EOLOGICAL SURVEY CIRCULAR 85

December 1950

SOME RESERVOIR SITES IN THE SIERRA NEVADA, CALIFORNIA

By

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WASHINGTON, D. C.

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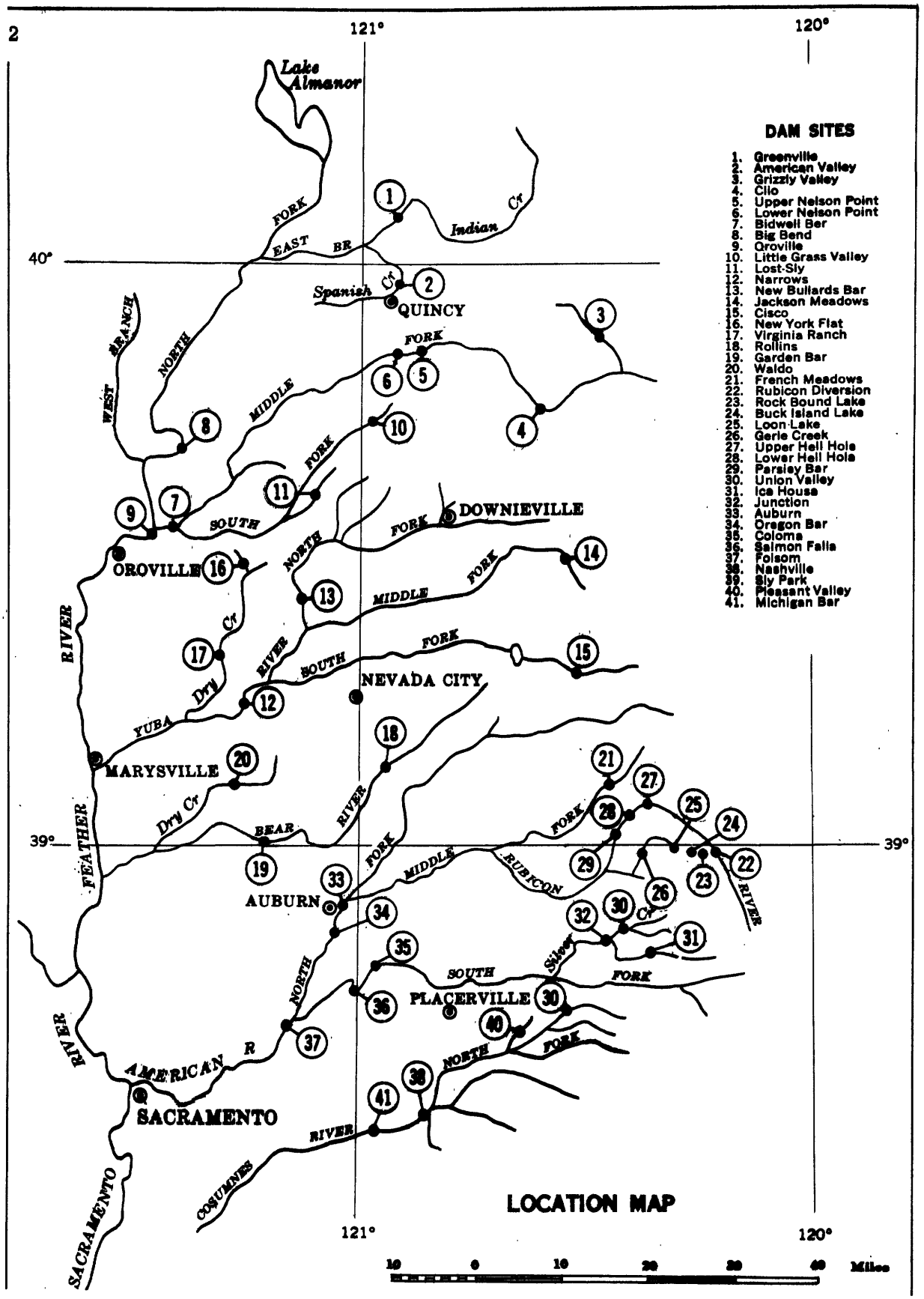
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INTRODUCTION

The following summary reports were prepared to provide the basis for the review of the classification of public lands within a group of reservoir sites, most of which were mapped recently by the Bureau of Reclamation. These sites are in foothill and headwater areas of several streams from the Feather River to the Cosumnes River, California.

The reports give brief summaries of proposals for use of the sites and information that is readily available as to potential storage capacities, water supplies, and power and irrigation possibilities. Recent applications to the State of California for appropriation of waters at several of the sites are listed.

These reports were prepared in the Water and Power Branch of the Conservation Division of the Geological Survey under the direction of H. J. Duncan, chief of the division, and B. E. Jones, chief of the branch. The Sacramento regional office of the Bureau of Reclamation; the Sacramento district office, Corps of Engineers; the San Francisco regional office, Federal Power Commission; and the Division of Water Resources, State of California, contributed reviews of material referring to the investigations and conclusions of the several agencies. Copies of reservoir-site maps were furnished by the Bureau of Reclamation and the Corps of Engineers, and information about current investigations was furnished by all the agencies. Thanks are due to the San Francisco office, Geological Survey, for reviewing the material relating to gaging stations and the records of runoff.

Many helpful suggestions were contributed by engineers of the Water and Power Branch in the preparation of these reports.

FEATHER RIVER DRAINAGE BASIN

Greenville (Indian Valley) reservoir site, Indian Creek

This site is between the altitudes of 3,450 and 3,600 feet along Indian Creek, a tributary of the East Branch of the North Fork Feather River. The dam site now under consideration is approximately in the east half of sec. 34, T. 26 N., R. 9 E., Mount Diablo base line and meridian. 1/ The proposed reservoir would flood more than 20 square miles of land, including several small towns, a railroad, and highways.

The site was described by F. E. Bonner in his report on "Water powers of California" (1928). The potential storage capacity was listed as 688,000 acre-feet with a 120-foot dam. It was pointed out that 500 feet of head could be developed by 3 miles of tunnel immediately below the dam. The controlled flow, plus the unregulated runoff of Spanish Creek, could then be diverted from Indian Creek through an 8-mile tunnel to the afterbay of the Caribou powerhouse on the North Fork Feather River for utilization in downstream plants. The maximum-flowage line was shown as 3,570 feet, and the altitude of the stream bed as 3,450 feet. Bonner did not list this project in his summation of potential powers of the Feather River because of uncertainty as to feasibility.

The Division of Water Resources, State of California, investigated the Greenville (Indian Valley) site, but it was not included in the State water plan as described in State Bulletin 26. According to the State investigators, a dam 140 feet high, the maximum considered, would flood 13,250 acres of land and create a reservoir capacity of 688,000 acre-feet. This is the same potential capacity listed by Bonner. It was estimated that the annual irrigation yield of the Feather River at Oroville would be increased nearly 500,000 acre-feet by the Greenville reservoir with a capacity of 688,000 acre-feet. (In a State review of a Bureau of Reclamation proposal for the Greenville site, it was mentioned that the site was first investigated by the U. S. Reclamation Service in 1905 and has been studied by the California Debris Commission and the Federal Power Commission.)

The Bureau of Reclamation listed the Greenville Reservoir as a major prospective reservoir in the plan for development of the Central Valley as described in the Department of the Interior report of November 1945. (This report, and reviews by State and Federal agencies, were published as Senate Document 113, 81st Congress, 1st session.) The potential capacity was listed as 833,000 acre-feet; the dead storage as 80,000 acre-feet; the maximum-flowage line as 3,590 feet; and the altitude of the stream bed as 3,440 feet. It was pointed out that the reservoir would be valuable for holding water from wet periods to dry periods and that releases would increase the power output in prospective single-purpose developments on the North Fork Feather River.

The State of California, commenting on the Bureau of Reclamation proposal in a review dated April 1946, concluded that the project is feasible from an engineering standpoint but that indicated data are not available to permit comment on the economic feasibility. The cost estimate ($8,500,000 for dam and reservoir, based on January 1940 prices) was judged to be low.

The Federal Power Commission, San Francisco office, commenting on the power feature of the Bureau proposal, concluded that the project probably is economically feasible but that considerable further investigation is needed. The potential power revenues were considered as being limited to those resulting from additional energy and capacity that could be produced at proposed plants 4, 5, and 6 of the Pacific Gas & Electric Co. on the North Fork Feather River because of better regulation. The annual irrigation yield was estimated as 144,000 acre-feet. It was pointed out that flowage costs, estimated as $4,800,000, constitute a serious drawback to the construction of this reservoir (report, not for release, dated January 1946).

A gaging station, Indian Creek near Crescent Mills, was operated at the lower end of the site from January 1906 to December 1909 and from September 1911 to March 1918. It has also been in operation from October 1930 to date. The average discharge for 24 years of complete record to September 30, 1945, was 534 second-feet. This corresponds to a mean annual runoff of 385,000 acre-feet. The average annual runoff for the 6 water years 1929-34 was about 150,000 acre-feet (partly estimated). There are some irriga-

1 The same base line and meridian apply to all land descriptions herein.

In view of the low period 1929-34, it seems unlikely that the dependable irrigation yield of the Feather River could be increased nearly 500,000 acre-feet per year by the Greenville reservoir, as was estimated by the State investigators. The contemplated capacities of 688,000 acre-feet or 833,000 acre-feet are more than would be needed for independent regulation of Indian Creek runoff in a critical period like that from 1929 to 1934. Evidently it is planned to use this reservoir for stand-by purposes and for coordinated operation with other Feather River reservoirs. The releases with such operation probably would be too irregular to justify development of power from Indian Creek water directly, as was contemplated by Bonner.

The Bureau of Reclamation obtained a map of the Greenville site (Fairchild Aerial Surveys, May 1946) showing the topography generally to an altitude of 3,600 feet. An assembled edition of the map is printed on a scale of 1:24,000, and the contour interval is 10 feet. The NW. corner of sec. 1 and the NE. corner of sec. 24, T. 26 N., R. 9 E.; the SW. corner of sec. 15, the SE. corner of sec. 14, and the NW. corner of sec. 4, T. 26 N., R. 10 E., are shown as having been found. Corners of the quarter sections at the W. boundary of sec. 28, the N. boundary of sec. 2, and the S. boundary of sec. 4, T. 26 N., R. 10 E., also are shown as found. For the purpose of listing land status, approximate locations in the reservoir area were determined by reference to these corners and the land net shown on a 1938 map of Plumas National Forest. The land net and topography as shown on this map match the found corners and topography of the reservoir-site map reasonably well.

The potential maximum-flowage line was assumed to be at the 3,600-foot contour, and tentative land classifications were made accordingly.

American Valley reservoir site, Spanish Creek

The American Valley reservoir site is between the altitudes of 3,380 and 3,640 feet along Spanish Creek, a tributary of the East Branch of the North Fork Feather River. The dam site under consideration is in the north half of sec. 6, T. 24 N., R. 10 E. A saddle dam would be required in sec. 35, T. 25 N., R. 9 E., for storage above an altitude of 3,440 feet.

The reservoir site covers a relatively broad area near the confluence of Spanish Creek and its tributary Spring Garden Creek (called Greenhorn Creek on the Forest Service map of Plumas National Forest). The site is crossed by a State highway and by tracks of the Western Pacific Railroad. The town of Quincy, county seat of Plumas County, is within the site between the altitudes of 3,410 and 3,500 feet.

F. E. Bonner, in "Water powers of California" (1928), reported that there are no favorable opportunities for power development on Spanish Creek, and he did not list any storage sites on this stream. In connection with possibilities for power development along the East Branch of the North Fork, he called attention to the fact that the Western Pacific Railroad in that canyon has a uniform, compensated gradient of 1 percent, the controlling maximum, and that, therefore, it could not be adjusted. In approximately 9 miles, up Spanish Creek to American Valley, the railroad climbs 420 feet to an altitude of 3,500 feet at the dam site, and 3 miles farther, near the upper end of the reservoir site, the railroad is above an altitude of 3,650 feet. The contemplated maximum-flowage line at the American Valley site apparently is at 3,640 feet.

The American Valley site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources. This bulletin also listed a site upstream on Spanish Creek, in sec. 13, T. 24 N., R. 8 E.

The Bureau of Reclamation obtained a map of the American Valley reservoir site (Fairchild Aerial Surveys, May 1946) showing the topography generally to an altitude of 3,640 feet and higher at the two dam sites. An assembled edition of the map was printed on a scale of 1:24,000, and the contour interval is 10 feet. The apparent location of the main dam site on Spanish Creek is in the NW¼ sec. 6, T. 24 N., R. 10 E. The altitude of the stream in this section is 3,380 feet. The width of the canyon at an altitude of 3,640 feet is 1,100 feet. A saddle dam would be required in the north half of sec. 35, T. 25 N., R. 9 E. The width of the gap at an altitude of 3,640 feet is 2,000 feet, and the altitude on the ground at the top of the saddle apparently is less than 3,450 feet. (It is shown as above the 3,500-foot contour on the Geological Survey map of the Downieville quadrangle.) The saddle is crossed by highways and a railroad line.

Rough determinations from the Bureau map indicate that areas flooded on the reservoir site would be as follows: 1,070 acres at 3,400 feet; 4,000 acres at 3,450 feet; and 6,160 acres at 3,500 feet. Additional flooded area above 3,500 feet would be relatively small. It appears from these figures that the potential capacity below an altitude of 3,400 feet probably is less than 10,000 acre-feet. The potential capacity between the altitudes of 3,400 and 3,450 feet may be more than 100,000 acre-feet, and between 3,450 and 3,500 feet more than 200,000 acre-feet. The town of Quincy would be largely flooded at an altitude of 3,430 feet.

Discharge records have been obtained, since 1913, for Spanish Creek near Keddie, a few miles downstream from the American Valley site. The gage was moved in 1933; the drainage area at the original gage was 196 square miles, and at the present gage it is 184 square miles. The average discharge for the 12 years 1933-45 was 260 second-feet, corresponding to an average of 188,000 acre-feet per year. The dependable yield of Spanish Creek might be limited by critical periods such as that from 1929 to 1934, when the average annual runoff for the 6 years was only 96,000 acre-feet. It is judged that a storage capacity of 150,000 acre-feet would provide for substantial regulation through such periods. If a much larger capacity is contemplated, it perhaps would be for stand-by purposes so as to provide for heavy release in very dry years.

In listing the status of lands and tentative classifications based on the Bureau of Reclamation map, it was assumed that the entire area to an altitude of 3,640 feet might be utilized. In view of the probable high cost of highway, town, and railroad relocations this possibility seems very doubtful. A substantial storage capacity could be developed below an altitude of 3,450 feet, probably without relocation of the main-line railroad and with only a small saddle dam in sec. 35, T. 25

N., R. 9 E. However, a reservoir with a capacity of much more than 20,000 acre-feet would flood the main business section of Quincy.

No land lines were shown on the reservoir-site map. The SE. corner of sec. 1, T. 24 N., R. 9 E.; the SW. corner of sec. 15, T. 24 N., R. 10 E.; the SE. corner of sec. 11 and the SE. corner of sec. 12, T. 24 N., R. 8 E., are shown as found. Locations of lands in the area were approximately determined by reference to the found corners and the land net shown on the Forest Service map of Plumas National Forest.

Grizzly Valley reservoir site, Grizzly Creek

The Grizzly Valley reservoir site is between the altitudes of 5,640 and 5,800 feet along Grizzly Creek, a tributary of the Middle Fork Feather River. The dam site now under consideration is near the south boundary of sec. 1, T. 23 N., R. 13 E. There is another possible site for a low dam in the NE¼ sec. 2, at a stream altitude of 5,710.

F. E. Bonner, in "Water powers of California" (1928), suggested this site for the storage of 92,000 acre-feet for power purposes. Storage was shown on the profile as between the altitudes of 5,595 feet and 5,708 feet. An additional storage capacity of 130,000 acre-feet at the proposed Clio reservoir and 116,000 acre-feet at the proposed Nelson Point reservoir on the Middle Fork Feather River would provide for substantial control of the runoff. Power would be developed in six stages from a headwater altitude of 4,030 feet at Nelson Point to a stream altitude of 160 feet on Feather River.

The Bureau of Reclamation obtained a map of the reservoir site (Fairchild Aerial Surveys, May 1946) showing the topography generally to an altitude of 5,800 feet and, at the lower dam site, to an altitude of 5,960 feet. An assembled edition of the map is printed on a scale of 1:12,000, and the contour interval is 10 feet.

The Geological Survey obtained discharge records of Grizzly Creek below the reservoir site for the water years 1926-32. The gage was in the NE¼ sec. 12, T. 23 N., R. 13 E., at an altitude of about 5,500 feet. It was described as being 1½ miles below the Grizzly Valley reservoir site. This would point to a dam site near the north boundary of the township. Judging from a map of the site obtained by the Bureau of Reclamation in 1946, the topography is favorable for a dam at this location to an altitude of 5,750 feet and possibly, with a long saddle dam, to 5,770 feet. The stream bed is at an altitude of about 5,710 feet, but water at an altitude of 5,750 feet would cover a considerable area upstream. The Bureau map shows a possible dam site near the south boundary of sec. 1, T. 23 N., R. 13 E., where the topography is favorable for storage to an altitude of 5,800 feet, the top contour of the reservoir-site map. The stream altitude at this section is 5,640 feet. (If the Bureau map is correct, it appears that Bonner's altitudes for the proposed reservoir are possibly 50 feet too low.)

A Grizzly Valley site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources. The location was given as sec. 2, T. 23 N., R. 13 E.

As roughly determined from the reservoir-site map, the areas enclosed by the 5,800-, 5,770-, 5,750-, and 5,720-foot contours are 6,500, 3,600, 1,400, and 160 acres, respectively. It is judged that the potential capacity at a pool altitude of 5,800 feet would be more than 200,000 acre-feet.

The drainage area at the former gaging station was listed as 45 square miles. The average annual runoff from 1926 to 1932 was about 20,000 acre-feet. Runoff in the water year 1931 was only 5,600 acre-feet, and in 1929 only 6,700 acre-feet. The greatest runoff was 38,600 acre-feet in 1927.

Since there appear to be no favorable possibilities for diversions into the site from other sources, it is judged that the full potential capacity to an altitude of 5,800 feet could not be used advantageously even with long hold-over operation. It seems likely that adequate regulation of the small Grizzly Creek runoff could be obtained in the prospective Clio reservoir if this proves feasible.

Status of lands and tentative classifications were based on the Bureau of Reclamation map, with an assumed flowage line at 5,800 feet and with a dam site near the south boundary of section 1. The SW. corner of sec. 19 and the NE. corner of sec. 20, T. 24 N., R. 13 E.; and the quarter-section corner at the W. boundary of sec. 2, T. 23 N., R. 13 E., were shown on the reservoir-site map as found corners. The approximate location of lands was determined on the basis of the location of these corners and the land net shown on a topographic map of the Plumas National Forest published in 1938.

Clio reservoir site, Middle Fork Feather River

The Clio reservoir site is between the altitudes of 4,370 feet and 4,540 feet along the Middle Fork Feather River. The dam site is in the north half of sec. 26, T. 22 N., R. 12 E. The site includes the town of Clio and is crossed by a State highway.

F. E. Bonner, in "Water powers of California" (1928), listed the Clio site as having a potential storage capacity of 130,000 acre-feet between the altitudes of 4,358 feet and 4,500 feet. He reported that with the proposed Grizzly Valley and Nelson Point reservoirs this would provide substantial control for cyclic regulation of the upper Middle Fork for power development downstream from Nelson Point.

The Clio reservoir site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources.

A map of the site obtained by the Bureau of Reclamation (Fairchild Aerial Surveys, 1946) shows the topography to an altitude of 4,540 feet. An assembled edition is on a scale of 1:12,000, and the contour interval is 10 feet. The 4,540-foot contour is just below the grade of the Western Pacific Railroad at the dam site. At an altitude of 4,540 feet the valley width at the dam site is 4,400 feet. The width at an altitude of 4,500 feet is 2,200 feet. The altitude of the stream at the dam site is shown as 4,370 feet.

Reservoir areas and capacities, roughly determined from the Bureau of Reclamation map, are as follows:

Altitude (feet)	Area (acres)	Capacity (acre-feet)
4,370	0	0
4,400	250	3,000
4,450	1,200	40,000
4,500	2,500	130,000
4,540	3,400	240,000

A gaging station has been operated on the Middle Fork in sec. 23, T. 22 N., R. 12 E., just below the dam site, since 1925. The drainage area is 699 square miles at this place. The average discharge for the 20 years ending September 30, 1945, was 257 second-feet, corresponding to an average annual runoff of 185,000 acre-feet. The dependable yield perhaps would be limited by critical periods such as the six water years 1929-34, when the average annual runoff was only 95,000 acre-feet. It is judged that a storage capacity of 130,000 acre-feet might be sufficient for cyclic operation through similar periods.

For the listing of land status and tentative classifications it was assumed that the maximum-flowage line might be at an altitude of 4,540 feet. The Bureau of Reclamation map of the reservoir sites does not show land lines or found corners. Most of the site is shown on a recent planimetric map of the Sierra City quadrangle made by the Forest Service. The location of lands on the reservoir-site map was approximately determined by reference to the land net shown on the Forest Service map, as related to topographic features.

Nelson Point reservoir site, Middle Fork Feather River

There are at least two possible sites for storage along the Middle Fork Feather River near Nelson Point. One lies between the altitudes of 3,720 and 4,050 feet, and the other between the altitudes of 3,800 feet and 4,050 feet. The lower dam site is in the SE¼ sec. 13, T. 23 N., R. 9 E., and the upper dam site is in the west half of sec. 16, T. 23 N., R. 10 E. These reservoir sites are at the upper end of the Middle Fork canyon and include very little bottom land; mostly it is a V-shaped canyon.

The upper Nelson Point site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources. The location was given as sec. 16, T. 23 N., R. 10 E. This bulletin also listed a possible Bald Rock reservoir site downstream on the Middle Fork. The location was not stated, but the drainage area was listed as 1,113 square miles, or 208 more than at Nelson Point.

F. E. Bonner, in "Water powers of California" (1928), listed the Nelson Point site as having a potential storage capacity of 116,000 acre-feet between the altitudes of 3,700 feet and 4,030 feet. He noted the altitude of the Western Pacific Railroad at the Spring Garden tunnel near the upper end of the site as 4,043 feet, Western Pacific datum. The reservoir was to be operated for power regulation in connection with the proposed Clio, Grizzly Valley, and Gold Lake reservoirs upstream. Power would be developed in six stages from Nelson Point downstream to an altitude of 160 feet on the main Feather River. The average usable flow at the Nelson Point site was estimated as 590 second-feet.

A map of the site obtained by the Bureau of Reclamation (Fairchild Aerial Surveys, May 1946) shows the topography to an altitude of 4,050 feet throughout and to 4,400 feet at two possible dam sites. The width of the canyon at an altitude of 4,050 feet is about 800 feet at the lower site and 650 feet at the upper site. The Western Pacific Railroad is shown as adjacent to the site through sec. 8, T. 23 N., R. 11 E., just above the 4,050-foot contour.

Reservoir areas and capacities, roughly determined from the Bureau of Reclamation map, are as follows:

	Lower site		Upper site	
Altitude (feet)	Area (acres)	Capacity (acre-feet)	Area (acres)	Capacity (acre-feet)
3,720	0	0	0	0
3,800	90	3,000	0	0
3,850	165	9,000	30	1,000
3,900	340	20,000	150	5,000
3,950	590	45,000	350	17,000
4,000	920	80,000	625	50,000
4,050	1,330	140,000	960	90,000

Discharge records were obtained at a station near Nelson Point, from December 1923 to September 1932, about at the location of the upper dam site mentioned herein. Records also have been obtained since December 1940 at a station below Sloat, approximately at the upper end of the proposed Nelson Point reservoir site. The drainage area at the former gage was listed as 898 square miles; that at the present gage as 835 square miles.

Comparison of these discharge records with the record for the Middle Fork Feather River at Clio indicates that the runoff is proportionately much greater downstream from Clio. The drainage area at the former Nelson Point gage is only 30 percent more than at Clio, but the runoff was more than twice as much in the period of overlapping records from 1926 to 1932. During the three water years 1926, 1929, and 1931, when precipitation was low, the runoff near Nelson Point was more than three times that at Clio.

The average runoff at Nelson Point may be estimated on the basis of the relation between the runoff of the Middle Fork at Nelson Point and downstream at Bidwell Bar during 9 years of overlapping records. This relation, applied to the Bidwell Bar record for the 34 water years 1912-45, indicates that the corresponding average runoff at Nelson Point was 435,000 acre-feet per year, equivalent to a mean flow of 600 second-feet. It is judged that the average was about the same for the period of 20 years ending September 30, 1945, during which the mean discharge at Clio was recorded as 257 second-feet. The mean inflow between Clio and Nelson Point, therefore, was about 343 second-feet, equivalent to an average of 249,000 acre-feet per year.

On the same basis, it is estimated that the average discharge near Nelson Point for the six water ears

1929-34 was 345 second-feet, when the average at Clio was recorded as 130 second-feet. The corresponding inflow below the Clio reservoir site thus was about 215 second-feet, or an average of 156,000 acre-feet per year. The total potential capacity at the Nelson Point site, 140,000 acre-feet, probably would not be sufficient for complete regulation of the Clio-Nelson Point runoff in a critical period such as that from 1929 to 1934. With annual-use operation, the potential capacity probably would be sufficient for equalization of the Clio-Nelson Point runoff in a year of average flow.

Lists of land status and tentative classifications were based on the Bureau of Reclamation map, with an assumed flood line at an altitude of 4,050 feet and a dam at the lower site. No land lines nor found corners were shown on the Bureau map. The location of lands on this map was approximately determined by reference to the land net shown on a topographic map of Plumas National Forest published in 1938.

Bidwell Bar reservoir site, Middle Fork Feather River

Several proposals have been made for the storage of water on the Middle Fork Feather River with a dam near Bidwell Bar at a stream altitude of about 310 feet. Headwater altitudes as high as 1,040 feet have been contemplated. The dam site for recent proposals is in the east half of sec. 32, T. 20 N., R. 5 E., half a mile downstream from the junction of the South Fork with the Middle and 2 miles upstream from the mouth of the Middle Fork.

The Bidwell Bar site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources. The location was given as in sec. 32, T. 20 N., R. 5 E. However, the large Oroville reservoir, as proposed in that bulletin and in subsequent State recommendations, would flood the Bidwell Bar site.

F. E. Bonner, in his report on "Water powers of California" (1928), described a tentative plan for a reservoir at the Bidwell Bar site with a 280-foot dam just above the confluence of the Middle and North Forks. The maximum-flowage line was listed as at 580 feet; the tailrace altitude as 300 feet; and the storage capacity as 60,000 acre-feet. It was proposed to construct a power plant with an installed capacity of 40,000 kilowatts. The average output was estimated as 15,356 kilowatts, with an estimated average flow of 1,050 second-feet. The over-all plan for power development on the Middle Fork called for considerable storage regulation upstream at the proposed Nelson Point, Clio, and Grizzly Valley reservoirs.

The Bureau of Reclamation, in the Department of the Interior report on water-resources development of the Central Valley basin (November 1945), proposed the construction of a 679-foot dam at the Bidwell Bar site to create a storage capacity of 1,200,000 acre-feet, including 140,000 acre-feet of dead storage. The altitude of the stream bed was listed as 310 feet; the maximum-flowage line as at 979 feet; and the dead-storage line as at 646 feet. This large project was to be constructed with a similar large reservoir at the Big Bend site on the North Fork Feather River (estimated active capacity, 906,000 acre-feet) to provide considerable regulation in the lower Feather River basin for irrigation, flood control, power, and other purposes. Power would be developed at both the main dams and at two afterbay dams on Feather River downstream from the confluence of the Middle and North Forks. It was planned to export surplus water to the San Joaquin Valley. The Bidwell Bar and Big Bend projects, being in the reservoir area of the proposed Oroville reservoir on the Feather River (State water plan) are alternative to that project and would serve substantially the same function.

The Sacramento District, Corps of Engineers, prepared a report on comprehensive flood control of the Sacramento-San Joaquin basin streams (February 1945). This report was brought up to date by means of a supplement June 1, 1948. The report included proposals for the Bidwell Bar reservoir that were substantially the same as those of the Bureau of Reclamation. The proposed Bidwell Bar reservoir and an afterbay were also reported on by the Corps of Engineers in House Document 649, 78th Congress, 2nd session. Both reports suggested a capacity of 1,200,000 acre-feet at Bidwell Bar. The flood-control report suggested a maximum flood-control reservation of 190,000 acre-feet. The new irrigation yield was estimated at 500,000 acre-feet per year. The first cost of the Bidwell Bar dam, reservoir, and power plant was given as $111,571,000 on the basis of May 1948 prices. It may be noted that this agrees closely with an estimate of the cost of the Bidwell Bar project, capacity 1,250,000 acre-feet, as listed in the office report of the State Division of Water Resources, dated August 1949 and based on April 1949 prices.

The State of California commented on both the Bureau and Army proposals for the Bidwell Bar and Big Bend projects in reviews dated April 1946. It was concluded that further investigations should be made, including consideration of the alternative Oroville site. On the basis of further investigations made by the State and the interested Federal agencies, the State issued a report in August 1949 giving a detailed comparison of the several sites. The study included consideration of dams at the Bidwell Bar site as high as 730 feet above stream bed, with a corresponding reservoir capacity of 1,700,000 acre-feet. From this analysis it was concluded that major storage capacity on the Feather River can be most feasibly and economically provided at the Oroville site. In October 1949 a joint statement was issued by officials of the State of California, Bureau of Reclamation, and Corps of Engineers verifying this general conclusion and recommending that further studies be made of the proposed Oroville project. According to the State report, a large storage capacity at the Bidwell Bar site would be much cheaper than the same capacity at the Oroville site, mainly because of lesser flowage costs. However, the Bidwell Bar reservoir alone would not be adequate for control of the Feather River without an extremely large diversion from the North Fork to the Middle Fork.

The Bidwell Bar site is partly covered by a plan and profile of the Middle Fork Feather River prepared by the Geological Survey in 1912. The scale is 1:31,680, and the contour interval 100 feet on land and 5 feet on the water. The topography is shown from 100 to 400 feet above the water surface. The map was published in the report of the State Water Commission of California for 1912.

The Bureau of Reclamation obtained a map of the Bidwell Bar reservoir site (Fairchild Aerial Surveys, May 1946) showing the topography generally to an altitude of 1,050 feet and higher in the dam-site area. An assembled edition of this map is on a scale of 1:24,000, and the contour interval is 10 feet. In addition, topographic maps of quadrangles in this region are being prepared on a scale of 1:24,000, with a contour interval of 25 feet.

A gaging station has been operated on the Middle Fork at Bidwell Bar since October 1911. The average discharge for 34 years, to 1945, was 1,807 second-feet, corresponding to an average annual runoff of 1,310,000 acre-feet. The average annual runoff for the six water years 1929-34 was 775,000 acre-feet. There are relatively small irrigation diversions upstream. The potential effective storage capacity on the upper Middle Fork is estimated as 140,000 acre-feet at the Nelson Point site and 130,000 acre-feet at the Clio site.

Areas and potential capacities at the Bidwell Bar site, as determined by the Bureau of Reclamation, are listed in the following condensed table. The figures have been verified by the State Division of Water Resources.

Altitude (feet)	Area (acres)	Capacity (acre-feet)
320	0	0
400	83	2,769
500	375	24,889
600	950	88,754
700	1,929	230,062
800	3,176	484,008
900	4,584	870,661
1,000	6,489	1,420,667
1,050	7,524	1,770,972

For the purpose of making tentative land classifications, it was assumed that the maximum-flowage line might be at the 1,050-foot contour of the Bureau map. The classifications would not be greatly different for a flowage line at 979 feet.

Big Bend reservoir site, North Fork Feather River

The Bureau of Reclamation proposed the construction of a large dam at the Big Bend site as part of a project for the utilization of storage capacity and power drop in the lower Feather River basin (Department of the Interior report on Central Valley development, November 1945). The dam site is at a stream-bed altitude of 720 feet on the North Fork Feather River, approximately in the NW¼ sec. 10, T. 21 N., R. 5 E. The proposal called for the construction of a 624-foot dam to create a storage capacity of 1,000,000 acre-feet, including 94,000 acre-feet of dead storage. The maximum-flowage line was listed as at 1,334 feet, and the dead-storage line as at 920 feet.

The project was contemplated in connection with a similar large project on the Middle Fork at Bidwell Bar, as an alternative to the proposed Oroville project on the Feather River below the confluence of the North and Middle Forks. (See p. 7.) In addition to two afterbay dams below the confluence, it was planned to construct the Kennedy afterbay dam on the North Fork at a stream altitude of about 300 feet. This would be approximately in sec. 2, T. 20 N., R. 4 E. The afterbay dams would provide for minor reregulation and for utilization of the power drop downstream from the Big Bend site.

The Sacramento District, Corps of Engineers, in a flood-control survey report dated February 1945 and revised by a supplement dated June 1, 1948, included the Big Bend project in its plan of development. The reservoir design evidently was the same as that of the Bureau of Reclamation. A maximum flood-control reservation of 225,000 acre-feet was suggested. A power plant having an installed capacity of 149,000 kilovolt-amperes was proposed in connection with this project, and the maximum head was listed as 879 feet. This would develop the power drop down to the tailwater of the existing Big Bend plant. The new irrigation yield was estimated as 500,000 acre-feet. The capital cost of the Big Bend reservoir and power plant was estimated as $140,291,000 on the basis of prices as of May 1948. The over-all benefit-cost ratio was found to be about 1:1. It may be noted that the cost of the proposed Big Bend reservoir, with power plant, given in a report of the State Division of Water Resources was about $206,000,000. This estimate was made on the basis of April 1949 prices and after further investigations by the interested agencies. It is for a dam about 50 feet higher than that reported on by the Bureau of Reclamation and the district office of the Corps of Engineers. Recent maps had shown that the potential capacity of the site is much lower than first estimated.

The State of California discussed the proposals of the Bureau of Reclamation and the Corps of Engineers in a review dated April 1948. As a result of further studies by the State and the interested Federal agencies, joint conclusions were reached as summarized herein on page 7. The later studies favor the proposed Oroville site on the main stem of the Feather River. This site is an alternative to the Bidwell Bar and Big Bend projects and, for maximum development, would flood both sites. In the event that the Oroville site should not be constructed to maximum height, development of the Big Bend site as a coordinate feature with a lesser Oroville reservoir might be advantageous. It would be possible to obtain a storage capacity of at least 1,400,000 acre-feet at the Oroville site and at least 700,000 acre-feet at the Big Bend site. The headwater altitude of the Big Bend reservoir would be limited by the tailwater altitude, 1,380 feet, at the Cresta power plant of the Pacific Gas & Electric Co. The headwater altitude of the Oroville reservoir might be determined within limits by the altitude at which there would be optimum conditions for storage and power development. With 1,400,000 acre-feet of capacity the headwater altitude would be at the low-water altitude of the Big Bend site. A substantially greater capacity might be obtained by encroaching slightly on the power drop at the Big Bend site. Although the cost of the two units doubtless would be more than that of a single unit of the same storage capacity at the Oroville site, investigation may show that the benefit-cost ratio would be greater. A considerably greater power drop would be utilized, and with coordinated operation of the two reservoirs there might be an increase in irrigation yield. The flood-control reservation could be limited to the Oroville reservoir. It may be noted, also, that there would not be a proportionate increase in flowage costs owing to the

addition of the Big Bend unit, since the Oroville reservoir alone would flood the existing Big Bend power plant and would necessitate a major part of the required railroad relocation.

If the Oroville dam should be constructed to the maximum altitude of about 870 feet, there would be a power drop of roughly 500 feet between the Cresta power plant and the headwater of the reservoir. This could be developed by tunnel diversion to a power plant at the headwater of the reservoir, or possibly by a large storage and power dam upstream from the Big Bend site, or by a combination of dam and tunnel diversion. However, a large storage capacity upstream from the maximum Oroville reservoir to the Cresta plant probably would not be required for optimum control of the North Fork water and would be relatively costly. Previous plans for power in this reach of the North Fork Feather River, as outlined by F. E. Bonner in "Water powers of California," contemplated the construction of a dam and a 7-mile tunnel to utilize the power drop between the altitudes of 1,455 feet and 960 feet. The recently constructed Cresta plant is downstream from the headwater of this proposed unit.

The Big Bend dam would necessitate a relocation of the Western Pacific Railroad totaling about 27 miles, and would flood the diversion works of the existing Big Bend power plant.

Gaging stations have been operated on the North Fork Feather River at or near Big Bend for varying periods since 1911. The present gage is in sec. 6, T. 22 N., R. 5 E., 10 miles upstream from the Big Bend dam site. The average discharge for 29 years of complete record since 1911 is 2,702 second-feet. This corresponds to an average annual runoff of 1,960,000 acre-feet. For the six water years 1929-34, the average annual runoff was about 1,200,000 acre-feet (partly estimated). There is considerable storage regulation at Lake Almanor, Bucks Creek Reservoir, and Butt Valley Reservoir.

Preliminary estimates of the potential storage capacity at the Big Bend site presumably were based on the Geological Survey map of Bidwell Bar quadrangle. This is on a scale of 1:125,000, with a contour interval of 100 feet. Probably owing to the limitations of map preparation on this scale and the reconnaissance nature of the survey, the canyon is made to appear considerably wider than it actually is.

The Bureau of Reclamation obtained a map of the reservoir site (Fairchild Aerial Surveys, May 1946) showing the topography generally to an altitude of 1,400 feet and higher at the dam site. An assembled edition of this map was printed on a scale of 1:24,000, and the contour interval is 10 feet. The part of the site south of latitude 39°45' is shown on a map of Las Plumas quadrangle prepared under the direction of the Bureau of Reclamation. This is on a scale of 1:24,000, with a contour interval of 25 feet. The reservoir-site map and a preliminary edition of the quadrangle map were used for the purposes of this report.

These maps indicate that the river altitude is 725 feet at the dam site. The canyon width is about 1,800 feet at an altitude of 1,385 feet at the dam site. The potential capacity at an altitude of 1,385 feet would be about 730,000 acre-feet.

Rough determinations of reservoir areas and capacities are as follows:

Altitude (feet)	Area (acres)	Capacity (acre-feet)
725	0	0
800	80	3,000
900	240	19,000
1,000	690	65,500
1,100	1,160	158,000
1,200	1,730	302,500
1,300	2,330	505,500
1,400	3,150	779,500

Land classifications in the Big Bend reservoir area were made on the assumption that the maximum-flowage line might be at the top contour of the Bureau map, 1,400 feet. The classifications would be substantially the same for the proposed storage altitude, 1,385 feet. The land net was not shown on the reservoir-site map. Locations of lands upstream from the boundary of the Las Plumas quadrangle map were determined roughly by reference to the locations shown on the Forest Service map of Plumas National Forest.

Oroville reservoir site, Feather River

The Oroville reservoir is a major unit of the State water plan, as proposed in Bulletin 26 of the State Division of Water Resources. The dam site is at a stream-bed altitude of 190 feet in secs. 1 and 2, T. 19 N., R. 4 E. The original proposal was for a dam 580 feet high, creating a storage capacity of 1,700,000 acre-feet.

The alternative proposals of the Bureau of Reclamation and Corps of Engineers for use of the Bidwell Bar and Big Bend sites, and the increased storage requirements indicated by a sequence of dry years subsequent to the State report, led to further investigations of the lower Feather River sites.

An office report of the State Division of Water Resources, dated August 1949, gives the results of these further studies by the State agency in cooperation with the Bureau of Reclamation and Corps of Engineers. Four sizes of reservoir were contemplated at the Oroville site: 1,000,000; 1,700,000; 2,400,000; and 3,000,000 acre-feet. Estimates of cost and performance were compared with the cost and performance of Bidwell Bar reservoirs with capacities of 1,000,000 and 1,700,000 acre-feet, operated with a Big Bend reservoir having a capacity of 700,000 acre-feet. An afterbay power plant of 25,000 kilowatts was used with each combination. It was concluded that major storage capacity on the Feather River can be most feasibly and economically provided at the Oroville site. The joint statement, issued by officials of the State, the Bureau of Reclamation, and the Corps of Engineers, also pointed out that a reservoir capacity of 2,500,000 to about 3,000,000 acre-feet should be provided on the lower Feather River for proper control and conservation.

The State report of August 1949, based on prices as of April 1949, indicates that the Oroville reservoir, with a capacity of 2,400,000 acre-feet, would cost about $262,000,000; the accompanying power plant (capacity,

350,000 kilowatts) $46,000,000; and the afterbay dam and power plant about $14,000,000. The annual energy output was estimated as 1,402 million kilowatt-hours, and the irrigation yield, with incidental power, as 1,371,000 acre-feet. With a capacity of 3,000,000 acre-feet it was estimated that the Oroville reservoir would cost $296,000,000 and the accompanying 400,000-kilowatt power plant $51,000,000. The annual energy output would be increased 147 million kilowatt-hours and the irrigation yield 99,000 acre-feet by this increase in capacity. In comparison it was estimated that the Bidwell Bar-Big Bend reservoirs with a total capacity of 2,400,000 acre-feet, and their power plants, would cost about as much as the maximum Oroville reservoir and produce considerably less power and less irrigation water.

A maximum flood-control reserve of 400,000 acre-feet was used in the Oroville reservoir studies, and 415,000 acre-feet for the Bidwell Bar-Big Bend combination; these figures were suggested by the Corps of Engineers. The amount of reserve was varied between November 1 and May 15, with the maximum in effect from January 1 to April 1. The reserve was allocated between the Big Bend and Bidwell Bar reservoirs in the ratio of 60:40, which is roughly the ratio of the average flow of the North Fork to that of the Middle Fork Feather River.

The Oroville dam, to have a capacity of 2,400,000 acre-feet, would be 629 feet above the stream bed, with a crest length of 4,820 feet. At any of the heights considered it would necessitate a relocation of the Western Pacific Railroad, totaling 19½ miles and estimated to cost about $44,000,000, and a relocation of a State highway estimated to cost nearly $7,000,000. It would also flood the existing Big Bend power plant of the Pacific Gas & Electric Co. estimated to cost about $37,000,000.

An afterbay dam and powerhouse would be provided downstream from the Oroville site, and in the comparative studies the same afterbay unit was considered as a part of the Bidwell Bar-Big Bend project. The installed capacity would be 25,000 kilowatts, and the annual output about 140 million kilowatt-hours. The afterbay would provide for some day-to-day reregulation to equalize power releases for irrigation diversions. The power drop would be 60 feet.

The Oroville reservoir and the afterbay would flood power sites considered by previous investigators. On the North Fork Feather River, a scheme outlined by F. E. Bonner in "Water powers of California" (1928) would develop the drop between the altitudes of 920 and 445 feet by enlargement of the existing Big Bend power plant. Downstream it was proposed to develop the drop to an altitude of 160 feet in two stages by means of power dams. On the Middle Fork, powerhouses would have been located at the altitudes of 580 and 300 feet, with some storage at the Bidwell Bar site. On the South Fork a plant would have been located at an altitude of 610 feet with conduit-type development for a drop of 1,490 feet. The afterbay and maximum Oroville reservoir would lie between the altitudes of 150 feet and 865 feet.

As noted on page 8, it would be possible to construct both the Oroville and Big Bend reservoirs by limiting the capacity at the Oroville site to less than 2,000,000 acre-feet. Construction of both reservoirs might be advantageous if it is determined that a total capacity of approximately 2,500,000 acre-feet would be adequate for control of the Feather River. In that event, the maximum pool altitude of the Oroville reservoir might be limited to about 770 feet.

A gaging station has been operated on the Feather River at and near Oroville since January 1902. The average discharge for 43 years, to Sept. 30, 1945, was 5,881 second-feet, corresponding to an average annual runoff of nearly 4,300,000 acre-feet. There are some irrigation diversions upstream and considerable regulation by storage reservoirs. The recent studies presented in the State report of August 1949 were based on runoff during the 25 years ending Sept. 30, 1945. The average annual runoff for this period was 3,604,000 acre-feet. The future water supply at the Oroville site was estimated by correcting recorded flows for the storage effect of the Lost Creek and Little Grass Valley reservoirs in the South Fork basin. (The Palermo Canal, now diverting irrigation water from the South Fork, would be supplied from the Oroville reservoir.) Prospective storage developments in the upper North Fork, Middle Fork, and South Fork drainage basins may result in some modification of the future supply to the Oroville site.

The recorded mean annual runoff for the six water years 1929-34 was 2,230,000 acre-feet, and the ultimate requirements for diversions upstream presumably would reduce this to about 2,000,000 acre-feet in a similar critical period in the future. The existing storage capacity in the Feather River basin is about 1,500,000 acre-feet. With the recommended addition of a capacity of at least 2,500,000 acre-feet, there should be enough for substantial control through a critical period like the years 1929-34, provided the reservoirs are located properly in the basin. The Oroville site is below all major tributaries, including the West Branch Feather River. The West Branch would not be controlled by the proposed Bidwell-Big Bend project. The average discharge of the West Branch for the 15 years ending 1945 was 342 second-feet, or 250,000 acre-feet per year. The corresponding average for the period from 1921 to 1945 was 230,000 acre-feet, and for the six water years 1929-34 it was 120,000 acre-feet.

A map of the Oroville site obtained by the Bureau of Reclamation (Fairchild Aerial Surveys, May 1946) shows the topography to an altitude of 850 feet and higher in the vicinity of the dam site. An assembled edition of this map is on a scale of 1:24,000, and the contour interval is 10 feet. The Bureau, in cooperation with the Geological Survey, also is preparing topographic maps of quadrangles in this area on a scale of 1:24,000, with a contour interval of 25 feet. Preliminary editions of these sheets were used to determine locations in the reservoir site for the purpose of listing the status of lands.

Reservoir areas and capacities at high stages, as roughly determined on the basis of figures recently used by State investigators, are given in the following skeleton table. Areas and capacities are listed to two significant figures.

Altitude (feet)	Area (acres)	Capacity (acre-feet)
190	0	0
650	6,000	920,000
700	7,500	1,200,000
750	9,300	1,700,000
800	11,000	2,200,000
850	13,000	2,800,000
900	15,000	3,500,000

In view of uncertainty as to the final design of this reservoir, if it is selected, the maximum-flowage line was assumed to be at the 900-foot contour. This would correspond to a storage capacity of roughly 3,500,000 acre-feet. Classifications of public lands would be about the same, with flowage lines at 800 or 850 feet, except at extremities of reservoir arms where little public land is involved.

Little Grass Valley reservoir site, South Fork Feather River

The Little Grass Valley site is between the altitudes of 4,850 and 5,100 feet on the South Fork Feather River. The dam site is in sec. 31, T. 22 N., R. 9 E.

This site was included in a plan for development in the South Fork Feather River basin as proposed by the Oroville-Wyandotte Irrigation District. An outline of the plan was given by F. E. Bonner in "Water powers of California" (1928). The potential capacity of the Little Grass Valley site was listed as 70,000 acre-feet, with storage to an altitude of 5,100 feet. Power would be developed along the South Fork and Lost Creek in four stages through an over-all drop of 4,100 feet. The average output of the four plants was estimated as 32,876 kilowatts.

The Little Grass Valley site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit of the State water plan for maximum utilization of water resources.

The Bureau of Reclamation has obtained a map of this site (Fairchild Aerial Surveys, May 1946), which shows the topography to an altitude of 5,100 feet generally and to an altitude of 5,200 feet through the dam-site area. An assembled edition of the map is on a scale of 1:12,000, and the contour interval is 10 feet.

In June 1948 the Board of Supervisors of Yuba County applied to the State of California (application 12573) for a permit to appropriate 80,000 acre-feet per year from several streams, including the South Fork Feather River, for power purposes. One diversion point was listed as in sec. 31, T. 22 N., R. 9 E., evidently at the Little Grass Valley site.

The Bureau of Reclamation map of this site was used in listing the status of lands. Land lines and found corners were not shown on this map. The approximate location of lands was determined by the location of land lines relative to topography, as shown on a topographic map of the Plumas National Forest (1938) and the land plats. Part of the reservoir site is included in the topographic map of the American House quadrangle (scale, 1:24,000; contour interval, 25 feet), which is in preparation.

Lost-Sly Creek reservoir site, Lost Creek (South Fork Feather River basin)

The Lost-Sly Creek reservoir site lies mainly along Lost Creek between the altitudes of 3,290 and 3,500 feet. The dam site is on Lost Creek in sec. 20, T. 20 N., R. 8 E., just downstream from the mouth of Sly Creek.

This site is listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources.

The Lost-Sly Creek site was included in a plan for development of the South Fork Feather River basin as proposed by the Oroville-Wyandotte Irrigation District. An outline of the plan was given by F. E. Bonner in "Water powers of California" (1928). The potential capacity at this site was listed as 35,000 acre-feet, with storage to an altitude of 3,470 feet. The site is just upstream from the present Lost Creek Reservoir of the irrigation district. It was proposed to develop power in two stages through a drop of 2,496 feet along Lost Creek and the South Fork Feather River, downstream from the Lost Creek Reservoir.

The Bureau of Reclamation obtained a map of the site (Fairchild Aerial Surveys, May 1946) showing the topography generally to an altitude of 3,500 feet and to 3,600 feet in the dam-site area. An assembled edition of the map is on a scale of 1:9,600, and the contour interval is 10 feet.

Yuba County applied to the State of California in June 1948 (application 12573) for a permit to appropriate 80,000 acre-feet per year from the "South Fork Feather River, Sly River and Lost Creek, tributary to Feather River and Yuba River," for power purposes. One diversion point is listed as in sec. 20, T. 20 N., R. 8 E., evidently at the site of the proposed Lost-Sly Creek reservoir.

In August 1948 the Oroville-Wyandotte Irrigation District applied to the State of California (application 12644) for a permit to appropriate (1) 5,500 second-feet, (2) 2,000 second-feet, (3) 500 second-feet from (1) Lost Creek, (2) the South Fork Feather River, (3) Wyandotte Creek, tributaries of the Feather River, to be diverted in sec. 14, T. 18 N., R. 4 E., for irrigation and domestic purposes.

YUBA RIVER DRAINAGE BASIN

Narrows Reservoir site, Yuba River

This reservoir site is along the Yuba River and the South Fork Yuba River between the altitudes of 290 and 860 feet. The dam site is on the Yuba River just downstream from the existing Narrows debris-storage dam, in secs. 14 and 23, T. 16 N., R. 6 E.

The Narrows Reservoir was listed in Bulletin 26 of the State Division of Water Resources as a major unit in the State water plan. The reservoir was proposed primarily for irrigation purposes but would also be used for flood control and power generation. A description of the site and estimates of the performance of the project are given in Bulletin 26. It was concluded that a dam 580 feet high should be constructed to provide a

storage capacity of 853,000 acre-feet. A power plant at the dam would have a capacity of 160,000 kilovolt-amperes. With operation primarily for irrigation, it was judged that the annual yield would have been about 870,000 acre-feet of new water and the annual energy output about 528 million kilowatt-hours during a period like that from 1889 to 1929. It was pointed out that the water yield would have been only about half the potential supply.

The Bureau of Reclamation, in the Department of the Interior report on Central Valley development (November 1945), proposed the construction of a 483-foot dam at the Narrows site to provide a storage capacity of 500,000 acre-feet. The reservoir would be operated for irrigation, flood-control, power, and other purposes. With a 70,000-kilowatt power plant at the dam it was estimated that the average annual energy output would be 245 million kilowatt-hours during a period like that from 1928 to 1934.

A reservoir such as proposed in the State water plan, or by the Bureau of Reclamation, would flood the existing 240-foot dam used for debris control and the existing Colgate power plant of the Pacific Gas & Electric Co.

The State of California commented on the Bureau plan in a review dated April 1946. It was concluded that the project is feasible from the engineering standpoint but that there is no immediate need for an irrigation supply in the service area in an amount that would justify construction at this time. It was judged that an aggregate storage capacity of 1,500,000 acre-feet would be needed for the ultimate development of the water resources of the Yuba River. It was pointed out that this could be obtained with a capacity of 853,000 acre-feet at the Narrows site and with a capacity of 675,000 acre-feet at the Bullards Bar site.

In June 1948 Yuba County applied to the State of California (application 12517) for a permit to appropriate 60,000 acre-feet of water per year, to be diverted from the Yuba River in sec. 14, T. 16 N., R. 6 E., for irrigation and domestic purposes. The prospective diversion point is at the Narrows site.

A gaging station was operated on the Yuba River near Smartville from 1903 to 1941, and one has been in operation at the existing Narrows Dam since October 1941. The drainage areas are listed as 1,201 and 1,110 square miles, respectively. The average annual runoff at the former station, for 38 years of record, was 2,130,000 acre-feet. The average during the six water years 1929-34 was 967,000 acre-feet.

A map of the reservoir site was published by the Geological Survey in 1937. It is on a scale of 1:12,000, with a contour interval of 20 feet on land and 5 feet on the river surface. The topography is shown to an altitude of 900 feet. The map is designated "Upper Narrows reservoir site." A map of the dam site is included on a scale of 1:2,400 and with a contour interval of 10 feet.

New Bullards Bar Reservoir site, North Fork Yuba River

The New Bullards Bar Reservoir site lies between the altitudes of about 1,400 and 1,950 feet along the North Fork Yuba River and its tributary Willow Creek. The dam site is in sec. 24, T. 18 N., R. 7 E., just downstream from the existing Bullards Bar Dam.

The existing Bullards Bar site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum development of water resources.

The existing dam and power plant was constructed by the Yuba River Power Co. for the Pacific Gas & Electric Co. A plan for the ultimate development of the North Fork as proposed by the Yuba River Power Co. is described in "Water powers of California" by F. E. Bonner (1928). This includes a proposal for increasing the height of the present Bullards Bar Dam to 360 feet (altitude, 1,800 feet), providing additional storage capacity of 200,000 acre-feet for regulation to increase the power potential.

The New Bullards Bar Reservoir was listed as a major prospective project for the comprehensive development of the Central Valley basin in the Department of the Interior report of November 1945. The Bureau of Reclamation suggested a maximum-flowage line at 1,900 feet to create a storage capacity of 675,000 acre-feet. This would require a dam 520 feet above the stream bed, which would flood the present Bullards Bar Dam and powerhouse. The reservoir would be operated for several purposes, including irrigation and flood control in coordination with the Narrows Reservoir on the Yuba River downstream (proposed capacity, 500,000 acre-feet). Power would be developed between these reservoirs at New Bullards Bar and New Colgate plants with capacities of 60,000 and 50,000 kilowatts, respectively. The Pacific Gas & Electric Co. operates a power plant with a capacity of 6,500 kilowatts at Bullards Bar Dam. This company also operates the Colgate plant downstream at an altitude of about 534 feet, with water supplied by tunnel from the North Fork downstream from the Bullards Bar Dam. The capacity of this plant was 14,200 kilowatts until recently it was enlarged to about 40,000 horsepower. The drop between the stream bed at Bullards Bar and the maximum-flowage line of the proposed Narrows Reservoir is approximately 630 feet.

The New Bullards Bar Reservoir also was proposed, in 1945, by the Sacramento District, Corps of Engineers, with 330,000 acre-feet of the total, 675,000 acre-feet, listed for maximum flood-control reservation. The capacity of the proposed power plant was listed as 46,000 kilovolt-amperes. The Corps of Engineers did not recommend the Narrows project.

The State of California, commenting on both proposals in April 1946, found each to be economically feasible if it included the estimated irrigation benefits, but held that there is no immediate need for an irrigation supply in the tributary area and therefore that construction should be deferred. The State further concluded that the ultimate development of the Yuba River required an aggregate capacity of 1,500,000 acre-feet at the Bullards and Narrows sites and recommended that the Narrows site be developed to a capacity of 853,000 acre-feet, which, with 675,000 acre-feet at Bullards Bar, would meet the requirement.

In June 1948 Yuba County applied to the State of California (application 12519) for a permit to appropriate 130,000 acre-feet per year from the Yuba River, for

power purposes, to be diverted in sec. 24, T. 18 N., R. 7 E. The New Bullards Bar Dam site is within this section. Production was estimated as 772 million kilowatt-hours annually. (If it is intended to relate to the amount of water requested, this evidently is an erroneous estimate.)

The average annual runoff of the North Fork Yuba River at Bullards Bar since 1903, when records were first obtained on the Yuba River, is estimated as about 1,400,000 acre-feet. During the six water years 1929-34, the average annual runoff is estimated as about 570,000 acre-feet. These estimates are based on discharge records for the North Fork at the Colgate diversion dam since 1940, as compared with records for the Yuba River near Smartville and the Yuba River at Narrows Dam.

The New Bullards Bar site is partially covered in a plan and profile of the South, Middle, and North Fork Yuba River published by the Geological Survey in 1940. The topography is shown only to an altitude of 1,700 feet or less in much of the area.

The Bureau of Reclamation obtained a map of the reservoir site (Fairchild Aerial Surveys, May 1946) showing the topography to an altitude of 1,950 feet. An assembled edition of the map is on a scale of 1:12,000, and the contour interval is 10 feet. Land lines are not shown. The approximate location of lands was determined by reference to the location of land lines on the river survey map, relative to topographic features. For the tentative classification of public lands it was assumed that the maximum-flowage line might be at 1,950 feet. The area covered at 1,950 feet is not much more than at 1,900 feet.

Jackson Meadows reservoir site, Middle Fork Yuba River

The Jackson Meadows site lies between the altitudes of 5,820 and 6,060 feet along the Middle Fork Yuba River. The dam site is in sec. 18, T. 19 N., R. 13 E.

F. E. Bonner, in his report on "Water powers of California" (1928), suggested a storage capacity of 45,000 acre-feet for the Jackson Meadows site, with a 140-foot dam and a maximum-flowage line at an altitude of 6,020 feet. He noted that a capacity of 75,000 acre-feet might be created by a dam 30 feet higher. It is uncertain whether Bonner's altitudes are related to the datum of recent maps, which show the stream altitude as 5,830 feet at a fairly well defined dam site. This would correspond with a dam height of 190 feet at an altitude of 6,020 feet. Bonner judged that a capacity of 45,000 acre-feet would be sufficient unless considerable cyclic operation should be practised. At the time of his report the potential water supply was somewhat uncertain because of a conflict in the plans of the Yuba River Power Co. and the Nevada Irrigation District as to the diversion of Middle Fork waters. The Nevada Irrigation District diverts water from the Middle Fork at Milton, in sec. 12, T. 19 N., R. 12 E. The average diversion for 16 years, from 1928 to 1930 and from 1931 to 1945, was 71 second-feet. Bonner assumed that water in excess of the diversion at that time would be available for regulation at Jackson Meadows with diversion to the North Fork Yuba River at the proposed Sierra City reservoir for power development downstream. He judged that the amount of water available for diversion would be too small to justify development of the power drop between the Middle and North Forks.

The Jackson Meadows site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum development of water resources.

In the Department of the Interior report on water resources development of the Central Valley basin, the Bureau of Reclamation listed the Jackson Meadows site as under consideration in connection with the future development of the Nevada irrigation district. The potential storage capacity was listed as 67,000 acre-feet.

A gaging station was operated during 1926-30, 1931-34, 1935-40, and 1941-42 on the Middle Fork Yuba River at Milton. After 1943 it was again operated and has remained in operation to date. The average discharge for 14 complete years of record after Sept. 30, 1928, to Sept. 30, 1945, was about 29 second-feet. There was no flow during three of these water-years: 1931, 1934, and 1939. Water has been diverted just upstream from this station to the Milton-Bowman tunnel of the Nevada irrigation district since May 1928. The combined river and tunnel flow during the 15 years of overlapping records to 1945 was 104 second-feet. The dependable water supply may be limited by critical periods such as the six water years 1929-34, when the average discharge of the Middle Fork at Milton was less than 8 second-feet. During the same period the average Milton-Bowman diversion was about 61 second-feet. The combined river and tunnel discharge from 1929 to 1934 was equivalent to an average runoff of 50,000 acre-feet annually.

It seems unlikely that the small remainder after Milton-Bowman diversion during critical periods such as that from 1929 to 1934 would justify any separate development like the contemplated diversion to the North Fork. However, the Jackson Meadows storage might be used advantageously for power regulation through the Nevada Irrigation District-Pacific Gas & Electric Co. system if power releases can be reregulated at downstream sites. Hold-over operation at this site also might increase the dependable supply for irrigation.

The Jackson Meadows site is shown on a plan and profile map of the South, Middle, and North Forks Yuba River published by the Geological Survey in 1940. The scale is 1:31,680, with a contour interval of 20 feet. The topography is shown to an altitude of 6,000 feet. A map of the dam site was printed on a scale of 1 inch = 200 feet, with a contour interval of 5 feet.

The Bureau of Reclamation obtained a map of the Jackson Meadows site (Fairchild Aerial Surveys, May 1946) showing the topography generally to an altitude of 6,060 feet and to an altitude of 6,200 feet at the dam site. An assembled edition of this map is on a scale of 1:12,000, and the contour interval is 10 feet. The channel altitude at the dam site is 5,820 feet, and the width of the canyon at an altitude of 6,060 feet is about 1,200 feet. The potential storage capacity, as roughly determined from this map, is 97,000 acre-feet below an altitude of 6,060 feet and 59,000 acre-feet below an altitude of 6,025 feet. It is judged that a storage capacity of 70,000 or 80,000 acre-feet might be sufficient for con-

trol of the runoff during critical periods such as the years 1929-34.

The reservoir-site map of the Bureau of Reclamation does not show found corners or a land net. For the purpose of listing the status of lands, the approximate locations of lands were determined by reference to the land net shown on the river-survey map. For the tentative classification of public lands, it was assumed that the maximum-flowage line might be at an altitude of 6,060 feet.

Cisco reservoir site, South Fork Yuba River

The Cisco reservoir site lies between the altitudes of 5,590 and 5,850 feet along the South Fork Yuba River. The dam site is in secs. 19 and 30, T. 17 N., R. 13 E., on the South Fork a short distance downstream from the mouth of the Rattlesnake Creek.

The "Cisco" reservoir site of the Bureau of Reclamation map dated May 1946 (Fairchild Aerial Surveys) presumably is at the location of the "Rattlesnake" reservoir site mentioned by F. E. Bonner in "Water powers of California" (1928). Bonner said there was a possibility that this site might be used eventually to provide 26,000 acre-feet of storage for stand-by purposes, presumably in connection with power and irrigation projects of the ultimate Yuba-Bear River system. He did not suggest any power development at the site or in the reach downstream to the Lake Spaulding Reservoir. The Rattlesnake site was shown at a stream altitude of 5,600 feet, with storage to 5,730 feet.

This site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources.

In the Department of the Interior report of November 1945 on the development of the Central Valley basin, the Bureau of Reclamation listed the Cisco site as under consideration for the future development of the Nevada irrigation district. The potential capacity was listed as 93,500 acre-feet.

In October 1948 Placer County applied to the State of California (application 12748) for a permit to appropriate 500 second-feet and 150,000 acre-feet per year from the South Fork Yuba River for power purposes. The diversion point was listed as within sec. 19, T. 17 N., R. 13 E., presumably near the Cisco dam site.

Stream-flow records have been obtained on the South Fork Yuba River near Cisco since April 1942. The gage is in sec. 19, T. 17 N., R. 13 E., near the proposed dam site. The average discharge for the three water years 1943-45 was about 180 second-feet. It is judged that the long-time average may be about the same. The average discharge during the six water years 1929-34 is estimated as roughly 60 percent of this figure or 110 second-feet, equivalent to an average annual runoff of 80,000 acre-feet. Judging from these rough estimates, the proposed storage capacity of 93,500 acre-feet would not be sufficient for complete control during dry periods such as the years 1929-34, but it would provide for considerable hold-over operation during such periods.

The Bureau of Reclamation map was printed on a scale of 1:12,000, and the contour interval is 10 feet. The topography is shown generally to an altitude of 5,850 feet and to above 6,000 feet at the dam site. The channel altitude at the dam site is shown as 5,590 feet. The SE. and NW. corners of sec. 29, and the quarter-section corners at the W. boundary of sec. 29, T. 17 N., R. 13 E., are shown on the map as found corners, but land lines are not indicated. For the purpose of listing status and tentative land classifications, the approximate locations of lands were determined by reference to the land net on the river-survey map.

New York Flat reservoir site, New York Flat Creek (tributary by way of Dry Creek to Yuba River)

The New York Flat reservoir site lies between the altitudes of 2,290 feet and 2,480 feet along New York Flat Creek. The dam site is in secs. 25 and 26, T. 19 N., R. 6 E., just upstream from the junction of New York Flat Creek with Dry Creek.

This site was included in a plan of development of the South Fork Feather River which was proposed by the Oroville-Wyandotte Irrigation District. An outline of the plan is given in "Water powers of California," by F. E. Bonner (1928). It was proposed to develop power in four stages below the Little Grass Valley site on the South Fork Feather River and the Lost-Sly Creek site on Lost Creek, tributary to the South Fork Feather River. As an alternative to the direct routing of water along Lost Creek and the South Fork it was proposed to use the New York Flat reservoir site of the Yuba River basin for reregulation. This site has a potential storage capacity of more than 80,000 acre-feet, and its tributary drainage area is only a few square miles. By either plan the water would be utilized for power down to the intake of the Palermo Canal, which diverts from South Fork Feather River at an altitude of 610 feet for irrigation in the Oroville-Wyandotte district. The potential drop would be reduced by construction of the proposed Oroville or Bidwell Bar dams.

The New York Flat site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources.

In June 1948 the Board of Supervisors of Yuba County applied to the State of California (application 12573) for a permit to appropriate 80,000 acre-feet per year from the South Fork Feather River and certain tributaries of the South Fork Feather River and the Yuba River. One of the diversion points was listed as in sec. 25, T. 19 N., R. 6 E., evidently at the New York Flat dam site. The purpose was described as power, and the capacity has been estimated as 90,000 kilowatts.

In August 1948 the Oroville-Wyandotte Irrigation District applied to the State (application 12644) for a permit to appropriate waters from Lost Creek, the South Fork Feather River, and Wyandotte Creek for irrigation and domestic purposes. Details were not stated.

The average discharge of the Palermo Canal from 1911 to 1945 was 18.7 second-feet. The average discharge of the South Fork Feather River below the Palermo Canal diversion from 1911 to 1945 was 304 second-feet.

The Bureau of Reclamation has obtained a map of the New York Flat reservoir site (Fairchild Aerial Surveys, May 1946) showing the topography to an altitude of 2,480 feet. An assembled edition of the map is on a scale of 1:12,000, and the contour interval is 10 feet. The apparent location of the dam site is on New York Flat Creek about a quarter of a mile upstream from its junction with Dry Creek. The altitude of the stream at this point is 2,290 feet. For the purpose of listing the status of lands it was assumed that the maximum-flowage line would be at the top contour, 2,480 feet. The Bureau map does not show land lines. The NW. corner of sec. 25, T. 19 N., R. 6 E., was found. The site is included in a recent Forest Service planimetric map of part of the Bangor quadrangle. It is also included in the topographic maps of the Forbestown and Rackerby quadrangles now in preparation. The approximate locations of lands on the reservoir-site map were determined by reference to the land net shown on these maps, as related to topographic features.

Virginia Ranch reservoir site, Dry Creek (tributary to Yuba River)

The Virginia Ranch site is between the altitudes of 1,050 and 1,220 feet along Dry Creek. The dam site is in the NW¼ sec. 21, T. 17 N., R. 6 E.

The site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources.

This site evidently is the one mentioned in the Department of the Interior report of November 1945 as being under investigation by the Bureau of Reclamation for irrigation purposes. It would serve parts of the Browns Valley area, now partly under irrigation from the North Fork Yuba River, Dry Creek, and Tennessee Creek. The altitude of the stream bed at the dam site is 1,050 feet, and a dam to an altitude of 1,220 feet would have a crest length of nearly 3,000 feet. Water at this altitude would flood about 1,270 acres. It is judged that the potential storage capacity is 75,000 acre-feet or more. The tributary drainage area is roughly 75 square miles, mostly in foothill country. There is a small reservoir, Lake Mildred, on Dry Creek about a mile upstream from the Virginia Ranch site.

A gaging station was installed on Dry Creek in the SW¼ sec. 16, T. 17 N., R. 6 E., in June 1946 by the Bureau of Reclamation. The station has been operated by the Geological Survey since Oct. 1, 1948.

The Bureau of Reclamation obtained a map of this site (Fairchild Aerial Surveys, May 1946) which shows the topography to an altitude of 1,220 feet. The scale is 1:12,000, and the contour interval is 10 feet. No land lines nor found corners were shown on this map. For the purpose of listing land status, a land net was added by reference to the net shown on the Geological Survey map of the Bangor quadrangle, as related to topographic features and grids of the California coordinate system. The site is in the Oregon House quadrangle, now being mapped on a scale of 1:24,000 and with a contour interval of 25 feet. Lands within and adjacent to the reservoir site are all patented.

BEAR RIVER DRAINAGE BASIN

Rollins reservoir site, Bear River

The Rollins reservoir site is between the altitudes of 1,950 and 2,200 feet along Bear River and its tributary Greenhorn Creek. The dam site is in sec. 22, T. 15 N., R. 9 E., half a mile downstream from the mouth of Greenhorn Creek and near the intake of the Bear River Canal.

This site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources. (It was here called "Bear River reservoir site.")

The Rollins reservoir site was listed by the Bureau of Reclamation as a major prospective storage reservoir in the Department of the Interior report on the Central Valley basin of November 1945. The proposal was for the storage of 60,000 acre-feet, including 17,000 acre-feet for the control of mining debris. A total of 43,000 acre-feet would be utilized to conserve water for the irrigation, initially, of 8,000 acres of land near Wheatland and, eventually, of foothill areas. No power development was contemplated.

The proposal was reviewed by the State of California in April 1946, and it was concluded that the project probably is feasible from an engineering standpoint and that there may be need for the reservoir to control mining debris in the near future, but that there is no apparent immediate need for the project for irrigation. It was recommended that further studies be made, including investigations of alternative sites.

The Federal Power Commission, San Francisco regional office, commenting on power features of the Bureau proposals for Central Valley development, pointed out that a power plant of 5,000 kilowatts would be feasible in connection with the Rollins project unless the debris storage is to be filled quite rapidly.

A gaging station has been operated on Bear River near Auburn since December 1940. The gage is 13 miles downstream from the Rollins site, but there is relatively little intervening drainage. Water is diverted into the Bear River basin upstream from the Rollins site for power development. Water is diverted from the Bear River channel at the Rollins site by way of the Bear River Canal for power and irrigation purposes, with the surplus wasted to the American River. The canal discharge has been measured since 1914. According to F. E. Bonner, in "Water powers of California" (1928), a total of 73,000 acre-feet annually was to have been diverted into the Bear River basin for power development and returned to the Nevada irrigation district (Bear and Yuba River basins) for irrigation. A diversion point for this water from the Bear River channel presumably would be at the Combie Reservoir (operated by the Nevada Irrigation District), about 3 miles upstream from the gaging station near Auburn.

In view of the complicated system of storage and diversion upstream, it appears that the water supply available for conservation at the Rollins site cannot be determined readily from the published records. The average annual runoff of the Bear River near Auburn from 1942 to 1945 was about 243,000 acre-feet. It is judged that with similar storage and diversions the av-

erage runoff from 1929 to 1934 may have been roughly 100,000 acre-feet per year, but this estimate is subject to gross error.

The listing of land status and tentative classifications were based on a Bureau map of the site (Fairchild Aerial Surveys, May 1946) showing the topography to an altitude of 2,200 feet. An assembled edition of this map is printed on a scale of 1:9,600, and the contour interval is 10 feet. The land lines were approximately located on this map relative to topographic features by reference to the Forest Service map of the Giant Gap quadrangle, which shows planimetric features and land lines on a scale of 1:31,680.

Garden Bar reservoir site, Bear River

The Garden Bar reservoir site is between the altitudes of 290 feet and 610 feet along the Bear River. The dam site on the river is in sec. 31, T. 14 N., R. 7 E., and a saddle dam would be required in adjacent section 30 for development above an altitude of 555 feet.

The Garden Bar reservoir site was proposed by the Bureau of Reclamation in the Department of the Interior report of November 1945 as a major project in the development of the Central Valley basin. The maximum-flowage line was listed as at an altitude of 590 feet. The total storage was listed as 200,000 acre-feet, including 30,000 acre-feet of dead storage. A power plant with a capacity of 4,000 kilowatts was proposed in connection with this reservoir. The average annual output for a period like that from 1928 to 1934 was estimated as 20 million kilowatt-hours. The primary purpose of the reservoir would be irrigation, but it would also serve for flood control.

The Sacramento District, Corps of Engineers, in the flood-control survey report of February 1945, brought up to date by means of a supplement of June 1, 1948, also included the Garden Bar reservoir in its plan of development. A maximum flood-control reservation of 42,000 acre-feet was recommended. Power development was not included in this plan.

The State of California, reviewing both proposals, found that the project is not economically feasible and recommended that further studies be made of Garden Bar and alternative sites on the Bear River, including the Camp Far West and Rollins sites (State reviews dated April 1946). The Camp Far West site was proposed in Bulletin 26 of the State Division of Water Resources as a major reservoir unit in the State water plan. There is an existing reservoir at this site with a capacity of 5,000 acre-feet for irrigation use by the Camp Far West irrigation district. The State proposed the construction of a 180-foot dam to create a storage capacity of 151,000 acre-feet. It was estimated that this would provide a seasonal yield of 130,000 acre-feet of new water. There would have been a maximum flood-control reservation of 50,000 acre-feet but no power installation. The dam site is in sec. 21, T. 14 N., R. 6 E., and it is roughly 10 miles downstream from the Garden Bar site.

The Federal Power Commission, in a report of the San Francisco regional office (not for release), reviewed the Garden Bar proposal of the Bureau of Reclamation as to power features and suggested no change, although commenting that the proposed power plant seemed larger than necessary.

The listing of land status and tentative classifications were based on a map of the reservoir site obtained by the Bureau of Reclamation (Fairchild Aerial Surveys, May 1946). This shows the topography to an altitude of 610 feet, which was assumed as the possible flowage line of the reservoir. The scale is 1:12,000, and the contour interval is 10 feet. Land lines and found corners are not shown. The approximate location of lands as related to the topographic features of this map was determined by reference to the land net shown on a recent Forest Service map of the Grass Valley quadrangle (scale 1:31,680). The reservoir site also is included in a topographic map of the Wolf quadrangle (scale, 1:24,000; contour interval, 20 feet) which is in preparation.

Waldo reservoir site, Dry Creek (Bear River drainage system)

The Waldo reservoir site is along Dry Creek and several of its tributaries between the altitudes of 225 feet and 409 feet. The main dam site is in sec. 33, T. 15 N., R. 6 E.

The site is approximately the same as one that was surveyed and studied by the State of California in connection with investigations for the State water plan. It is designated "Cabbage Patch reservoir site" in Bulletin 26 of the State Division of Water Resources.

The Bureau of Reclamation listed the Waldo site as a major prospective reservoir of the Central Valley basin plan in the Department of the Interior report dated November 1945. It was proposed to construct a 199-foot dam to create a storage capacity of 202,000 acre-feet, with a dead storage of 5,000 acre-feet. The reservoir would flood an area of 3,275 acres. This reservoir would be used in connection with the proposed Narrows and New Bullards Bar projects in the Yuba River drainage basin. It was proposed that power releases be diverted by means of a canal to the Waldo reservoir for reregulation, and it was stated that this would materially improve the power output of the Yuba plants. (The headwaters of the Waldo reservoir would be roughly 6 miles southwest of the prospective Narrows dam.) Gravity diversion from a plant at the Narrows dam to the Waldo site evidently would entail a sacrifice of power drop at the Narrows site, which is at a stream-bed altitude of 286 feet. The State and Bureau reports indicate that the potential water supply from the Yuba River will be in excess of that needed for local irrigation requirements. It is assumed, therefore, that the plan of development utilizing the Waldo site may contemplate the routing of water southward by means of canals along the foothills.

The State of California, commenting on the proposal in a review dated April 1946, concluded that more data would be needed to judge the engineering and economic feasibility and the desirability of the project as compared with equivalent storage on the Yuba River or its branches.

The drainage area at the Waldo site was listed as 80 square miles. The State review reports the mean annual runoff as about 35,000 acre-feet.

The Bureau of Reclamation used a map of the reservoir site showing the topography to an altitude of 460 feet. (It is believed that the map was prepared by Fairchild Aerial Surveys for the Army military establishment at Camp Beale.) An assembled edition of the map is on a scale of 1:12,000, and the contour interval is 20 feet. The map indicates that a small saddle dam would be required above an altitude of 400 feet near the south end of the site. The entire area, taking in the Waldo and Narrows reservoir sites and intervening terrain, is being mapped by the Geological Survey on a scale of 1:24,000.

AMERICAN RIVER DRAINAGE BASIN

The several reservoir sites described in the following paragraphs are at relatively high altitudes and would control runoff from the most productive parts of the American River drainage basin. There is a potential storage capacity of about 600,000 acre-feet at the sites on the Middle Fork American River and its main tributary, the Rubicon River, above an altitude of 4,000 feet. There are several alternative routes for the conveyance of storage releases by means of tunnel and conduit for utilization at high-head plants on the Rubicon and Middle Fork channels. From the junction of the Rubicon River with the Middle Fork at an altitude of 1,150 feet, downstream to the headwater of the proposed Folsom reservoir at an altitude of 466 feet, utilization of the controlled and uncontrolled flows could be accomplished by means of power dams, unless a multiple-purpose reservoir should be constructed on the North Fork.

In the upper South Fork American River drainage basin the main storage possibilities are at the Union Valley site on Silver Creek, above an altitude of 4,500 feet, and at the Icehouse site on the South Fork Silver Creek above an altitude of 5,300 feet. The potential active capacities are about 225,000 and 50,000 acre-feet, respectively. Water could be conveyed from these sites by means of tunnel and conduit for utilization at high-head plants down to an altitude of 1,890 feet at the South Fork American River channel. There would be an additional drop of 1,000 feet along the South Fork down to the headwater of the proposed Coloma reservoir. Power could be developed in this reach by means of power dams and conduits or tunnels.

The descriptions of sites in the upper American River basin are followed by descriptions of major projects in the lower basin that have been proposed for flood-control, irrigation, and power uses. These comprise the Auburn and Oregon Bar reservoirs on the North Fork; the Coloma and Webber Creek (Salmon Falls) reservoirs on the South Fork; and Folsom reservoir on the American River.

French Meadows reservoir site, Middle Fork American River

The French Meadows reservoir site is between the altitudes of 5,050 feet and 5,380 feet along the Middle Fork American River. The dam site is mainly in sec. 36, T. 15 N., R. 13 E., extending into adjacent sec. 25.

The site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources.

Various proposals have been made for use of the French Meadows site for power purposes. The California Power Board, reporting to the Federal Power Commission in 1924, listed the available capacity as 64,000 acre-feet. F. E. Bonner, in "Water powers of California" (1928), suggested that a capacity of 55,000 acre-feet would be needed to control the runoff. This would be provided by a 150-foot dam to an altitude of 5,140 feet. In his "Report on power withdrawals on Middle Fork American River" (1935), W. R. Farley proposed a capacity of 210,000 acre-feet for the French Meadows site, to be provided by a 277-foot dam having a crest length of 3,000 feet. Flood level would be at an altitude of 5,335 feet. (Bonner shows the stream-bed altitude as 4,990 feet; Farley puts it at 5,063 feet. Farley reported that a line of levels run into French Meadows by the Forest Service in 1934 found the altitude of the Middle Fork at French Meadows to be 63 feet higher than is shown on the 1912 plan and profile of the stream.) The larger storage capacity suggested by Farley would provide for hold-over operation and also for the regulation of waters diverted into the site from the North Fork American River (drainage area, 30 square miles) and from Duncan Creek (drainage area, 9.2 square miles).

E. F. Sullivan, of the Bureau of Reclamation, in an unpublished report dated Nov. 10, 1943, suggested an active-storage capacity of 200,000 acre-feet for French Meadows. His proposal included diversion into the site as suggested by Farley. The maximum headwater altitude of the French Meadows reservoir site was listed as 5,325 feet.

In March 1948 Placer County applied to the State of California (applications 12456 and 12457) for permits to appropriate waters in the American River basin, including diversion from the Middle Fork American River in sec. 36, T. 15 N., R. 13 E., the location of the French Meadows dam site. The water would be used for power, municipal, irrigation, stock-watering, and domestic purposes. Details of the plan were not stated.

The French Meadows reservoir would control runoff from 87 square miles, including areas of the North Fork and Duncan Creek basins. It is judged that the average annual flow subject to capture would be roughly 170,000 acre-feet for 40-year periods similar to that ending with 1945 and 150,000 acre-feet for periods like that from 1921 to 1945.

A map of the site obtained by the Bureau of Reclamation (Fairchild Aerial Surveys, May 1946) shows the topography to an altitude of 5,380 feet. The altitude of the stream at the apparent location of the dam site is shown as 5,050 feet. An assembled edition of the map is on a scale of 1:9,600, and the contour interval is 10 feet. For the purpose of obtaining the status of lands in the reservoir area, it was assumed that 5,380 feet would be the maximum pool altitude. Land lines and found corners are not shown on the Bureau map. Locations of lands on this map were approximately determined from the location of land lines shown on a recent Forest Service planimetric map of the Granite Chief quadrangle, as related to topographic features. The dam site is in secs. 25 and 36, T. 15 N., R. 13 E.,

about 2,400 feet west of the township boundary according to this determination.

Rock Bound diversion and Buck Island Lake reservoir sites, Rubicon River drainage basin

The Rock Bound diversion area is between the altitudes of 6,500 feet and 6,600 feet along the Rubicon River and Rock Bound Lake. The dam site is on the Rubicon River in sec. 9, T. 13 N., R. 16 E. There is a saddle west of this site, at an altitude of 6,560 feet, separating the Rubicon River and Rock Bound Lake. The outlet of Rock Bound Lake is at an altitude of 6,525 feet, and the drainage is to the west through Buck Island Lake (altitude, 6,430 feet) to the Rubicon River downstream from the prospective diversion point. A dam on the Rubicon River; another dam 2,000 feet long across the outlet of Rock Bound Lake in secs. 6 and 7, T. 13 N., R. 16 E., and a short saddle dam near the boundary joining sections 5 and 6 would provide for storage in the entire diversion area. About half a mile of tunnel or cut would be required to connect the Rubicon area with the Rock Bound area at the present level of Rock Bound Lake. The Rock Bound Lake site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources. The location was given as sec. 6, T. 13 N., R. 16 E.

The Buck Island Lake reservoir site is between the altitudes of 6,430 feet and 6,490 feet, and storage would be obtained by constructing a dam extending 1,400 feet across the outlet. The dam site is in sec. 6, T. 13 N., R. 16 E.

In a report to the Federal Power Commission by the California Power Board in April 1924, the Rock Bound and Buck Island sites were listed as having a potential storage capacity of 24,000 acre-feet. It was proposed that water from the Rubicon River be routed by way of Rock Bound, Buck Island, and Loon Lakes to Gerle Creek and back to the Rubicon River near Parsley Bar for power development.

F. E. Bonner, in "Water powers of California" (1928), suggested diversion to Rock Bound Lake and Buck Island Lake from the Rubicon River, with a storage capacity of 7,000 acre-feet at Rock Bound Lake and a small additional amount at Buck Island Lake. Water would be routed thence to Loon Lake Reservoir for power development downstream. Storage at Rock Bound Lake was listed as between the altitudes of 6,450 and 6,555 feet.

W. R. Farley, in his "Report on power withdrawals of Middle Fork American River" for the Forest Service in 1935, suggested a similar scheme with a storage capacity of 22,000 acre-feet at the Rock Bound site below an altitude of 6,575 feet. He listed the potential capacity of the Buck Island site as 2,300 acre-feet below an altitude of 6,445 feet.

E. F. Sullivan, of the Bureau of Reclamation, also suggested diversion of upper Rubicon River water by way of Rock Bound and Buck Island Lakes to the proposed Loon Lake and Gerle Creek reservoirs for power development (unpublished report, Nov. 10, 1943).

In March 1948 the Georgetown Divide Public Utility District applied to the State of California (applications 12421, 12422, and 12423) for permits to appropriate waters from several drainage basins within the American River basin, including the Rubicon River area. Water would be used for irrigation, domestic, stock-watering, and power purposes. One of the diversion points was listed as Rock Bound Lake, sec. 6, T. 13 N., R. 16 E. Details of the plan were not stated.

Investigations of power possibilities in the upper Rubicon River area were made by the Stone & Webster Engineering Corp., from about 1908 to 1912, for the Loon Lake Water & Power Co. (controlled by the Southern Pacific Co.). Several gaging stations were operated for this study, including one on the Rubicon River at Rubicon Springs, a mile downstream from the proposed diversion point. The drainage area at the gage was listed as 31.6 square miles. The drainage area tributary directly and by diversion to Rock Bound and Buck Island Lakes is roughly 32 square miles. During the three water years ending Sept. 30, 1913, the annual runoff of the Rubicon River at Rubicon Springs was recorded as 4,050, 1,820, and 2,120 acre-feet per square mile. The 1910-11 water year was unusually wet, whereas the following 2 years were relatively dry. From November 1910 to August 1911, the runoff of the Little Rubicon River near the outlet of Buck Island Lake was recorded as 4,570 acre-feet per square mile.

Records also were obtained at a downstream station on the Rubicon River during these early years and have been kept from 1944 to date. This station is now called Rubicon River near Georgetown. Its drainage area is listed as 198 square miles and included the Little South Fork Rubicon River drainage basin. Comparisons with the long-time record of the American River at Fair Oaks indicate that the average annual runoff at this station from 1905 to 1945 was about 2,100 acre-feet per square mile. The records for the early years show that the unit runoff at Rubicon Springs was roughly 20 percent more than at the Georgetown station during wet seasons and 30 to 40 percent more during the drier seasons. From these and other comparisons it is judged that the average annual runoff subject to capture at the Rock Bound Lake and Buck Island Lake reservoir sites is 2,650 acre-feet per square mile during periods like that from 1905 to 1945 and 2,500 acre-feet per square mile during periods like the years from 1921 to 1945. Thus the average annual supply from diversion and inflow at Buck Island Lake may be between 80,000 and 85,000 acre-feet. The records indicate that the runoff in the upper Rubicon River area is unusually well sustained during dry years and periods. The average annual runoff during the dry period of six water years ending Sept. 30, 1934, is estimated as 1,850 acre-feet per square mile, or a total of 59,000 acre-feet from the Rubicon diversion and natural inflow at Rock Bound and Buck Island Lakes.

The Bureau of Reclamation obtained a map of the Rock Bound Lake and Buck Island Lake areas (Fairchild Aerial Surveys, May 1946) showing the topography to an altitude of 6,600 feet at Rock Bound Lake and along the Rubicon and to 6,490 feet around Buck Island Lake. The scale is 1:12,000, and the contour interval is 10 feet. This map shows the altitude of the Rubicon channel as 6,500 feet at the dam site. The width of the can-

yon at an altitude of 6,600 feet is about 1,000 feet. No land lines nor found corners were shown, and for the purposes of this report the locations were approximately determined by reference to a planimetric map of the Fallen Leaf quadrangle prepared by the Forest Service (scale, 1:31,680).

Rough determinations from the reservoir-site map indicate that the potential storage capacity of the Rock Bound site, including the Rubicon diversion area, is perhaps 30,000 acre-feet between the altitudes of 6,525 and 6,600 feet. At Buck Island Lake the potential capacity between the altitudes of 6,420 and 6,490 feet is perhaps 8,000 acre-feet. It is judged that the potential storage capacity is not sufficient for complete control in a year of average runoff, since the annual runoff is largely concentrated in the snow-runoff period.

For the purpose of listing land status and reviewing the classifications, possible flow lines were assumed to be at the limiting contours of the Bureau map. Rock Bound Lake is within the Desolation Primitive Area of Eldorado National Forest, although the site was substantially covered by power withdrawals before this area was set aside. It seems possible that the decision as to the range of permissible reservoir operations may depend partly on the effect of varied reservoir levels on scenic and recreation values.

Loon Lake Reservoir site, Gerle Creek (Rubicon River drainage basin)

The Loon Lake Reservoir site is between the altitudes of 6,315 and 6,430 feet and comprises the present Loon Lake Reservoir and surrounding areas. The main dam site is in sec. 5, T. 13 N., R. 15 E., at the Gerle Creek outlet of the lake. The stream bed is at an altitude of 6,315 feet, and the crest of the present dam is at an altitude of 6,350 feet, as shown on a map of the site obtained by the Bureau of Reclamation in 1946. There is an auxiliary dam at another outlet of the lake (tributary to Gerle Creek) in sec. 7, T. 13 N., R. 15 E., at a stream-bed altitude of 6,340 feet. A saddle dam would be required in sec. 33, T. 14 N., R. 15 E., for development above an altitude of 6,390 feet. Another saddle dam would be required near the west boundary of sec. 5, T. 13 N., R. 15 E., for development above an altitude of 6,415 feet. The Loon Lake area, like the upper Rubicon drainage basin, is characterized by extensive granite outcrops and scanty growth of timber.

The Loon Lake Reservoir was constructed in 1884 to provide a water supply for mining purposes on Georgetown Ridge. Later the supply was used mainly for irrigation. The present reservoir capacity is 11,000 acre-feet, increased from 8,000 acre-feet in 1934. The reservoir, as well as a canal system from Gerle Creek by way of Pilot Creek to Georgetown Ridge, is operated by the Georgetown Divide Water Co.

The Loon Lake site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources.

Various plans have been suggested for an increase in the capacity of the reservoir and use for power purposes. In "Water powers of California" (1928), F. E. Bonner listed the ultimate capacity as 44,000 acre-feet below an altitude of 6,397 feet. He suggested the diversion of water to Loon Lake from the Rubicon River by way of Rock Bound and Buck Island Lakes and also from the Little South Fork Rubicon River. Power would be developed through a drop of 425 feet to the proposed Gerle Creek reservoir and thence through a series of plants with an additional drop of more than 5,000 feet. In his "Report on power withdrawals on Middle Fork American River" (1935), W. R. Farley suggested the same plan for the Loon Lake site, listing the headwater altitude as 6,400 feet and the storage capacity as 42,000 acre-feet with a 50-foot drawdown. He suggested that the irrigation requirements on Georgetown Ridge could be supplied by storage on Pilot Creek and diversion to Pilot Creek from Rubicon River conduits at a lower altitude than Loon Lake. Farley's plan also contemplated the storage of about 24,000 acre-feet at the Rock Bound Lake and Buck Island Lake sites.

E. F. Sullivan, of the Bureau of Reclamation, in an unpublished report dated Nov. 10, 1943, also proposed the use of Loon Lake site for power purposes. He estimated that the ultimate requirement for diversion to Georgetown Ridge may be 26,700 acre-feet per year, including an allowance for transport losses.

In March 1948 the Georgetown Divide Public Utility District applied to the State of California (applications 12421 and 12423) for permits to appropriate 220 second-feet and 260,000 acre-feet from some American River basin streams, including several tributaries of Rubicon River, for irrigation, domestic, and stock-watering purposes and 240 second-feet and 260,000 acre-feet from the same sources for power. Prospective diversion points included Rock Bound Lake and Loon Lake, the latter in sec. 5, T. 13 N., R. 15 E., presumably at the Gerle Creek outlet.

As pointed out by Bonner and Farley, it would be possible to divert water from the Little South Fork Rubicon River for an additional supply to Loon Lake. About half a mile of conduit leading from the stream channel to the southwest corner of the reservoir site would tap 4 square miles of the headwater area in the Little South Fork drainage basin. It is judged that the potential additional supply would be equal to 50 percent of that directly tributary to the lake from its drainage area of 8 square miles.

A gaging station was operated on Gerle Creek at the outlet of Loon Lake from July 1910 to April 1914, but the records are incomplete and the discharge was affected by storage in Loon Lake. Records for the Little South Fork Rubicon River at stations upstream and downstream from the mouth of Gerle Creek, corrected for diversions from Gerle Creek, indicate that the annual runoff from the entire Gerle Creek drainage area of 33 square miles was roughly 3,190, 1,070, and 1,390 acre-feet per square mile, respectively, during the three water years ending Sept. 30, 1913. The unit runoff during this period apparently was somewhat less than from the upper Little South Fork drainage basin and was roughly only 70 percent of that of the upper Rubicon River drainage basin. The area directly tributary to Loon Lake is about 8 square miles and is in the upper part of the Gerle Creek drainage basin. Figuring the unit runoff from this area as 80 percent of the estimated Rubicon figures (and ignoring evaporation losses

from Loon Lake), the potential annual supply would be roughly 2,100 acre-feet per square mile for periods like that from 1905 to 1945 and 2,000 acre-feet per square mile for periods like that from 1921 to 1945. The entire supply from the 8 square miles thus would be roughly 17,000 and 16,000 acre-feet per year for periods like the years 1905-45 and 1921-45, respectively. It is judged that the difference in unit runoff as compared with that of the upper Rubicon results mainly from lesser precipitation, rather than from a difference in drainage-basin losses. The average annual runoff during the dry period 1928 to 1934, therefore, is also estimated on the basis of 80 percent of the Rubicon rates, or a total of 12,000 acre-feet per year at Loon Lake.

The Bureau of Reclamation obtained a map of the Loon Lake site (Fairchild Aerial Surveys, May 1946) showing the topography to an altitude of 6,430 feet. An assembled edition is printed on a scale of 1:12,000, and the contour interval is 10 feet. Rough determinations from this map indicate that the potential storage capacity between the altitudes of 6,350 and 6,400 feet is 60,000 acre-feet; between the altitudes of 6,400 and 6,415 feet, 21,000 acre-feet; and between the altitudes of 6,415 and 6,430 feet, 24,000 acre-feet. Thus it would be topographically feasible to provide a capacity of more than 100,000 acre-feet above the present flowage line of the reservoir. This evidently is more than required for the control of runoff directly tributary to the site, but possibly it could be used advantageously for control of the entire potential supply from inflow and diversion. For a period like that from 1921 to 1945 it is estimated that the average annual supply from all sources would be 104,000 acre-feet. The potential capacity at Loon Lake would provide for substantial control without regulation at Rock Bound and Buck Island Lakes. It is probable, therefore, that the storage requirement will depend primarily on the relative economy of the several sites.

For the purpose of listing land status and tentative power-site classifications, it was assumed that 6,430 feet represents the possible headwater altitude from the ultimate dam. The reservoir-site map does not show land lines or found section corners. The approximate locations of lands were determined from land lines indicated on recent planimetric maps of the Robbs Peak and Granite Chief quadrangles obtained by the Forest Service (scale, 1:31,680).

Gerle Creek reservoir site, Gerle Creek (Rubicon River drainage basin)

The Gerle Creek reservoir site is between the altitudes of 5,800 feet and 6,020 feet along Gerle Creek, a few miles downstream from Loon Lake. The main dam site is in secs. 2 and 3, T. 13 N., R. 14 E. A short saddle dam would be required in secs. 1 and 2, T. 13 N., R. 14 E., for development above an altitude of 5,950 feet. Another saddle dam would be required in sec. 34, T. 14 N., R. 14 E., for development above an altitude of 5,975 feet. The Rubicon River is 3 miles west of this site, at an altitude of 4,200 feet.

This site was listed by F. E. Bonner, in "Water powers of California" (1928), for a small storage of 8,000 acre-feet and diversion from the reservoir at an altitude of 5,850 feet via tunnel and penstock to a powerhouse on the Rubicon River at an altitude of 4,170 feet. Investigations of the project had been made previously by the Stone & Webster Engineering Corp. for the Loon Lake Water & Power Co. Test borings of the dam site were made in 1911. (Unlike the Loon Lake and upper Rubicon sites, this section has a considerable overburden of sand, boulders, and clay.)

W. R. Farley, of the Forest Service, included the Gerle reservoir site in his plan for the development of the Middle Fork American River, suggesting a capacity of 83,000 acre-feet between the altitudes of 5,830 and 5,980 feet.

A brief report by E. F. Sullivan, of the Bureau of Reclamation, dated Nov. 10, 1943 (unpublished), suggested a reservoir at this site with an active capacity of 70,000 acre-feet between the altitudes of 5,860 and 5,964 feet.

Applications were made to the State of California (applications 12421 and 12423) in March 1948 by the Georgetown Divide Public Utility District for permits to appropriate waters of Gerle Creek in sec. 2, T. 13 N., R. 14 E., for irrigation, domestic, and power purposes, in addition to waters from several other locations in the upper Middle Fork and South Fork American River basins.

The drainage area downstream from Loon Lake to the Gerle Creek site is approximately 13 square miles. Records for the Little South Fork Rubicon River at stations upstream and downstream from the mouth of Gerle Creek indicate that the unit runoff in the Gerle Creek drainage basin from 1911 to 1913 was only 70 percent of that in the upper Rubicon River drainage basin. On this basis, it is judged that the average annual runoff from the 13 square miles below Loon Lake would be 1,850 acre-feet per square mile for periods like that from 1905 to 1945. It is believed that losses in this area are relatively large, as compared with losses in the upper Rubicon drainage basin, because of greater soil and forest cover and a somewhat lower altitude. The average annual supplies for drier periods like the years 1921-45 and 1929-34 accordingly are estimated as even less than 70 percent of the corresponding Rubicon rates, or 1,700 acre-feet per square mile during the 25-year period and 1,100 acre-feet per square mile during the 6-year period. The corresponding averages for the drainage area of 13 square miles are 24,000 acre-feet per year from 1905 to 1945; 22,000 acre-feet per year from 1921 to 1945, and 14,000 acre-feet per year from 1929 to 1934.

The Bureau of Reclamation obtained a map of the reservoir site (Fairchild Aerial Surveys, May 1946) showing the topography to an altitude of 6,020 feet and higher at the dam site. An assembled edition is on a scale of 1:12,000, and the contour interval is 10 feet.

The reservoir areas and capacities, roughly determined from this map, are listed in the following skeleton table:

Altitude (feet)	Area (acres)	Capacity (acre-feet)
5,800	0	0
5,850	120	6,000
5,900	720	30,000
5,950	900	70,000
6,000	1,160	120,000

The potential capacity evidently is considerably more than needed for the control of runoff below Loon Lake. The degree of use probably will depend largely on the relative economy of storage at this and upstream sites.

For listing land status and making power-site classifications, it was assumed that the maximum-flowage line would be at an altitude of 6,020 feet. The Bureau map shows the corners of the quarter sections at the W. boundary of sec. 35, T. 14 N., R. 14 E., and the W. boundary of sec. 2, T. 13 N., R. 14 E., as having been found. The approximate location of lands was determined by reference to these corners and to land lines as shown on the Forest Service map of the Granite Chief quadrangle (scale, 1:31,680).

Upper Hell Hole, Lower Hell Hole, and Parsely Bar reservoir sites, Rubicon River

These sites cover almost a continuous reach of the Rubicon canyon in T. 14 N., Rs. 14 and 15 E. The Upper Hell Hole dam site is in sec. 2, T. 14 N., R. 14 E., a mile downstream from the mouth of Five Lakes Creek. The Lower Hell Hole dam site is in sec. 16, T. 14 N., R. 14 E. The Parsley Bar dam site is in the NW¼ sec. 32, T. 14 N., R. 14 E. The range of altitude is from 4,030 feet on the channel at the Parsley Bar site to 4,820 feet at the contemplated maximum-flowage line of the proposed Upper Hell Hole reservoir. The dam sites are on bedrock granite, exposed or with only a sparse overburden.

According to W. R. Farley's report, "Power withdrawals on Middle Fork American River" (1935), the Parsley Bar site was investigated by the Stone & Webster Engineering Corp., and F. Baum & Co., for the Loon Lake Water & Power Co., from 1908 to 1912. In 1905 a survey was made of the Lower Hell Hole site by the Rubicon Water & Power Co. (controlled by the Southern Pacific Co.), and a survey of Upper Hell Hole site was made by F. Baum & Co. about 1908. Farley suggested net capacities of 80,000, 115,000, and 25,000 acre-feet, respectively, for the Upper Hell Hole, Lower Hell Hole, and Parsely Bar reservoirs. Active storage was listed as between the altitudes of 4,800 and 4,600 feet; 4,500 and 4,323 feet; and 4,150 and 4,025 feet, respectively. The function of the reservoirs would be the power regulation of runoff downstream from a proposed diversion point on the upper Rubicon to the Loon Lake-Gerle Creek project which would return water to the Rubicon at Parsely Bar.

Previously the California Power Board, reporting to the Federal Power Commission in April 1924, had listed capacities of 32,000 acre-feet available at Hell Hole and 13,000 acre-feet at Parsley Bar. F. E. Bonner's report to the Federal Power Commission in 1928 listed a capacity of 14,000 acre-feet for the Parsley Bar site but did not include the Hell Hole sites.

The Lower Hell Hole site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit of the State water plan for maximum utilization of water resources.

Recently E. F. Sullivan, of the Bureau of Reclamation, has suggested an active storage capacity of 160,000 acre-feet for the Lower Hell Hole site and a dam below Parsley Bar for reregulation and diversion (unpublished report of Nov. 10, 1943).

In March 1948 applications were made to the State of California by Placer County (applications 12456, 12457, and 12458) for permits to appropriate waters of the Middle and North Fork American Rivers, including diversions from the Rubicon River in secs. 2 and 16, T. 14 N., R. 14 E., presumably at the Upper and Lower Hell Hole dam sites. Municipal, irrigation, and power uses were listed.

The Bureau of Reclamation obtained maps of the three sites in May 1946 (Fairchild Aerial Surveys). The topography at the Upper Hell Hole site is shown to an altitude of 4,820 feet, and the altitude of the river at the dam site is shown as 4,520 feet. The topography at the Lower Hell Hole site is shown to an altitude of 4,480 feet, and the altitude of the river at the dam site is 4,250 feet. The topography at the Parsley Bar site is shown to an altitude of 4,260 feet, and the altitude of the stream at the dam site is 4,030 feet. The maps are printed on a scale of 1:6,000, and the contour interval is 10 feet.

Rough determinations from these maps indicate that potential storage capacities at the Upper Hell Hole, Lower Hell Hole, and Parsley Bar sites are about 93,000 acre-feet, 68,000 acre-feet, and 51,000 acre-feet, respectively. The drainage area above Upper Hell Hole to the diversion point to the Loon Lake-Gerle Creek project is 71 square miles; above Lower Hell Hole 82 square miles; and above Parsley Bar 88 square miles.

The runoff of the Rubicon River near Georgetown was measured from 1910 to 1914 and has likewise been measured from 1944 to date. The gaging station is 6 miles downstream from the Parsley Bar site and a mile downstream from the mouth of the Little South Fork Rubicon River. The annual runoff at the Rubicon station for other years can be estimated fairly accurately by correlation of the record with the long-time record of the American River at Fair Oaks. Also, there is a fair correlation between the figures of annual runoff for the Rubicon River and Little South Fork stations during the early years. From these relations it is deduced that the average annual runoff of the Little South Fork for a period like that from 1921 to 1945 would be 1,800 acre-feet per square mile. This is taken as a rough measure of the unit runoff from the entire area of 76 square miles between Parsley Bar and the Rubicon River near Georgetown, which includes 17 square miles in addition to the South Fork drainage area at a similar altitude. Allowing for runoff in the upper Rubicon drainage basin as estimated on page 18, the average annual rate for the intervening 88 square miles upstream from Parsley Bar is computed, accordingly, as 2,000 acre-feet per square mile from 1921 to 1945. The runoff from this area represents the dependable supply at Parsley Bar after the prospective diversion through Rock Bound and Buck Island Lakes to Loon Lake.

The water supplies available from intervening areas between the Parsley Bar and other Rubicon River sites, as similarly estimated, are as follows:

Area	Extent (sq. miles)	Average annual runoff (acre-feet)		
		1905-45	1921-45	1929-34
Between Rubicon diversion and Upper Hell Hole	71	141,000	134,000	89,000
Between Upper Hell Hole and Lower Hell Hole	11	22,000	20,000	13,500
Between Lower Hell Hole and Parsley Bar	6	11,500	10,700	7,000

The Bureau of Reclamation maps of 1946 do not show land lines or found corners. For the purpose of listing status of lands and tentative power-site classifications, the land lines were approximately located on these maps from the land net shown on recent Forest Service planimetric quadrangle maps. Flow lines were taken as at the top contour of the Bureau maps.

Union Valley reservoir site, Silver Creek (South Fork American River drainage basin)

The Union Valley reservoir site is along Silver Creek and the North and Middle Forks Silver Creek between the altitudes of 4,510 and 4,900 feet. The dam site is a mile downstream from the confluence of the North and Middle Forks, mainly in sec. 20, T. 12 N., R. 14 E., and possibly extending into adjacent section 29.

This reservoir site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources. It was designated Silver Creek No. 2. Another site was listed in sec. 15, T. 12 N., R. 14 E., as Silver Creek No. 1 (on North Fork Silver Creek). The latter would be within the Union Valley site.

The Union Valley site was investigated by the City of Sacramento and later by the Sacramento Municipal Utility District with a view to storage and regulation for proposed municipal and power developments. The district plans call for a storage capacity of 225,000 acre-feet below a pool level of 4,843 feet and an outlet at an altitude of 4,625 feet for diversion by tunnel to the proposed Big Bend powerhouse on Silver Creek at an altitude of 3,705 feet. Water from the Icehouse reservoir on South Fork Silver Creek would be diverted into the Union Valley reservoir by way of the Middle Fork Silver Creek. In February 1948 the Sacramento Municipal Utility District applied to the State of California for permits to appropriate water from Silver Creek and the South Fork for municipal, irrigation, and power purposes (applications 12321, 12322, and 12323).

W. R. Farley, in his report on "Power withdrawals of the South Fork American River" (June 1936), suggested the use of Silver Creek waters primarily for power purposes, substituting water from the proposed Folsom or Coloma reservoirs downstream for other proposed uses. He suggested a storage capacity of 160,000 acre-feet for the Union Valley site, with a 330-foot dam to an altitude of 4,815 feet. Water would be conveyed by tunnel and penstock to the Junction powerhouse at an altitude of 4,300 feet.

A gaging station was operated near the dam site from 1924 to 1927 and has been operated continuously since 1928. Discharge records show that the average flow for 20 years was 200 second-feet, corresponding to an average annual runoff of 145,000 acre-feet. The average during the six water years 1929-34 was 90,000 acre-feet. It is judged that a storage capacity of 160,000 acre-feet would provide for complete regulation during such periods.

The Bureau of Reclamation has obtained a map of the Union Valley site (Fairchild Aerial Surveys, May 1946) showing the topography to an altitude of 4,900 feet. An assembled edition of this map is on a scale of 1:12,000, and the contour interval is 10 feet. The status of lands and tentative power-site classifications were determined on the assumption that the flowage line would be at 4,900 feet. The Bureau map shows the SW. corner and the quarter-section corners at the W. boundary of sec. 23, T. 12 N., R. 14 E. as found. Land lines used for listing status were approximately located on the Bureau map on the basis of these corners and the land net shown on a recent Forest Service planimetric map of the Robbs Peak quadrangle (scale, 1:31,680).

Icehouse reservoir site, South Fork Silver Creek (South Fork American River drainage basin)

The Icehouse site is along the South Fork Silver Creek between the altitudes of 5,300 and 5,460 feet. The dam site is in sec. 1, T. 11 N., R. 14 E.

This site was listed in Bulletin 26 of the State Division of Water Resources as a possible unit in the State water plan for maximum utilization of water resources.

The City of Sacramento (later the Sacramento Municipal Utility District) has planned the full development of Silver Creek and made extensive investigations of the project. The original plan contemplated the storage of 45,000 acre-feet at the Icehouse site on the South Fork Silver Creek between the altitudes of 5,275 and 5,420 feet in addition to 165,000 acre-feet at the Union Valley site on Silver Creek. In February 1948 the Sacramento Municipal Utility District applied to the State of California for permits (applications 12321, 12322, and 12323) to appropriate 310 second-feet and 275,000 acre-feet from the South Fork and Silver Creek for municipal and irrigation purposes and 400 second-feet and 275,000 acre-feet from these sources for power purposes (112,600 horsepower). These applications listed diversion points as in sec. 1, T. 11 N., R. 14 E.; sec. 20, T. 12 N., R. 14 E.; sec. 33, T. 12 N., R. 13 E.; sec. 15, T. 11 N., R. 12 E.; and sec. 19, T. 11 N., R. 12 E. These recent applications presumably have been made to protect the interests of the district in view of the accelerated development of California streams.

In a report on "Power withdrawals of South Fork American River" by W. R. Farley (June 1936), it was suggested that the Icehouse site be planned for active storage of 50,000 acre-feet between the altitudes of 5,325 and 5,435 feet and that water be conveyed from the reservoir by flume, tunnel, and penstock to the Junction powerhouse on Silver Creek at an altitude of 4,300 feet. The district plan contemplated diversion

from the Icehouse to the Union Valley reservoir on Silver Creek without utilizing the power drop above Union Valley.

A gaging station has been operated near the dam site since October 1924. The average discharge for the 21 years ending Sept. 30, 1945, was 71 second-feet, corresponding to an average annual runoff of 52,000 acre-feet. The average during the six water years 1929-34 was 34,300 acre-feet.

The Bureau of Reclamation has obtained a map of the Icehouse reservoir site (Fairchild Aerial Surveys, May 1946) showing the topography to an altitude of 5,460 feet. An assembled edition is on a scale of 1:12,000, and the contour interval is 10 feet. The status of lands and tentative power-site classifications were determined on the assumption that the flowage line might be at 5,460 feet. The Bureau map does not show land lines or found corners. Land lines were approximately located on this map from the land net as shown on a recent Forest Service planimetric map of the Robbs Peak quadrangle, as referred to topographic features.

Junction reservoir site, Silver Creek (South Fork American River drainage basin)

The Junction reservoir site is between the altitudes of 4,290 and 4,500 feet along Silver Creek and the South Fork Silver Creek. The dam site is in the SW¼ sec. 30, T. 12 N., R. 14 E. It is half a mile downstream from the mouth of the South Fork Silver Creek.

This site was suggested by W. R. Farley in his report on "Power withdrawals of South Fork American River" (June 1936). It consists of narrow reaches of Silver Creek and South Fork Silver Creek canyons not favorable for storage.

The stream altitude at the proposed dam site is 4,290 feet. The topography is shown on a recent Bureau of Reclamation map to 4,540 feet. The average canyon width in the reservoir area at an altitude of 4,540 feet is less than 500 feet, and the over-all length of the reservoir (including tributary arms) would be about 3 miles. It is judged that the reservoir capacity with a 250-foot dam would be less than 10,000 acre-feet.

Farley estimated the usable capacity as 15,000 acre-feet with a 135-foot dam (4,300 feet to 4,435 feet) on the basis of topography shown on the Pyramid Peak quadrangle map. The drawdown would have been 85 feet. The reservoir was proposed for the control of runoff from 30.6 square miles below the Icehouse and Union Valley sites.

In view of the unfavorable possibilities for storage, the writer judges that a 250-foot dam would not be justified. It is conceivable, however, that a diversion dam might be needed below the junction of Silver Creek and the South Fork Silver Creek for the capture of some unregulated runoff. Also, public lands in sec. 30, T. 12 N., R. 14 E., might be needed for proposed tunnel or conduit locations. It is doubtful that public lands in section 19 would be affected by either pondage or conduit locations.

In September 1948 Placer County applied to the State of California (applications 12689 and 12690) for permits to appropriate 1,000 second-feet and 250,000 acre-feet per year from Silver Creek in sec. 30, T. 12 N., R. 14 E., for power, domestic, and irrigation purposes.

Auburn and Oregon Bar reservoir sites, North Fork American River

The Auburn reservoir site is along the North Fork and Middle Fork American Rivers between the altitudes of 520 and 960 feet. Two dam sites have been investigated. The lower site is on the North Fork American River in the south half of sec. 11, T. 12 N., R. 8 E., 1.4 miles downstream from the junction of the Middle Fork with the Nork Fork, at a stream altitude of 520 feet. The upper site is on the North Fork in the NW¼ sec. 12, extending into sec. 11. It is just downstream from the mouth of the Middle Fork, at a stream altitude of about 533 feet.

The Oregon Bar reservoir site is along the North Fork and Middle Fork American Rivers between the altitudes of 410 and 950 feet. The dam site is on the North Fork, mainly in sec. 35, T. 12 N., R. 8 E., extending into sec. 34. The site is just downstream from the mouth of Pilot Creek and is at the upper end of the Pilot Creek dam site, considered as an afterbay site for the prospective Auburn dam.

The Auburn site was selected as a major unit of the State water plan and is described in Bulletin 25 of the State Division of Water Resources. It was proposed to construct a 440-foot dam at the lower site to create a storage capacity of 831,000 acre-feet. The project was considered in connection with the prospective Coloma reservoir on the South Fork American River and the prospective Folsom reservoir on the main stem downstream. A power plant with a capacity of 85,000 kilovolt-amperes would have been constructed at the dam. Power also would have been developed at the prospective Pilot Creek dam, 6 miles downstream at a stream altitude of 407 feet, to utilize a head of 110 feet between the Auburn dam and the Folsom reservoir. A capacity of 90,000 acre-feet would have been used at the Auburn site for flood-control reserve. With operation primarily for irrigation, it was estimated that the annual yield in new water would have been 838,000 acre-feet for periods like that from 1889 to 1929 with permissible deficiencies. A recent decision to provide a storage capacity of 1,000,000 acre-feet instead of 355,000 acre-feet at the Folsom site affects the possibilities at the Auburn and Pilot Creek sites. The Pilot Creek site will be inundated.

The Bureau of Reclamation did not select the Auburn site or alternatives on the North Fork in the plan of development outlined in the Department of the Interior report dated November 1945. However, the Bureau has investigated the Auburn site and has been making investigations of other North Fork sites. One preliminary proposal has been for the construction of a 300-foot dam at the Oregon Bar site at a stream altitude of about 410 feet. There would be an active capacity of 110,000 acre-feet with a drawdown of 60 feet, and the dam would be used for power development. The reservoir would flood the Auburn site. The proposed Oregon Bar dam would be subject to some backwater

from the Folsom reservoir. This site also has been considered for a high dam as an alternative to the Auburn dam. Preliminary investigations by the Bureau of Reclamation have indicated that it may be better than the Auburn site.

The State of California commented on the Bureau of Reclamation proposals for Central Valley development in a review dated April 1946. It was brought out in this review that additional information has been obtained recently about the foundation conditions at the Auburn site. The investigations have shown that stripping for the foundation would be much greater than originally estimated. The Bureau of Reclamation also reported that recent geological investigations have indicated that the cost of the Auburn reservoir would be very high. However, the State review concludes with a recommendation that the reservoir, as a feature of the State water plan, be included for future consideration in a study for formulating an ultimate plan for development of the water resources of the American River for all beneficial purposes. In connection with the review of the Department of the Interior report, the State made additional studies of the Auburn, Coloma, and Folsom units and afterbays. It was concluded that the total energy output of all the units would be in excess of a billion kilowatt-hours annually and that the irrigation yield would be 1½ million acre-feet of new water per year. There would be a maximum flood-control reserve of 260,000 acre-feet. The over-all benefit-cost ratio, figuring the amortization of reimbursable costs without interest, was estimated as about 1:2.

The State of California described some further studies and investigations of the Auburn and Oregon Bar sites in a "Supplemental report with reference to size of Folsom reservoir of American River development" (Aug. 8, 1947). These studies favored the upper site, instead of the lower site previously contemplated. The cost and performance were listed for four sizes of reservoir at the Auburn site, ranging from 250,000 to 850,000 acre-feet in capacity. Similar figures also were listed for reservoirs with capacities of 450,000, 650,000, and 850,000 acre-feet, operated coordinately with reservoirs of varied capacities at the Folsom and Coloma sites so that the three would provide a total of 2,500,000 acre-feet. Power plants would be operated in connection with each reservoir and at an afterbay below the Folsom reservoir. The maximum flood-control reserve for the three American River units of this study was 400,000 acre-feet, instead of the 260,000 acre-feet assumed for earlier studies. This was in accord with a recommendation of the Sacramento District, Corps of Engineers, dated July 2, 1947. The studies indicated that the cost and incremental cost of irrigation yield would be less at the Folsom site than at the North or South Fork sites, thus favoring the Folsom site for initial development.

An examination of the several American River dam sites was made by a board of consultants for the purpose of this supplemental report. The conclusions of the supplemental report include a statement that the limit of capacity at the Upper Auburn site would be about 650,000 acre-feet and, at the Oregon Bar site, about 700,000 acre-feet. The board of consultants reported on the Upper Auburn site, the Lower Auburn site, and the Oregon Bar site. Foundation conditions at the Oregon Bar site were found to be the most favorable; those at the Lower Auburn site were considered the least favorable.

In October 1948 El Dorado County and Placer County applied to the State of California (applications 12755 and 12759) for permits to appropriate water from the North Fork American River at or near the Auburn dam site. Power, irrigation, domestic, and stock-watering purposes were listed.

Stream-flow records have been obtained for the American River and its main branches for varying periods and published in water-supply papers of the Geological Survey. The runoff at the Auburn dam site may be estimated from these records, with allowances for diversions and inflow. The State Division of Water Resources, using data supplied by the Sacramento District, Corps of Engineers, has estimated the mean annual runoff for the 27-year period from 1915 to 1942 as 1,490,200 acre-feet.

The Geological Survey published a river plan and profile in 1942 which includes the Lower Auburn and Pilot Creek sites. The scale is 1:24,000, and the contour interval is 20 feet on land and 5 feet on the river surface. The topography is shown to a minimum altitude of about 960 feet on the Auburn reservoir site. The Lower Auburn dam site was mapped on a scale of 1:2,400, with a contour interval of 10 feet on land and 1 foot on the river surface. The topography is shown to an altitude of 1,000 feet. The Pilot Creek dam site was mapped on the same scale and with the same contour interval, and the topography is shown to an altitude of 560 feet.

The Bureau of Reclamation has prepared a map of the Oregon Bar dam site on a scale of 1:1,200 and with a contour interval of 5 and 10 feet. The topography is shown to an altitude of 1,020 feet.

Coloma and Webber Creek (Salmon Falls) reservoir sites, South Fork American River

The Coloma reservoir site is along the South Fork American River between the altitudes of 545 and 920 feet. The dam site is at a stream altitude of 543 feet in sec. 28, T. 11 N., R. 9 E., a mile and a half upstream from the mouth of Webber Creek.

A site three-quarters of a mile downstream from Webber Creek (Webber Creek or Salmon Falls dam site), at a stream altitude of 460 feet, also has been considered for a high dam as an alternative to the Coloma dam or for a low dam to develop the power drop between the Coloma dam and the Folsom reservoir. Preliminary investigations by the Bureau of Reclamation have indicated that this site may be better than the Coloma site for a high dam. The location is near the south boundary of sec. 30, T. 11 N., R. 9 E.

The Coloma site was selected as a major unit of the State water plan and is described in Bulletin 26 of the State Division of Water Resources. It was proposed to construct a 345-foot dam to create a storage capacity of 766,000 acre-feet. The project was considered in connection with the prospective Auburn reservoir on the North Fork American River and the prospective Folsom reservoir on the American River below the confluence of the North and South Forks. It was proposed that a capacity of 35,000 acre-feet be reserved for flood control at the Coloma site. The annual irrigation yield in new water (subject to permissible deficiencies) was estimated as 637,500 acre-feet. Power would

be developed at the Coloma dam through a maximum drop of 340 feet and, at the Webber Creek dam, through a drop of 105 feet. The output was considered only in connection with the entire system output, which included production for the prospective Auburn, Folsom, Pilot Creek, and Folsom-afterbay units. A recent decision to provide a storage capacity of 1,000,000 acre-feet instead of 355,000 acre-feet at the Folsom site affects the possibilities at the Coloma and Webber Creek sites as outlined in the original State proposal.

The Bureau of Reclamation selected the Coloma site as a major prospective reservoir of the Central Valley project, as proposed in the Department of the Interior report dated November 1945. A 363-foot dam would be constructed to provide a capacity of 800,000 acre-feet. The project was considered in connection with the prospective storage of 1,000,000 acre-feet at the Folsom reservoir, now authorized. A power plant with a capacity of 40,000 kilowatts would be constructed at the Coloma dam, and the average annual output for the dry period from 1928 to 1934 was estimated as 130 million kilowatt-hours. A low dam would be constructed at the Salmon Falls site to develop the head of about 80 feet between the proposed Coloma dam and the Folsom reservoir. The output at the Salmon Falls site was estimated as 55 million kilowatt-hours with an installed capacity of 12,000 kilowatts.

The State of California commented on the Bureau proposal in a review dated April 1946. It was pointed out that there have been recent additional investigations of the foundation conditions at the Coloma site which have an appreciable influence on estimates of cost. It was stated that the foundation rock is suitable for a concrete dam but that moderate excavation would be required in the stream bed and considerable excavation on the abutments. The State review recommended that a reservoir with a capacity of 800,000 to 1,000,000 acre-feet be deferred at the Coloma site until the unit is needed and justified as a step in American River development. (The storage of 1,000,000 acre-feet would back water to an altitude of about 920 feet.)

The State of California described some further studies and investigations of the Coloma and Salmon Falls sites in a "Supplemental report with reference to size of Folsom reservoir of American River development" (Aug. 8, 1947). The cost and performance were listed for four sizes of reservoir, at the Coloma site, ranging from 300,000 to 1,050,000 acre-feet in capacity. Similar figures also were listed for a reservoir with a capacity of 1,050,000 acre-feet, operated coordinately with reservoirs of three different capacities at the Folsom and Auburn sites so that the three reservoirs would provide a total capacity of 2,500,000 acre-feet. These studies indicated that the cost and performance of the several combinations would not be greatly different. The range was limited to capacities of 600,000, 800,000, and 1,000,000 acre-feet at the Folsom site.

An examination of the several American River dam sites was made by a board of consultants for the purposes of this supplemental report. The conclusions of the supplemental report include a statement that the upper limit of capacity at the Coloma site would be about 800,000 acre-feet and, at the Salmon Falls site, about 1,000,000 acre-feet. The board of consultants pointed out that a higher dam would be required at the Salmon Falls site than for the same capacity at the Coloma site, but that the foundation conditions are better and the topography is favorable for the construction of a spillway at a saddle some distance from the dam.

In November 1948 El Dorado County applied to the State of California (applications 12783, 12784, and 12785) for permits to appropriate water from the South Fork American River at or near the Coloma and Salmon Falls sites. The purposes were listed as power, irrigation, domestic, and stock watering.

A gaging station was operated on the South Fork American River at Coloma from 1929 to 1941. The average discharge for 12 years was 964 second-feet, corresponding to an average annual runoff of 700,000 acre-feet. The drainage area at the gaging station is 635 square miles and, at the dam site 6 miles downstream, 708 square miles. The State Division of Water Resources, using data supplied by the Sacramento District, Corps of Engineers, has estimated the mean annual runoff at the Coloma site as 734,800 acre-feet for the 27-year period 1915 to 1942.

The Geological Survey published a river plan and profile in 1942 which includes the Coloma reservoir site. The scale is 1:24,000, and the contour interval is 20 feet on land and 5 feet on the river surface. The topography is shown to a minimum altitude of 940 feet. The Coloma dam site was mapped on a scale of 1:4,800 and with a contour interval of 10 feet on land and 1 foot on the river surface. The topography is shown to an altitude of 1,000 feet. The Webber Creek dam site was mapped on the same scale and with the same contour interval, and the topography was shown to an altitude of 650 feet.

The Bureau of Reclamation has prepared a map of the Salmon Falls (Webber Creek) dam site on a scale of 1:1,200 and with a contour interval of 5 and 10 feet. The topography is shown to an altitude of 1,000 feet.

Folsom reservoir site, American River

The Folsom reservoir site is along the American River and the North Fork and South Fork American Rivers, between the altitudes of 196 and 487 feet. (The normal maximum pool altitude will be 466 feet.) The main dam site is on the American River in sec. 24, T. 10 N., R. 7 E., a mile downstream from the mouth of the South Fork. A number of auxiliary or saddle dams will be required for a considerable distance on both sides of the river. The aggregate crest length of the dams will be 5 1/3 miles.

The reservoir was selected as a major unit of the State water plan, and a proposal for development to a capacity of 355,000 acre-feet, with a description of the site, is given in Bulletin 26 of the State Division of Water Resources.

The Bureau of Reclamation selected the site as a major prospective reservoir of the Central Valley project, with a storage capacity of 1,000,000 acre-feet at the maximum-flowage line, 466 feet. The proposal is contained in the Department of the Interior report of November 1945.

The Corps of Engineers first proposed a reservoir with a capacity of 355,000 acre-feet at the Folsom site, and the project was so authorized for construction in Public Law 534, 78th Congress, 2d session. It was authorized in the same form by the California legislature, California statutes of 1945, chapter 1514, section 47.

A flood-control survey report of the Sacramento District, Corps of Engineers, of February 1945, brought up to date by a supplement of June 1948, proposed the construction of Folsom reservoir to a capacity of 1,000,000 acre-feet, with a maximum flood-control reservation of 260,000 acre-feet. One of the reasons for the change in plan is the fact that investigations had indicated less favorable conditions for storage upstream at the Auburn and Coloma sites than was anticipated.

The State of California discussed the proposals of the Bureau of Reclamation and the Corps of Engineers in reviews dated April 1946. As a result of further studies by State investigators it was concluded that the optimum storage capacity would be 600,000 acre-feet. The studies indicated that the financial aspect of the project became progressively less favorable with an increase in capacity above 355,000 acre-feet, but that a capacity of 600,000 acre-feet was needed at the Folsom site to meet requirements. It was also concluded, however, that with Federal financing a project having a reservoir capacity of 1,000,000 acre-feet would be financially feasible, assuming that the estimated water and power revenues would be realized.

The State of California described some further studies and investigations of the Folsom site in a "Supplemental report with reference to size of Folsom reservoir of American River development" (Aug. 8, 1947). The cost and performance were listed for five sizes of reservoir at the Folsom site, ranging from 600,000 to 2,500,000 acre-feet in capacity. Similar figures also were listed for reservoirs with capacities of 600,000, 800,000, and 1,000,000 acre-feet, operated coordinately with reservoirs of different capacities at the Auburn and Coloma sites so that the three reservoirs would provide a total capacity of 2,500,000 acre-feet. The maximum flood-control reserve for the three American River units of this study was 400,000 acre-feet, instead of the 260,000 acre-feet assumed for earlier studies. It was concluded that a capacity of 1,000,000 acre-feet at the Folsom site is the practicable limit. It was recommended that the reservoir be constructed to this capacity, and because of favorable performance in flood control, irrigation, and power it should be the initial unit for American River development.

The studies and recommendations of the several interested State and Federal agencies have led to authorization of the construction of the Folsom reservoir to a capacity of 1,000,000 acre-feet. The reservoir is to be constructed by the Corps of Engineers, with operation and maintenance by the Bureau of Reclamation. The Bureau is authorized to construct a power plant in connection with the project, with a capacity of approximately 120,000 kilowatts, and an afterbay dam and power plant (Public Law 356, 81st Congress, 1st session).

The State of California has estimated that the annual irrigation yield with a capacity of 1,000,000 acre-feet at the Folsom reservoir will be about a million acre-feet annually. This will be more than needed in the local service area, and there will be a surplus available for export to the San Joaquin Valley and other regions. The State investigators estimated the energy output as 480 million kilowatt-hours per year, with a capacity of 140,000 kilovolt-amperes at the dam and 25,000 kilovolt-amperes at the afterbay.

According to the State review of April 1946, there will be an ultimate need for a reservoir capacity of 2,500,000 acre-feet in the lower American River drainage basin for complete control and utilization. This could be obtained with the future addition of the Auburn and Coloma units. The Bureau of Reclamation, in the Department of the Interior report dated November 1945, concluded that a considerable portion of the American River flow could be stored in the proposed Ione reservoir in the Mokelumne River drainage basin. This would be accomplished by diversion of water from the Folsom reservoir southward by canal for eventual use in the San Joaquin Valley. The Bureau concluded that this would limit the major storage requirements on the lower American River to the Folsom and Coloma sites. The State of California, commenting on this proposal in 1946, questioned that the proposed Folsom-Ione-Mendota canal with off-stream storage of American River water is justified. It was proposed instead to use the Ione reservoir in the plan of development for the Mokelumne River. Canal diversion southward from Folsom would provide a supplemental irrigation supply in the service areas dependent on the Cosumnes, Mokelumne, and Calaveras Rivers.

A gaging station has been operated on the American River at Fair Oaks since 1904. The mean annual runoff for 42 years of record, to 1947, was 2,680,000 acre-feet. The drainage area at the gage is 1,918 square miles and, at the Folsom dam site, 1,875 square miles. The State Division of Water Resources, using data furnished by the Sacramento District, Corps of Engineers, estimated the mean annual runoff at the Fair Oaks gage as 2,447,000 acre-feet for the 27-year period from 1915 to 1942.

The prospective storage reservoirs in the upper American River drainage basin that have been described herein would have some incidental effect in reducing the storage requirements for flood control and irrigation, but it is judged that this would be relatively small.

COSUMNES RIVER DRAINAGE BASIN

Nashville reservoir site, Cosumnes River

The Nashville reservoir site is along the Cosumnes River and its tributaries, the North Fork and Middle Fork Cosumnes Rivers, and Big Indian Creek, between the altitudes of 765 and 1,100 feet. The dam site is on the Cosumnes River half a mile downstream from the confluence of the North and Middle Forks and a quarter of a mile downstream from the mouth of Big Indian Creek. It is in secs. 14 and 15, T. 8 N., R. 10 E.

The Nashville reservoir is a unit of the State water plan and is described in Bulletin 29 of the State Division of Water Resources. The State proposal called for a storage capacity of 281,000 acre-feet as adequate for regulation of the flow without waste. A storage capacity of 56,000 acre-feet was to be used for flood control. The maximum water-surface altitude was listed as 1,020 feet, and the height of the dam above stream bed

as 270 feet. It was pointed out that the water supply available from the Nashville reservoir would not be sufficient for the irrigation requirements of the Cosumnes River service area and that supplemental supplies would ultimately be obtained from the American River. The State proposal did not contemplate the development of water power.

The Bureau of Reclamation, in the Department of the Interior report on the Central Valley basin of November 1945, proposed a reservoir with a storage capacity of 550,000 acre-feet at the Nashville site and with a dead storage of 44,000 acre-feet. The maximum-flowage line was listed as at 1,087 feet, and the stream-bed altitude as 765 feet. It was estimated that the reservoir would provide a firm water supply of 100,000 acre-feet annually and that surplus water would be available for export southward in the San Joaquin Valley. (On the basis of records then available, the State investigation indicated that there would have been a mean annual yield for irrigation of 163,000 acre-feet for the period from 1918 to 1929.) The Bureau proposed to install a power plant with a capacity of 18,000 kilowatts in connection with the reservoir. The average annual output was estimated as 55 million kilowatt-hours during a period like that from 1928 to 1934.

The Sacramento District, Corps of Engineers, in a flood-control survey report of February 1945, brought up to date by a supplement of June 1948, also contemplated use of the Nashville site. The proposal was for a reservoir with a capacity of 550,000 acre-feet and a maximum flood-control reservation of 300,000 acre-feet. The project would include a power plant with a capacity of 10,000 kilovolt-amperes, and the annual output was estimated as 61 million kilowatt-hours.

The State of California, commenting on both the Bureau's and the Corps of Engineer's proposals in reviews published April 1946, found that they were not economically feasible at that time. It was recommended that the project be reexamined on the basis of a smaller capacity of 250,000 to 300,000 acre-feet, as this was judged to be sufficient for irrigation and flood-control purposes. The mean annual runoff at the dam site was listed as 333,000 acre-feet, and the estimated maximum flood for the period of record as 27,500 second-feet.

The Federal Power Commission, San Francisco office, commenting on the power features of the Bureau of Reclamation's proposals, pointed out that the cost of the Nashville power installation would be relatively high and that the full plant capacity would be used for only 2 months in an average year. It was mentioned that the plant would be located 1.5 miles downstream from the dam, connected to an arm of the reservoir by a 4,400-foot tunnel. The report suggested an installed capacity of about 12,000 kilowatts as more appropriate than the Bureau's proposed 18,000 kilowatts (report, not for public release, dated January 1946).

In February 1948 Amador County applied to the State of California (application 12342) for a permit to appropriate 100 second-feet and 18,322 acre-feet from the Cosumnes River in sec. 14, T. 8 N., R. 10 E., and sec. 18, T. 9 N., R. 12 E., the former location being at the Nashville dam site.

In November 1948 El Dorado County applied to the State of California for 21 permits to appropriate waters of the Cosumnes River and tributaries for municipal, irrigation, stock-watering, and power purposes. Three of the applications (12830, 12831, and 12832) were for permits to appropriate 2,000 second-feet and 795,000 acre-feet per year from the Cosumnes River in sec. 14, T. 8 N., R. 10 E., at the Nashville dam site. A number of the applications were for permits to appropriate substantial amounts of water (up to 1,000 second-feet and 100,000 acre-feet per year) from tributaries upstream from the Nashville site.

Discharge records have been obtained on the Cosumnes River at Michigan Bar since October 1907. The average yearly discharge to Sept. 30, 1945, was 478 second-feet, corresponding to a mean annual runoff of 347,000 acre-feet. During the six water years 1929-34 the mean annual runoff was about 146,000 acre-feet. The drainage area at the Nashville dam site is 435 square miles, or 81 percent of that at the gaging station, but the State investigators judged that about 93 percent of the runoff originates above the dam site. There are some diversions to the American River basin and some irrigation diversions within the basin upstream from the dam site, and there have been proposals for larger diversions.

The State investigators determined the potential capacity of the Nashville site from a topographic map prepared by Stephen E. Kieffer in 1925 (scale, 1:24,000). Areas and capacities were tabulated to an altitude of 1,100 feet, corresponding to a capacity of 613,000 acre-feet. (See Bulletin 26 of the State Division of Water Resources.)

The Bureau of Reclamation obtained a map of the Nashville site (Fairchild Aerial Surveys, March 1946) showing the topography to an altitude of 1,100 feet generally and higher at the dam site. An assembled edition of this map is on a scale of 1:24,000, and the contour interval is 10 feet. The approximate locations of lands with reference to the topographic features of this map were determined from comparable locations as shown on other maps. A planimetric map of the Placerville quadrangle by the Forest Service was the main source for this information.

It was assumed for the purpose of this report that the maximum-flowage line might be at an altitude of 1,100 feet. This presumably would require a saddle dam in the south half of sec. 2, T. 7 N., R. 10 E., near the northern boundary of the town of Plymouth. The altitude of the valley bottom in that section is 1,050 feet, and the width at an altitude of 1,100 feet is about 1,500 feet.

Sly Park and other reservoir sites, Sly Park Creek, Clear Creek, and Consumnes River

The Sly Park reservoir site is along Sly Park Creek between the altitudes of 3,310 and 3,478 feet. The dam site is in sec. 17, T. 10 N., R. 13 E. Sly Park Creek joins Camp Creek, a tributary of the North Fork Cosumnes River.

The Bureau of Reclamation, in the Department of the Interior report on the Central Valley basin of November 1945, reported that storage at the Sly Park site would

be desirable for irrigation use. The prospective service area was described as lands in and adjacent to the El Dorado irrigation district, on the ridge between the South Fork American River and Cosumnes River basins. Further studies and investigations of this project were reported by the Bureau in "Supplement to legislative report on American River development, Central Valley basin, Calif.," dated Feb. 25, 1949. It was reported that there are about 33,000 acres of irrigable land in the Sly Park division, 20,000 acres of which are within the El Dorado irrigation district and the remainder adjacent to it. The new water supply from Sly Park reservoir would be used in coordination with present supplies to continue service to 1,480 acres now receiving an adequate supply and to provide supplemental water to 3,850 acres now receiving only a partial supply. An additional 3,500 acres of dry lands would be brought under irrigation.

The Sly Park reservoir, with a capacity of about 40,000 acre-feet; a diversion dam on Camp Creek; and works including diversion and delivery waterways were authorized as part of the Central Valley project. (Public Law 356, 81st Congress, 1st session). The Bureau of Reclamation was authorized to make the necessary investigations.

The Bureau of Reclamation has obtained a map of the Sly Park site (Fairchild Aerial Surveys, May 1946) showing the topography to an altitude of 3,500 feet. An assembled edition of the map is on a scale of 1:12,000, and the contour interval is 10 feet.

A similar map was obtained of the Pleasant Valley reservoir site on Clear Creek, a tributary of the North Fork Cosumnes River west of Sly Park and Camp Creeks. This map indicates that there is considerable potential capacity between the altitudes of about 2,350 and 2,520 feet in a broad area along Clear Creek and a tributary. The dam site is in sec. 32, T. 10 N., R. 12 E. (An assembled edition of the map is printed on a scale of 1:9,600.)

The Bureau of Reclamation also has obtained a map of the Michigan Bar reservoir area along the main stem of the Cosumnes River downstream from the Nashville site. This shows a possible dam site in sec. 31, T. 8 N., R. 9 E., at a stream altitude of 190 feet. The topography is shown to an altitude of 310 feet along the river upstream and to varying altitudes over a considerable area downstream. The site presumably is being considered as a diversion point for irrigation, possibly with some reregulation of releases from the prospective Nashville reservoir and its power plant. An assembled edition of the map is on a scale of 1:12,000, and the contour interval is 10 feet.