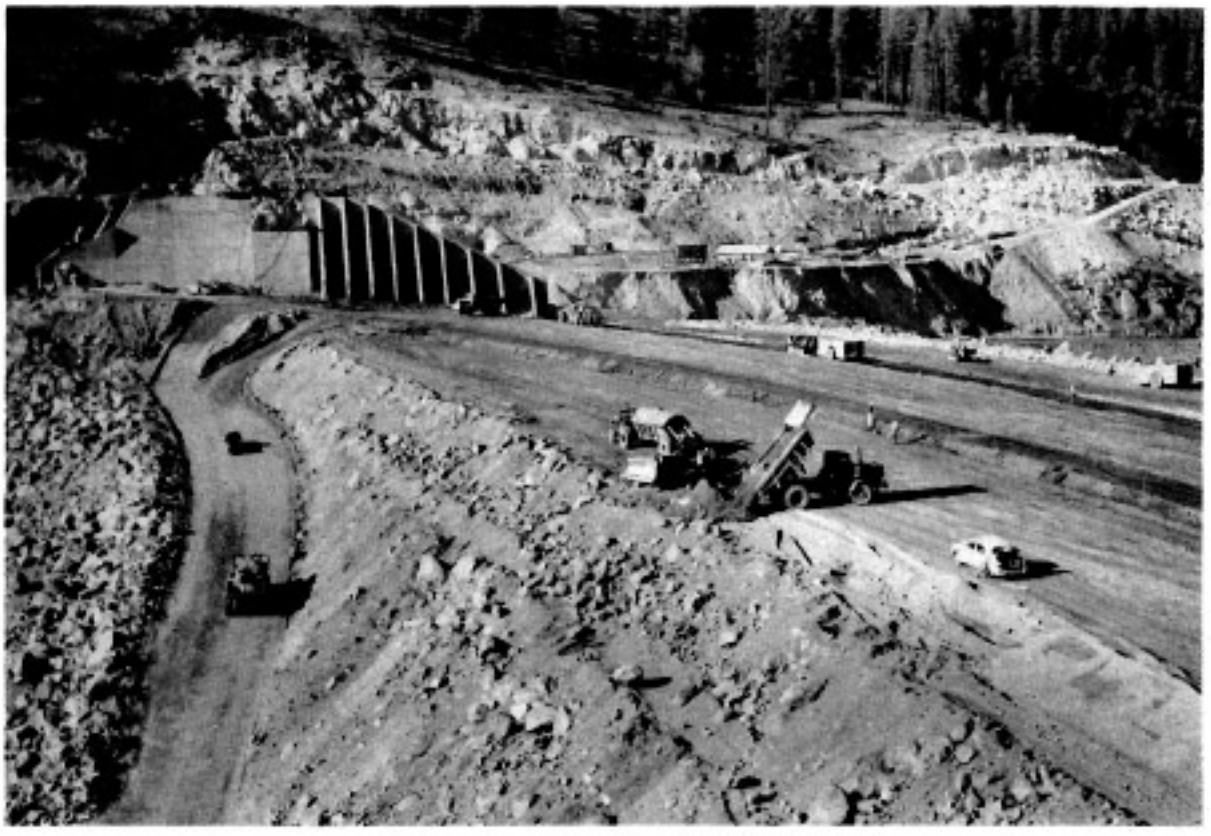
spillway excavation that would be suitable for rockfill. From the information thus derived, it was possible to designate in advance exactly where each type material required for the dam was to be obtained and this information also disclosed the amount of rock that would have to be obtained from sources other than the spillway.

Excavation work continued in the spillway throughout the summer of 1956. This was initially for the purpose of obtaining adequate foundation for the approach walls and spillway crest section after which the work proceeded down the chute section. Suitable material from the spillway was hauled to the rock zone of the dam, but this work was not prosecuted as aggressively as it could have been and the rockfill was not kept in balance with the placement of the core and shell materials.

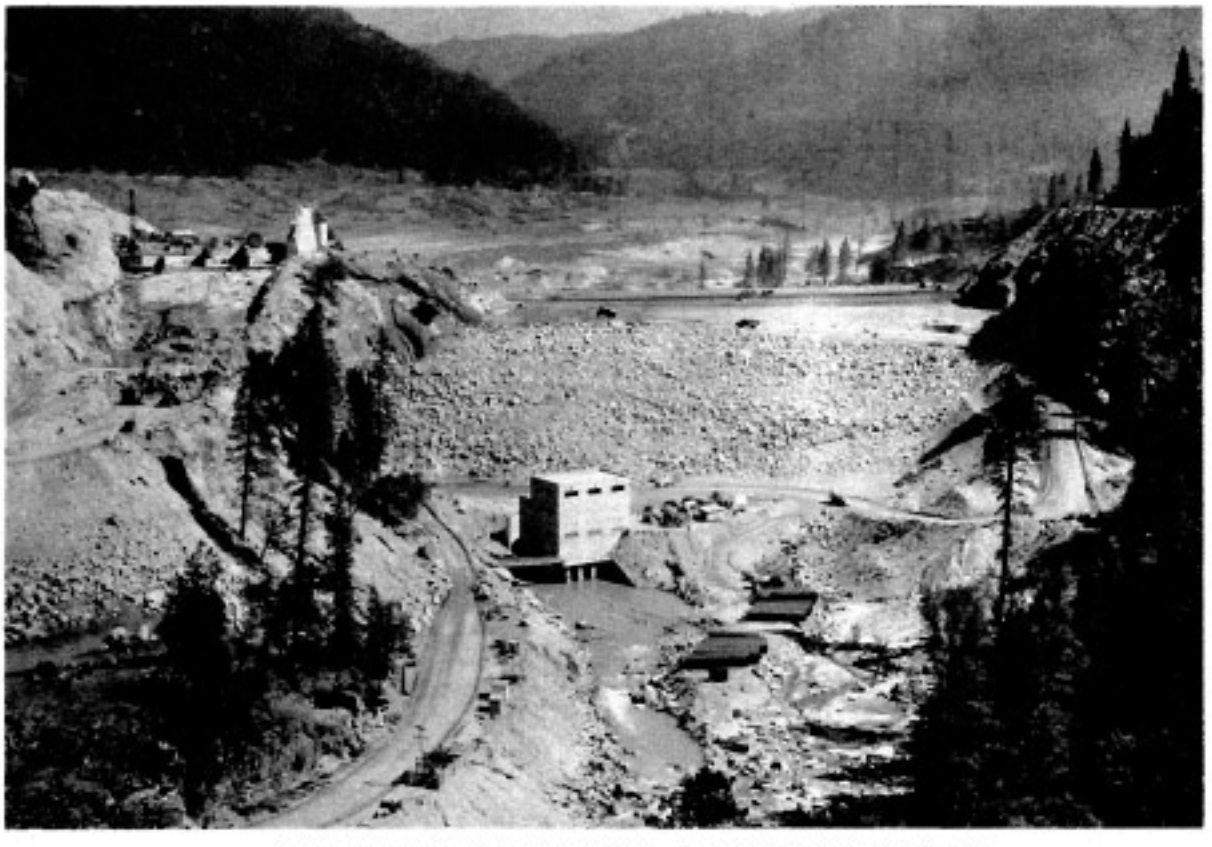
Embankment work, initially started in the fall of 1955 and interrupted by the flood of December, was resumed in April, 1956 and carried on through the summer and early fall months, twenty hours per day, six days per week. All zones in the dam were completed in December of 1956 except for the rock facing which was not completed in its entirety until March, 1957. A total of 3,221,807 cubic yards of material were placed in all zones of the dam.

Simultaneously with the placing of the embankment, the contractor completed the grout cutoff curtain into the foundation rock across the whole of the upstream area of the embankment and the spillway. This provided effective protection against water seepage through the foundation of the dam.

The principal concrete work involved in the dam included the lining of the tunnel, construction of the counterfort wall required at the right end of the dam to define the spillway channel, construction of the overflow crest and the lining in part of the spillway channel. The concrete in the spillway crest was completed during the summer and fall of 1956. However, the concrete in the spillway chute was not com-



BEARDSLEY DAM DURING CONSTRUCTION
(Photo by Allen Holbrook, OID)



BEARDSLEY DAM AND SPILLWAY - DURING CONSTRUCTION
(Photo by Allen Holbrook, OID)

pleted until much later because of the delays in completion of the spillway excavation. Placing the spillway chute concrete was started in October 1956 and completed during the latter part of February, 1957.

Water releases over the spillway are controlled by means of four 40-foot long by 30 foot high steel tainter gates, which are operated by hoists. There is also a 14 foot wide by 12 foot high vertical lift skimmer gate which can be used to pass trash over the spillway. These gates are operated from the deck of the spillway bridge. The installation work on these gates was performed in the period from October, 1956 to February, 1957, at which time all final testing and adjustments were made and completed.

C. The Power Plant

The Beardsley Power Plant is located on the right bank of the river near the downstream toe of the dam. The plant is supplied with water through the tunnel which was constructed initially to divert the river flow during construction of the dam. It was later altered to permit the installation of a 96-inch diameter steel penstock and the required concrete transition sections. This penstock, which is made up of 1/2-inch thick plate welded into 40-foot long sections with the sections joined together with Dresser type couplings, was placed in the tunnel for a distance of 610 feet upstream of the power plant. Flow of water in the penstock is normally controlled by a butterfly valve just upstream of the turbine. A 48-inch branch pipe, equipped with a ring follower gate and needle valve, permits water to be released for downstream use without passing through the power plant.

The design of the power plant building is similar to that previously mentioned at Donnells. It is a fairly massive concrete structure up to ground level above which there is a structural steel frame with concrete walls and roof. The lower part of the

power plant building was constructed during February, March and April, 1956, with the structural steel framework installed in May and June. The superstructure walls and roof were completed by June, 1956. Power plant equipment installation was essentially completed by the end of the year, although the electrical installations were not fully completed until April, 1957. First power was produced in this plant on May 6, 1957 and the plant operated regularly until it was shut down in November to permit some repair work to the tunnel which is hereinafter described. As at Donnells, the contractor made arrangements for the Allis-Chalmers Company to furnish all major power plant machinery and equipment. This worked as satisfactorily as at Donnells and the same comments are applicable here in regard to the use of equipment from one source. The Beardsley Power Plant was accepted as operable by the Pacific Gas and Electric Company at the same time as Donnells.

CONTROL ROOM FOR TRI-DAM POWER - BEARDSLEY
(Photo by Bob Hooe, Sonora)

The shutdown of the power plant at Beardsley Dam in November of 1957 resulted from a complicated chain of events which had taken place over a number of months. On March 15, 1957, a routine inspection of the penstock and transition section, downstream of the wheel gate, disclosed the fact that the transition section had bulged inward about 6 inches to 8 inches from external hydrostatic forces. The bulged sections of the steel transition liner were promptly removed, the cracked concrete repaired, and the plates re-welded into position and securely anchored. Thereafter, the concrete behind the entire liner was thoroughly grouted.

At the time this bulging was discovered, a diving crew was working in the upstream end of the tunnel in the vicinity of the trash rack. This crew discovered that there was an extensive deposit of sand and gravel present in the upstream section of the tunnel, adjacent to the trash rack and extending downstream nearly to the control shaft, with the major portion of the coarse material being upstream of the intake shaft. The matter was reviewed with the District's Consultant, Mr. O. W. Peterson, the designers, International Engineering Company, and the Pacific Gas and Electric Company. After some discussion the contractor was permitted to install a cement-sack dam, upstream of the intake shaft, to prevent the coarse material from moving down the tunnel.

Later, on April 18, 1957, while unsuccessfully attempting to raise the bulkhead gate in the penstock tunnel, some abnormal conditions were observed and extensive investigation by divers disclosed the fact that a steel plate in the section between the wheel gate and the bulkhead gate was ruptured and had been blown inward and free from the concrete. After this plate had been removed and the cement-sack dam previously mentioned had been completed by divers, it was decided that the power plant could continue in operation until the fall of 1957 when low-flow conditions in the

river would permit the unwatering of Beardsley Reservoir, with a minimum loss of use of water in the generation of hydro-electric power. Such unwatering would permit the complete repairs of the transition liner and the removal of the sand and gravel debris to be done in a normal manner, rather than by divers working under water. Therefore, this unwatering was eventually scheduled by Tri-Dam Constructors to coincide with the repair of the damaged turbine buckets at Donnells Plant described in Chapter 5.

The failure was determined to be the responsibility of the contractor due to the construction methods used and because of the omission of proper anchorage. The repair work was completed in a satisfactory manner during November, 1957, and without cost to the Districts. No power was produced at the Beardsley Plant from October 21 until December 21, 1957, when the lake had refilled to sufficient level to permit the power plant to resume operation, and since that time it has operated in a manner fully satisfactory to all parties.

D. Beardsley Afterbay

This structure is required to control the wide fluctuations in discharge from operation of the Beardsley Power Plant and permit uniform supply of water for downstream use by Stanislaus Power Plant. The structure is a gravel-filled timber crib dam with a timber cutoff wall along the front face. Discharge past the afterbay is either by flow over the crest during flood stages in the river or through a 72-inch diameter pipe during other periods. A slide gate controls the flow through the 72-inch conduit and is operated by remote control from the Beardsley Power Plant as well as from the gate chamber at the afterbay. The clearing for the dam site and the reservoir area was completed during the summer of 1955. During September, 1956 the excavation work was started, but was carried on rather haphazardly during that winter. The first timber was placed on February 11, 1957 and the timber crib was completed in April of that year.

BEARDSLEY AFTERBAY DAM
(Photo by Bob Hooe, Sonora)

E. Related Work

Tri-Dam Constructors were called upon to perform by change order, certain work which was necessary to complete the Project. Included in this category was the construction of a field office which was used during construction by the Project Engineer and then moved to the power house area for use as a warehouse; the construction of supports for equipment installed by the Tulloch Contractor, furnishing oils for the power plant, construction of reservoir and tailwater gauges, installation of facilities for commercial telephone service into the power house, and the construction of a guard fence along the railroad track.

The Districts made arrangements with the Pacific Gas and Electric Company to construct a stream measuring station downstream of Beardsley Afterbay. This work was completed in the fall of 1956. They also entered into an agreement with the Sonora

Wrecking Company to salvage the old railroad bridge in the reservoir area in the fall of 1957.

Three major auxiliary contracts were entered into by the Districts to complete the work at Beardsley including a contract to relocate the Pickering Railroad, a second one to relocate the Pickering camp and a third one to clear the reservoir area.

RELOCATED RAILROAD IN USE ACROSS
BEARDSLEY SPILLWAY BRIDGE
(Photo by Bob Hooe, Sonora)

The Tri-Dam Constructors were obligated to construct a new section of track across the dam and spillway to replace the old railroad line which passed by the left abutment and descended to a river crossing about two miles upstream of the dam and thence back up the right bank past the dam. A second contract was necessary to complete this relocation by constructing a new main line complete with necessary sidings on the right or north bank of the river and to connect this line to the existing line on the right bank. A contract was accordingly entered into with Harms Brothers and Andrew Gladney as that joint venture was the lower of two bidders at a bid open-

ing on May 14, 1956. This work progressed in a reasonable manner to full completion on June 14, 1957, although the work was substantially completed some time before that date. Pickering Lumber Corporation, who owned the railroad in the reservoir, wished to have heavier rail used in the new track than was in the existing line and agreed to pay the difference at a price bid by the contractor. This applied only to the section of line constructed by Harms and Gladney and not to that part installed by Tri-Dam Constructors, who later made an arrangement with Andrew Gladney to install their track as a sub-contractor. Gladney, accordingly, made an agreement with Pickering to install the heavier rail across the dam in exchange for the right to install some of the original rail in the relocated side tracks. Pickering Lumber Corporation claimed they were not aware of Gladney's position in the two jobs and it required considerable effort to straighten the matter out.

Delay in completion of rockfill portion of the dam delayed completion of the railraod across it (Tri-Dam's responsibility and not Gladney's) and Pickering would not consent to removal of the rail in the reservoir until the relocated track across the dam was fully completed. By that time, the rising storage behind Beardsley Dam inundated the railroad bridge, and prevented its salvage until the fall of 1957. By change order Harms and Gladney were given the work of salvaging the Pickering track, of installing guard rail and extending the telephone relocation across the dam, thus assuring a complete relocation and satisfaction of the Districts' agreement with Pickering Lumber Corporation.

The work of relocating the Pickering Lumber Corporation's camp was advertised for bids at the same time as the railroad work. The bids received were rejected and the work readvertised. Covington and Wolverton were low bidders when bids were opened the second time on July 12, 1956, and were awarded the contract. Notice to

Proceed was delayed until November, 1956, when Pickering had completed their use of the camp for the season. This contractor completed some work before Notice to Proceed was given, as he had decided to construct several new cabins rather than to attempt to move some of the existing cabins. It was also possible to install some of the utilities, including the camp water supply before that date. The contractor finished all required work by the first of January, 1957, after which two change orders were issued, one calling for painting of the buildings as requested by the U. S. Forest Service and the other for installation of additional sanitary facilities demanded by the Tuolumne County Public Health Office. This additional work was completed on March 15, 1957.

The third contract which was for clearing Beardsley Reservoir was awarded to Fred Teubert when, on May 14, 1956, he was the lowest of three bidders. The contractor started work in June, 1956 and made very good progress for the balance of the year. This good progress was made in those areas where machine methods could be employed but the contractor avoided performance of work where extensive hand labor was required. This was particularly true on the left bank of the river, upstream of the railroad bridge, where access was difficult. The specifications had provided for areas of priority in performance of the clearing, with the low lying areas and those in which flooding of the reservoir would make access more difficult being required to be cleared first. The area mentioned above was one of the areas of first priority. The contractor was not required to follow this schedule exactly because it was believed that he recognized the hazards inherent in the work and so long as he kept working and making good progress there was no point in upsetting his work schedule. In late April, 1957, the contractor announced that he was leaving the job to return in a few weeks when the lake was full. Because of the appearance of great masses of

debris on the surface of the reservoir, an order was issued to the contractor to return to work immediately to control the debris and protect the spillway gates from possible

DEBRIS LEFT IN HARTLEY RESERVOIR BY CONTRACTOR
(Photo by Bob Hooe, Sonora)

obstruction. This the contractor refused to do unless he was assured that he would be reimbursed for all expense. This was, obviously, a position that could not be accepted and the contractor was ordered to resume work and thereafter present any claim he might believe proper. Despite this, the contractor refused to return to work and the contract was thereupon formally terminated on May 29, 1957. District crews were assembled to control and dispose of the floating debris. The Districts did considerable work during the rest of 1957 and although they did not fully complete all work, they made arrangements satisfactory to the Federal Power Commission and the U. S. Forest Service to complete this work at the earliest possible date.

As an aftermath of the above termination of contract, Fred Teubert filed a complaint against the Districts and the Districts in turn filed a complaint against him and his sureties to reover the additional monies spent beyond that contemplated by the contract. The position of both sides was argued before a Board of Arbitration on December 2, 3 and 4, 1957. The Board decided in the Districts' favor in a decision dated March 27, 1958 and after some discussion the sureties settled the matter. The award was nearly equal to the total amount requested by the Districts and reimbursed them for nearly all expenses incurred through 1957, although it will still be necessary for the Districts to bear the expenses of full completion.

The construction of the Beardsley Unit had more complications than did either Donnells or Tulloch Units. There were several reasons for this, one being inherent in the type of the Beardsley Dam structure. While the ingredients entering into Portland cement concrete may vary somewhat, the final product is fairly uniform and its behavior can be accurately predicted. With the wide variation in earth fill materials occurring from their manner of deposition, it is necessary to have very rigid inspection, and this type of construction is also watched much more closely by the State Supervisor of Dams to insure that the structure as built conforms to the design. In addition, the close proximity of a logging operation in the form of the Pickering Railroad, and the fact that no direct control could be maintained over their operations presented some complications. The operation of this railroad was an obstacle to the dam construction, reservoir clearing and the railroad relocation. Despite the fact that the specifications required the bidders to take cognizance of such interference and required the work to be performed without interference to the railroad and camp operation, this problem was not fully measured by the bidders. This explains the reasons why the Districts' Boards of Directors listened to more discussions of the problems arising at Beardsley Unit than on the other two units combined.

CHAPTER 7

CONSTRUCTION OF TULLOCH

On October 25, 1955 The Arundel Corporation and L. E. Dixon Company as a joint venture were the lowest of three bidders for the construction of the Tulloch Unit and the raising of Goodwin Dam (Schedules V and VI). Award of contract was delayed until December 2, 1955, after the remaining $10,500,000 of bonds had been sold. A completion date of March 15, 1958, was set up in the specifications for this work and, similar to the Upper Works, the contractor was to receive any net power revenues earned prior to that date.

A. Preparatory Work

The Districts had contracted for the construction of the access road to Tulloch Dam by separate contract and this work was in progress at the time of the award to Arundel-Dixon. The rains of December, 1955 delayed this work and the road was not actually completed until February. However, the dam contractor was able to traverse this road with his equipment and thus was able to start his operations. Arundel-Dixon elected to divert the river through a diversion tunnel in the left abutment of the dam and construction of this tunnel was the first order of business. This 14 foot x 14 foot horseshoe-shaped tunnel 550 feet in length was driven in the period from January 15 to February 15, 1956.

The physical characteristics of the site allowed the contractor to locate all shops and storage areas on the left bank of the river, near the terminus of the access road. Arundel-Dixon decided to place the concrete by cableway and located a fixed tail tower on the right bank of the river with a movable head tower on the left bank, so located as to permit cableway handling to all structures. Capacity of the cableway was 25 tons and the span was 2292 feet. Aggregates were secured and processed in a

river bed pit some 10 miles downstream by road and were hauled by truck to the dam where they were stored and handled thereafter through the mixing plant.

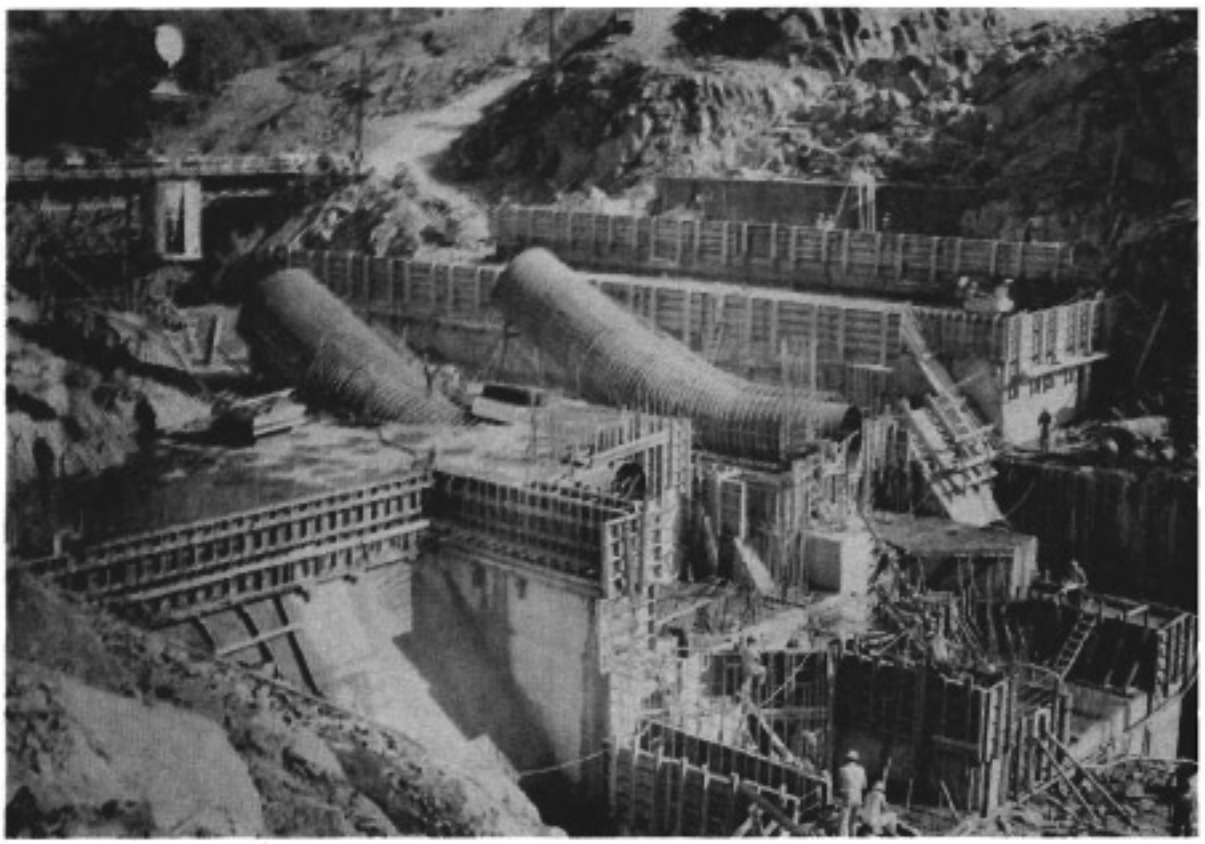
This plant was fully automatic and equipped with two four-cubic-yard mixers. The buckets were transported by railroad to the pickup point under the cableway. All of these facilities were located on the left bank of the river. Access to all parts of the job area was provided by means of a road which was constructed upstream of the dam and crossed the river on a steel girder bridge. All of this preparatory work was completed in the first several months of 1956, prior to the placement of the first concrete in the dam on August 6, 1956.

B. The Dam

Concurrently with the preparatory work described above, the contractor commenced excavation for the foundation of the dam. Initial work was on the left abutment until the river could be crossed, with work on both sides generally proceeding from the upper levels down to the river bottom.

TULLOCH RIVERBED DURING EXCAVATION
(Photo by Allen Holbrook, OID)

The common overburden was first taken off, after which the rock was excavated by conventional blasting methods and then cleaned up for inspection and acceptance. Final washing and cleanup was made just prior to placement of concrete. Work on the abutments was completed in the early months of 1956. The work in the river bottom was completed in June and July of that year following completion of the cofferdams and diversion of the river through the tunnel. The last bucket of concrete was placed on August 2, 1957, which was almost exactly one year after placement started. In that year almost 234,000 cubic yards of concrete were placed in the 39 monolithic blocks which comprise Tulloch Dam and spillway.

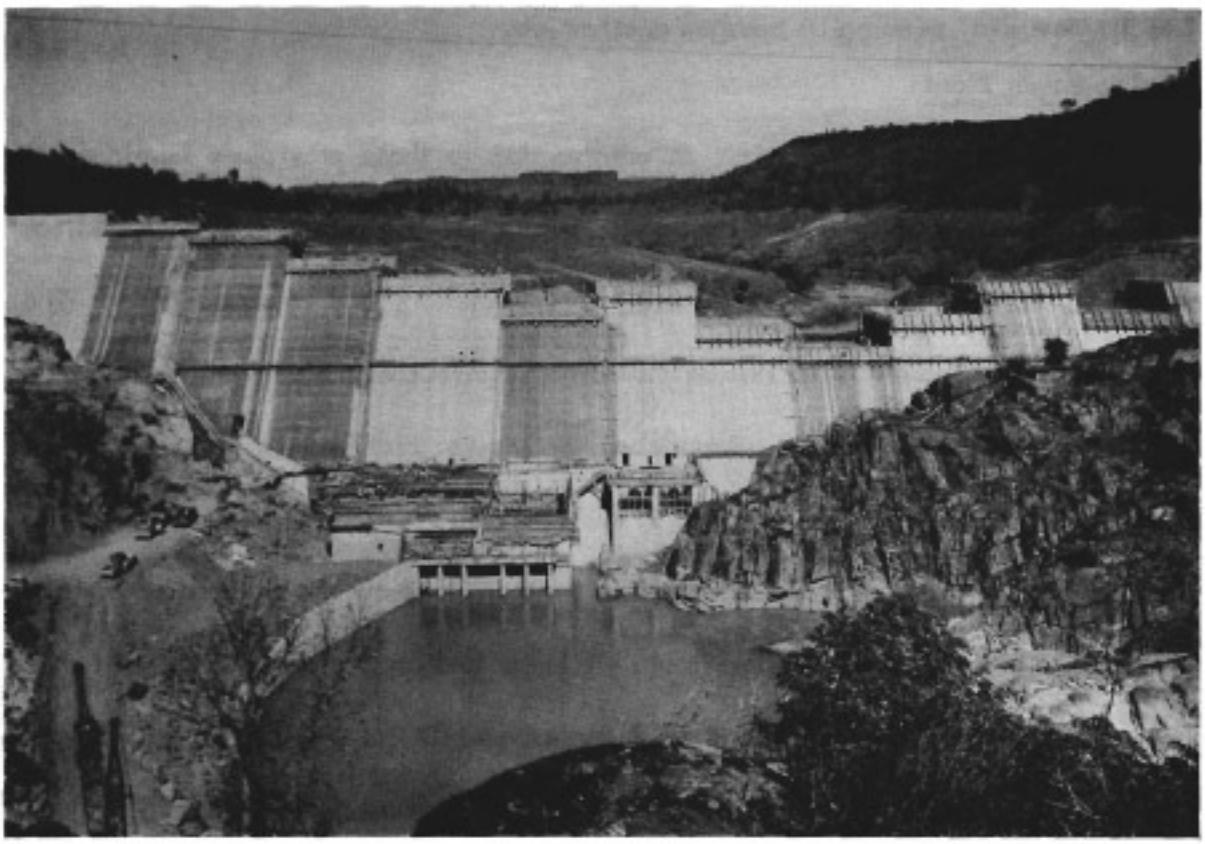


TULLOCH - DURING CONSTRUCTION
(Photo by Allen Holbrook, OID)

The spillway is located near the left end of the dam and is made up of seven overflow bays topped by tainter gates each 40 foot wide by 31 foot 4-inch high. There is also a 14 foot wide by 12 foot high vertical lift skimmer gate which can be used to

pass trash over the spillway. Below the spillway, there is an apron of concrete for a short distance and thence the discharge flows over the rock cliff back into the river. The spillway is crossed by a bridge with a special deck which accommodates the hoists needed to operate the spillway gates.

A grout curtain was provided near the upstream face of the dam. This curtain was placed from a special foundation and grouting gallery which extends through the major portion of the dam. The work proceeded simultaneously with the concrete work.



TULLOCH - DURING CONSTRUCTION
(Photo by Bob Hooe, Sonora)

Low level control of the reservoir water is provided for by means of two 72-inch diameter steel pipes which are embedded in the dam. Wheel gates at the upstream face of the dam, operated by hoists, provide a means of entirely stopping the flow in these pipes, which is normally regulated by ring jet valves at the lower end of the

pipe. Water for the power plant is provided through two 114-inch steel penstocks, also embedded in the dam. Control at the upstream end of these penstocks, is provided by means of wheel gates which are operated by hoists and the lower end of the penstocks are directly connected to the turbine scroll cases.

The contractor began dismantling his plant as soon as the concrete work was finished and essentially completed this work by the end of 1957. He did not move this equipment off the job, as he had obtained permission of the Districts to store much of it at the dam site, pending its need on another job.

C. The Power Plant

The Tulloch plant is similar in construction to those previously mentioned at Donnells and Beardsley. It is fairly massive reinforced concrete to the generator floor level, with a superstructure of structural steel framework and concrete walls. The lower levels of the power house rest on the downstream face of the dam and are fastened thereto by heavy steel dowels. Arundel-Dixon secured bids from various suppliers of power plant machinery. As a result, S. Morgan Smith Co. furnished the turbines, Elliott Company the generators, Woodward Governor Company the governors, and the General Electric Company the electrical switchgear and control equipment. All procurement work was carefully coordinated by Arundel-Dixon and so far as is known there were no delays attributable to non-receipt of vital items.

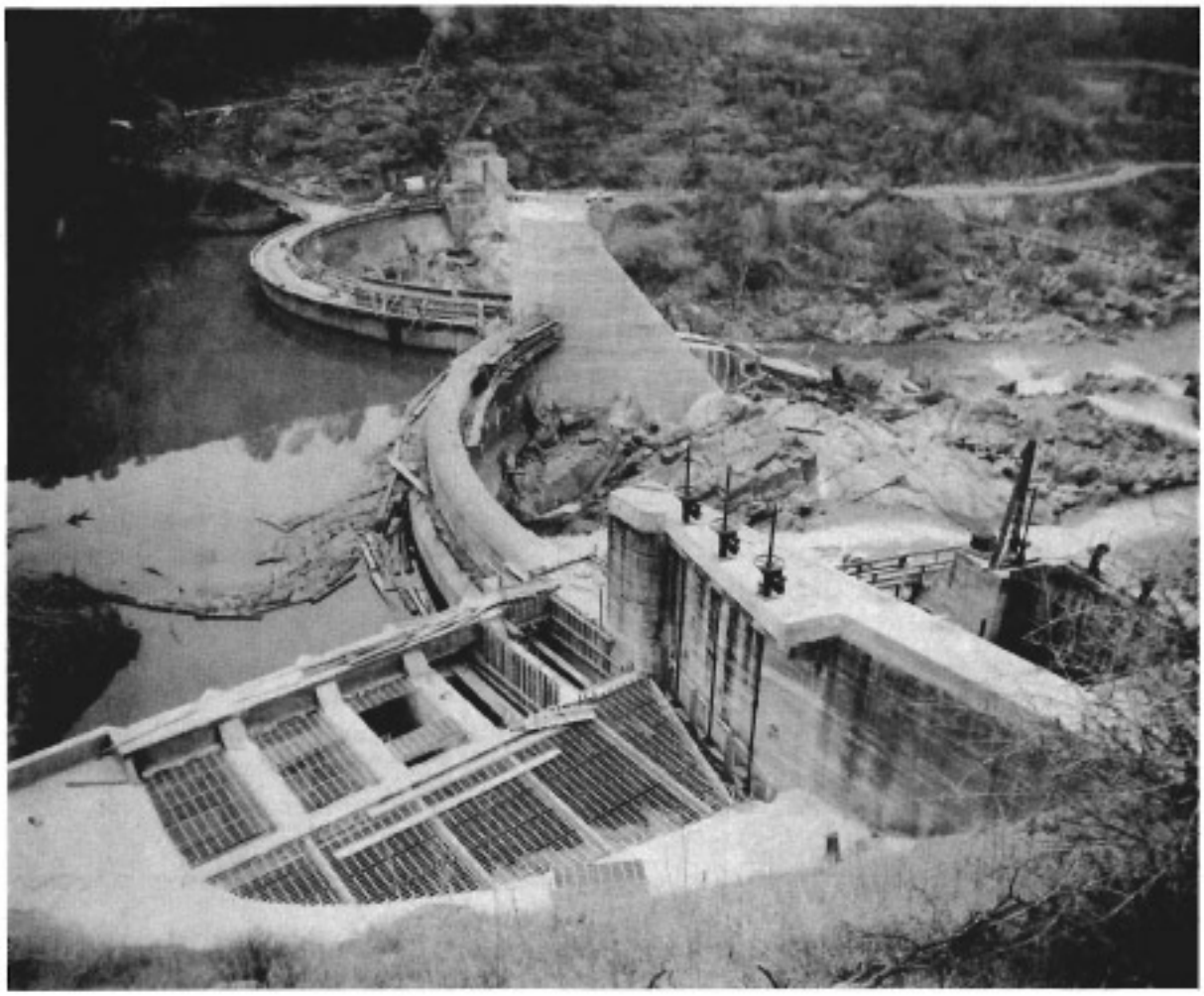
The first separate concrete pour for the power house was made on November 8, 1956 with the final roof pour on July 12, 1957. Embedment of the turbine parts was started in the spring of 1957, followed by installation of machinery, which was largely completed by the end of the year. The units were first turned over before Christmas of 1957 and the units were producing power for commercial delivery early in January, 1958. The Tulloch Unit was declared operable on February 6, 1958 by the Districts, and this date was accepted by the Pacific Gas and Electric Company.

D. Goodwin Dam

Work at Goodwin Dam involved the raising of the existing twin arch concrete dam, built in 1913, a total of seven feet. This also necessitated the placement of additional concrete in the central thrust block to support the river end of the new arch rings. The contract provided for considerable repair work on the existing gates and intake works of the Districts' canal system. It was necessary for the contractor, under the terms of the contract, to schedule the work at Goodwin Dam during the period of the year when the Districts did not require water to be diverted into their irrigation systems. Since Goodwin Dam passes flood waters over its crest, this work had to be done at a low water stage in the river which, for all practical purposes, meant that the work had to be done in the late fall and winter. Two years were provided in the specifications to complete this work, although the contractor actually only required the season of 1956. All possible work was performed during that summer, which did not interfere with passage of irrigation water. The Districts decided to entirely replace the old gates with new ones and this work was added to the contract by change order. Concrete for the dam revision was hauled from the Tulloch Plant and all work proceeded smoothly. The actual construction work was performed by the John C. Gist Co. as a sub-contractor to Arundel-Dixon.

E. Related Work

During the course of construction work by Arundel-Dixon, the Districts found it expedient for the contractor to perform certain work not included in the original contract in order to complete the Project. This extra work was provided for by change order and included some work on the access roads, construction of a permanent fence around part of the Project area, supply power plant lubricants, provision of added facilities required for the "Gibson" test, construction of a building used as a field



REVISION OF GOODWIN DAM
(Photo by Bob Hope, Sonora)

office by the Engineer during construction and which was later moved by the Districts for use as a warehouse at the power house, construction of reservoir level gauges in both Tulloch and Goodwin Reservoirs, and performance of certain maintenance work around the Project to control clearing floating debris. The contractor also installed certain additional electrical facilities at Goodwin under a change order.

There were several other smaller contracts necessary to complete the work. The clearing of the reservoir was awarded to three different contractors in four different sections. This work proceeded without particular incident from time of award in the

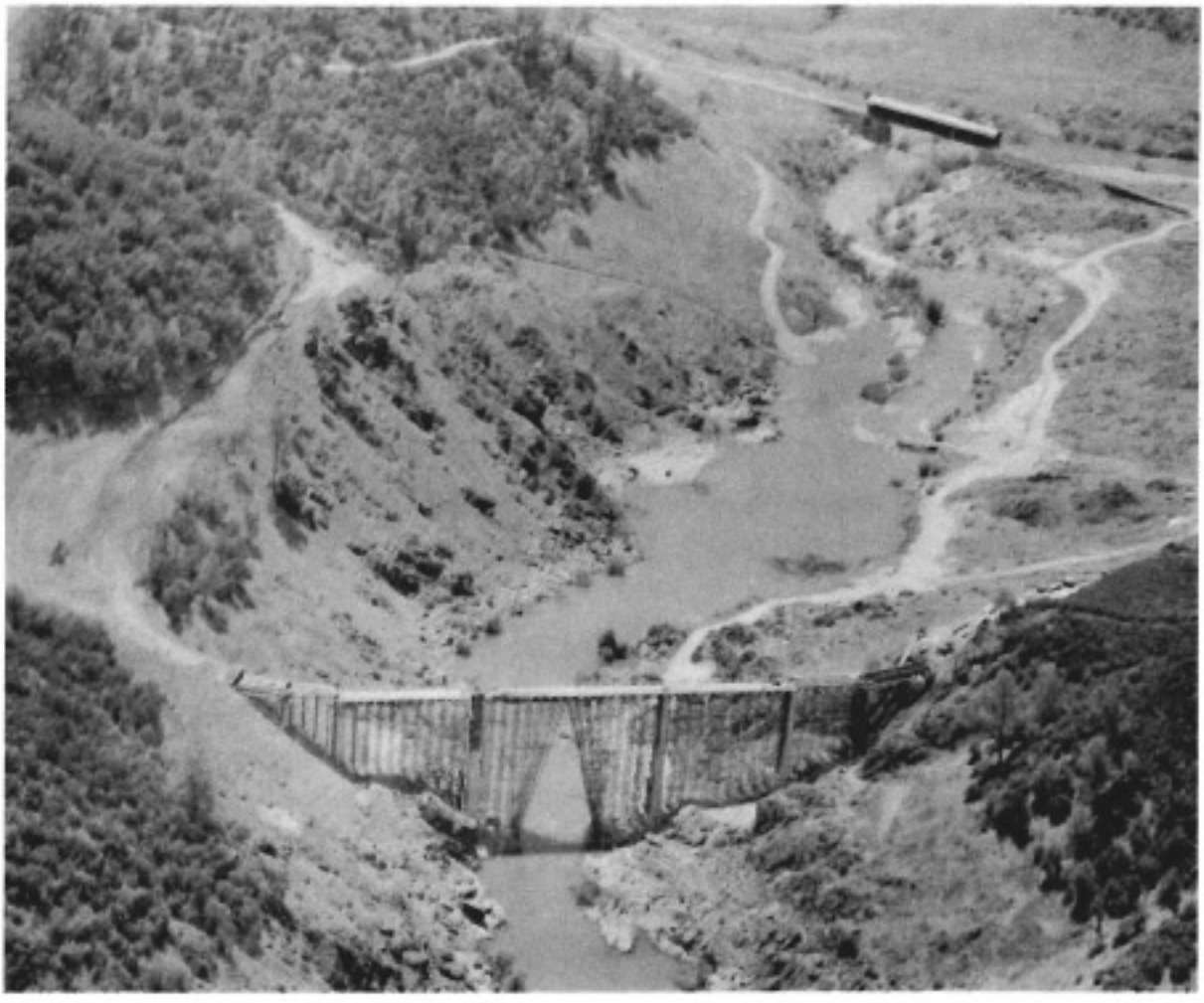
summer of 1956 to completion in the spring of 1957. Those having contracts were:

Area 1 - LeRoy E. Allison
Area 2 - Craft and Galbraith
Area 3 - Archie Till
Area 4 - Craft and Galbraith

It was also necessary to relocate the county road which crossed the river in the reservoir area over the O'Bryne ferry bridge. After considerable negotiation with Calaveras County on the right bank of the river and Tuolumne County on the left bank, it was decided to replace the old, obsolete single-lane timber bridge with a modern two-lane concrete bridge and the counties agreed to participate in the cost of this improvement. Thomas Construction Company was awarded the work based on his low bid received at a bid opening held on January 11, 1957. The contractor prosecuted the work with diligence and without undue incident except for a freak windstorm in July, 1957 which did considerable damage when the supporting falsework was blown down. Although this forced a delay, the work was completed in December, 1957. Traffic used the new bridge prior to that time, after the site of the original bridge had been inundated by the rising waters of Tulloch reservoir. The old bridge remained the property of the counties and was sold at public auction to private citizens, who were not permitted to remove it until such time as the new bridge had been opened to traffic.

Through arrangements made with the Pacific Gas and Electric Company, the crews of that company installed a gauging station below Goodwin Dam. This and the other stations made it possible to obtain complete water records throughout the Tri-Dam Project. This work was completed in December, 1956 and in January of 1957.

The Districts also organized crews and directed the work of construction of a house for the caretaker at Tulloch Dam. This house was constructed during 1958 on the left bank, above the dam.



NEW AND OLD BRIDGE AT O'BYRNE FERRY
(Poker Flat of Bret Harte Fame)
(Photo by Bob Hooe, Sonora)

F. Summary of the Tulloch Construction

Arundel-Dixon very carefully and soundly planned in advance for construction of the Tulloch Unit. Time schedules were adhered to almost to the day, in the case of the start and completion of concrete placement in the dam. The specifications provided ample time to do the work and the contractor accomplished the construction with a minimum of overtime. The work progressed steadily on five-day per week, eight-hour per day basis, except at the peak of concrete placement during October, 1956 and March, 1957 when the contractor placed concrete on two shifts.

Arundel-Dixon had several reasons for this relatively leisurely procedure which was not possible insofar as the construction of the Upper Works was concerned. The amount of power revenue which was available under early completion power payments was much less than was the case on the Upper Works. Tulloch Dam was near to a large labor supply, weather conditions and access were much better, and there was no necessity of providing inducement, in the form of greater take-home pay, to attract workers to the job. At the Upper Works, and in particular at Donnells, it took some such inducement to attract workmen to the area where housing was scarce and living somewhat difficult in the winter months.

CHAPTER 8

COST OF THE TRI-DAM PROJECT

From the standpoint of construction, the Tri-Dam Project was one of considerable magnitude and great interest to construction men.

The construction of Donnells Dam, in an extremely rugged area, with difficult access, was the most spectacular. Before construction, there was much discussion about the excavation of the buried channel below streambed and the difficulties that would be encountered in this work from water flowing into the deep excavation. As has been noted, the water was a minor problem but work on the bold granite cliffs above the river was a major accomplishment. The construction of the thin-arch concrete dam in the narrow canyon was spectacular. In point of overall height, Donnells Dam ranks as No. 10 in the list of the highest dams in the United States.

Donnells Tunnel was also the subject of a great amount of discussion before the construction stage was reached. The principal topic was relative to the quality of rock which would be encountered and how much length of tunnel would have to be lined with concrete to support the surrounding rock. The Stanislaus Tunnel, of the Pacific Gas and Electric Company, was located in the close vicinity but at a lower elevation. Mr. O. W. Peterson, a member of the Districts' Board of Consulting Engineers, had been in charge of the Stanislaus Tunnel driving and of course was very familiar with it. As a result, he concurred with the Engineers' opinion that Donnells Tunnel would not require major lengths of concrete lining and after some study the bidding schedule quantity was set at 2575 feet. Actually, 2461 feet of lining was required, a very close check of the estimate and proof of the excellent character of the rock encountered.

Neither Beardsley or Tulloch Units were particularly spectacular in their construc-

tion, but were structures of magnitude. Beardsley Dam ranks as No. 38 in the list of the highest dams in the United States, but Tulloch is well down the list. As has been noted, Beardsley Unit was the most difficult to construct and encountered the most trouble. Tulloch Dam was essentially a clean-cut structure, well located to take advantage of the best foundation rock available at the site and with few problems during its construction.

Actually, the Tri-Dam Project consisted of three major dams and power plants and two minor dams for a total of five. The construction of these structures was a major task and involved the following quantities of work:

2,768,600 cu. yds. of all classes of open cut excavation

281,900 cu. yds. of tunnel and shaft excavation

3,284,300 cu. yds. of embankments

504,700 cu. yds. of concrete in major structures

7,200 cu. yds. of concrete in minor structures

512,400 barrels of cement

5,979,100 lbs. of reinforcing steel

5,343,500 lbs. of structural steel

675,600 FBM of structural timber

2,328 acres of cleaning

A. Funds Available for Performance of the Work

As previously noted, the two bond issues totaled $52,000,000 which with other miscellaneous receipts provided an estimated $53,767,884 made up as follows:

Bond Principal	$52,000,000
Premium on Bond Sale	204,850
Accrued Interest at time of Bond Sale	66,846
Interest earned on Unexpended Balance during Construction	1,268,858
Power earnings - Tulloch - March 15 - December 15, 1959	227,330
TOTAL	$53,767,884

B. Funds Expended

The money expended for completion of the Tri-Dam Project, based on the Districts' December 31, 1958 statement and rounded to the nearest thousand dollars, was:

Contract Work (amplified below)	$42,980,000
Engineering Service	2,813,000
Land Acquisition & Protection	203,000
Housing & Buildings	104,000
Fees & Special Services	592,000
Administrative Costs	168,000
Not segregated (add't to construction cost)	166,000
SUB-TOTAL	$47,026,000

In addition, it was necessary to provide reserve funds of $6,323,750 which included:

Interest during Construction - Initial Sale	$ 5,063,000
Interest during Construction - 2nd Sale	800,625
Interest during Construction - Reserve	160,125*
Maintenance Fund	200,000
Operation Fund	100,000
Sub-Total reserve funds	$ 6,323,750
TOTAL EXPENDITURES	$53,349,750

*This reserve was not used. Together with interest of $12,205 it is available for return to the Districts.

This statement, including return of the reserve, indicates a probable balance of about $590,000 which will be returned to the two Districts to partially defray expenses incurred in the early stages of the Project. There are, however, obligations which may entail additional expenditures of approximately $150,000 against this probable balance.

C. Construction Costs

The following tabulation shows the final construction cost for the various schedules of work performed under contract:

Schedule	Original Bid	Final Cost	Change	% of Change
I-Donnells Dam	$ 9,525,630.00	$ 9,905,111.54	$ 379,481.54	+3.98
II-Donnells Tunnel	8,519,370.00	8,569,888.90	50,518.90	+ .59
III-Donnells Power House	3,370,000.00	3,464,186.90	94,186.90	+2.79
Total Donnells	$21,415,000.00	$21,939,187.34	$ 524,187.34	+2.45
IV-Beardsley	9,784,850.00	10,810,502.19	1,025,652.19	+10.5
Total Upper Works	$31,199,850.00	$32,749,689.53	$1,549,839.53	+4.97
V-Tulloch Dam & Power House	$ 8,052,630.00	$ 7,998,212.48	$ -54,417.52	-0.68
VI-Goodwin	238,797.50	312,872.39	74,074.89	+31.0
Total Tulloch	$ 8,291,427.50	$ 8,311,084.87	$ 19,657.37	+0.24

MISCELLANEOUS CONTRACTS

	Original Bid	Final Cost	Change	% of Change
Tulloch Road	$ 80,740.00	$ 114,173.00	$ 33,433.00	+41.1
Beardsley Railroad	342,727.90	418,360.07	75,632.17	+22.1
Beardsley Camp	30,888.00	32,686.00	1,798.00	+5.82
Donnells Clearing	592,000.00	592,000.00	--	--
Beardsley Clearing	118,404.00	118,404.00	--	--
Tulloch Clearing Area 1	59,946.90	59,946.90	--	--
Area 2	38,600.00	39,100.00	500.00	+1.30
Area 3	37,850.00	39,170.00	1,320.00	+3.49
Area 4	7,500.00	7,500.00	--	--
O'Byrne Bridge Replacement	458,355.00	461,242.19	2,887.19	+0.63
Operator's House Donnells Dam	18,995.90	19,444.90	449.00	+2.36
Operator's House Donnells Power House	16,462.00	17,006.00	544.00	+3.30
Total of Misc. Contracts	$1,802, 469.70	$1,919, 033.06	$ 11,563.36	+6.47
Grand Total of Contracts	$41,293,747.20	$42,979,807.46	$1,686,060.26	+4.08

D. Expenditures by Months

The following sums were expended monthly:

Month & Year		Total Spent in Month
July	1955	$ 582,000
August	"	1,026,000
September	"	676,000
October	"	587,000
November	"	584,000
December	"	1,767,000
January	1956	1,055,000
February	"	1,218,000
March	"	1,687,000
April	"	1,726,000
May	"	1,954,000
June	"	2,031,000
July	"	1,950,000
August	"	2,234,000
September	"	2,610,000
October	"	2,596,000
November	"	2,618,000
December	"	3,167,000
January	1957	2,341,000
February	"	2,211,000
March	"	2,328,000
April	"	2,292,000
May	"	1,594,000
June	"	1,122,000
July	"	553,000
August	"	459,000
September	"	441,000
October	"	240,000
November	"	1,696,000
December	"	139,000
January	1958	96,000
February	"	66,000
March	"	101,000
April	"	58,000
May	"	499,000
June	"	658,000
	TOTAL	$46,962,000

It is apparent that construction of the Tri-Dam Project was "Big Business" with expenditures averaging almost $1,700,000 per month.

CHAPTER 9

POWER PLANT OPERATION

Tudor-Goodenough Engineers, through a cooperative agreement with the Districts, employed the man who was selected to become the Districts' Chief Operator in September, 1956. Tudor-Goodenough Engineers employed him as an electrical-mechanical inspector, until the first power was produced at Beardsley in May, 1957. During that period he not only provided the Project Engineer with skilled, technical assistance in this difficult phase of construction, but himself gained invaluable knowledge of the plants. The Power Manager was added to the staff of the Project Engineer as a special assistant in January, 1957 and spent a considerable portion of the time perfecting his organizational plans and operating procedures. The Districts' crews were built up as the need developed and, except in the break-in period when two or more units were running simultaneously, the Districts had an adequate staff to operate the plants. In the exceptional case mentioned, the Power Manager, through his contacts with the Pacific Gas and Electric Company, was able to recruit help from the operators of that company, who arranged for their vacations at that time and went on the Districts' payroll as temporary employees.

Operating personnel were also of great assistance during the final testing program when the turbine and generator efficiency tests were performed.

The Tri-Dam Project was designed and built to function with the Beardsley Plant as the center of operations. That plant is always attended by a skilled operator and the maintenance crew is headquartered there. The Donnells and Tulloch Plants function with one trained attendant, who works a forty-hour week, subject to call in emergency. The attendant is housed near the plant, so as to be available if needed. To provide remote control of these outlying plants, it was necessary to construct an

elaborate communication and control system. This is accomplished by use of the Pacific Gas and Electric Company's transmission system coupled to carrier system electrical apparatus which enables the operator at Beardsley to know how the other plants are operating and to control them as may be necessary. An extensive communication system permits contact with any telephone outlet on the system, as well as the Pacific Gas and Electric Company's Spring Gap Power Plant.

At the time of this report, the plants of the Upper Works have been in operation for 1-1/2 years, and the Tulloch plant for nearly a year, and all have been in Operable Status, as defined by the Tri-Dam Project Contract, for almost a year. During that period, the plants have operated very satisfactorily, which reflects to the credit of the Districts and the care taken during the planning, design, and construction stages to insure first-class plants.

CHAPTER 10

CONCLUSION

The construction of the Tri-Dam Project was effectively completed at the time the power plants were accepted as capable of continuous operation by the Pacific Gas and Electric Company. This was January 1, 1958 in the case of Donnells and Beardsley and on February 6, 1958 in the case of Tulloch. On this latter date, the Districts had fulfilled all of their obligations to the Pacific Gas and Electric Company under the terms of the Tri-Dam Project Contract and the Project had attained "Fully Operable Status". Although there were a few minor deficiencies left to correct, none of these had any overall bearing on the capabilities of the several plants and they were all corrected in a timely and orderly manner by the operating forces of the Districts. As of February 7, 1958, construction ceased and operation and maintenance began, without the overlapping which had been present prior to that time.

DEDICATION CEREMONY
R. E. HARTLEY RECEIVING PLAQUE
(Photo by Bob Hooe, Sonora)

The formal dedication of the Tri-Dam Project took place on June 15, 1957, at Beardsley Power Plant, at which time the two upper plants were producing power and both reservoirs were full. The principal speakers at that ceremony were Norman R. Sutherland, President of the Pacific Gas and Electric Company and Harvey O. Banks, Director of the Division of Water Resources for the State of California. Both of these prominent men praised the vision and courage of the Districts' Boards of Directors in carrying this project through to completion. Also, at an appropriate time in the ceremony, Chief Engineer R. E. Hartley of the Oakdale Irrigation District was honored by having the Beardsley Reservoir renamed Hartley Lake. Although there are many others deserving of similar recognition, they consider the honoring of Mr. Hartley as a combined honor to all the men of courage and vision who had a part in the investigation and construction of the Tri-Dam Project.