"THE HARDEST WORKING WATER IN THE WORLD": A HISTORY AND SIGNIFICANCE EVALUATION OF THE BIG CREEK HYDROELECTRIC SYSTEM

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PREFACE

This report on the history of the Big Creek Hydroelectric System was prepared for Southern California Edison Company (SCE) during 1986 and 1987. It provides a detailed portrait of the founding and development of an industry physically located in a remote rural area, but made to serve urban needs. It is fitting that the Big Creek System should be the subject for such a detailed study, because no other hydroelectric system in California—itself a premier hydroelectric state—is larger or more important.

The purpose of this study has been to assist SCE in meeting its responsibilities for cultural resource review and management. This task involves the evaluation of historical significance of the Big Creek Hydroelectric System, and the potential for inclusion of the System (or portions thereof) on the National Register of Historic Places (NRHP). These tasks were mandated by SCE's proposed expansion and modification of the Big Creek System to increase generation. All activities were planned with the assistance of the State Office of Historic Preservation (OHP). The staff of the OHP took an active interest in this significance evaluation as both an exercise of its regulatory responsibilities and because the study presented the opportunity to develop new evaluation methodologies. Thus, in some ways the evaluation of the Big Creek System may serve as a model or case study applicable to the evaluation of similar classes of historical resources in the future.

Meetings were held with OHP staff to discuss basic concepts for the evaluation of the Big Creek System. Specific points of discussion concerned integrity, period of significance, contributing vs. non-contributing elements, and the form of the NRHP district, should one be warranted. OHP staff aided in preparation of the report outline, and their data requests were a major determinant in the focus and methods of research.

The present report was researched and written under the auspices of Theodoratus Cultural Research (TCR), and Dr. Dorothea Theodoratus and Clinton Blount of TCR were overall supervisors. Dr. Laurence H. Shoup of Archaeological Consultants, subcontractor to TCR, was the principal author of the report, which incorporates substantial contributions by Clinton Blount, Valerie Diamond, and Dana McGowan Seldner of TCR. Valerie Diamond was co-author of chapters 1 and 7. Dr. Shoup and TCR researchers consulted with OHP staff in preparing the outline upon which all writing was based.

The research was conducted during 1986 at a wide variety of institutions by Dr. Shoup, Ms. Diamond, Ms. McGowan, and Elizabeth McKee (also of TCR). SCE records (contained at corporate headquarters in Rosemead, at Big Creek, and also at a branch office in Long Beach) were crucial to the successful completion of the report. Maps, plates, and figures were prepared by Robert Hicks and Clinton Blount of TCR. Mildred Kolander of TCR was responsible for technical editing, word processing procedures, and report production; and Valerie Diamond made many valuable contributions to the production of the manuscript. Chris Espinoza, also of TCR, gave important aid in various aspects of report preparation.

We would like to thank, especially, Dr. David White of SCE for his unfailing support and patience during the long period it took to research and prepare this report. Mr. Art Fletcher and Mr. R. C. "Bud" Meyers of the SCE's Northern Hydro Division were particularly helpful in assisting us with our research in the Big Creek area. Many other people were helpful along the way, giving generously of their time to help make the project a success. We especially wish to thank Gene Griffiths, SCE maintenance foreman at Big Creek; Madeline Reynolds, also at the SCE Hydro Division Office at Big Creek; and the following residents of the Big Creek area who so kindly consented to share the history of their lives and experiences in the area with our researchers: Mrs. John Marvin, Mr. Silas "Buck" DeMasters, Mr. Larry Waite, Mr. and Mrs. Roy Landers, Mr. and Mrs. George Marshall, Mr. and Mrs. Carl Kent, Mr. and Mrs. Dale Bush, Mr. and Mrs. Woodhy Van Vleet, Ms. Winnie Maddock, and Mr. and Mrs. Rodger Taylor. We also appreciate very much the guidance offered by Dr. Hans Kreutzberg, Ms. Cindy Woodward, and others of the State Office of Historic Preservation.

TABLE OF CONTENTS

LIST OF MAPS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

APPENDIX

List of Tables

List of Maps

List of Figures

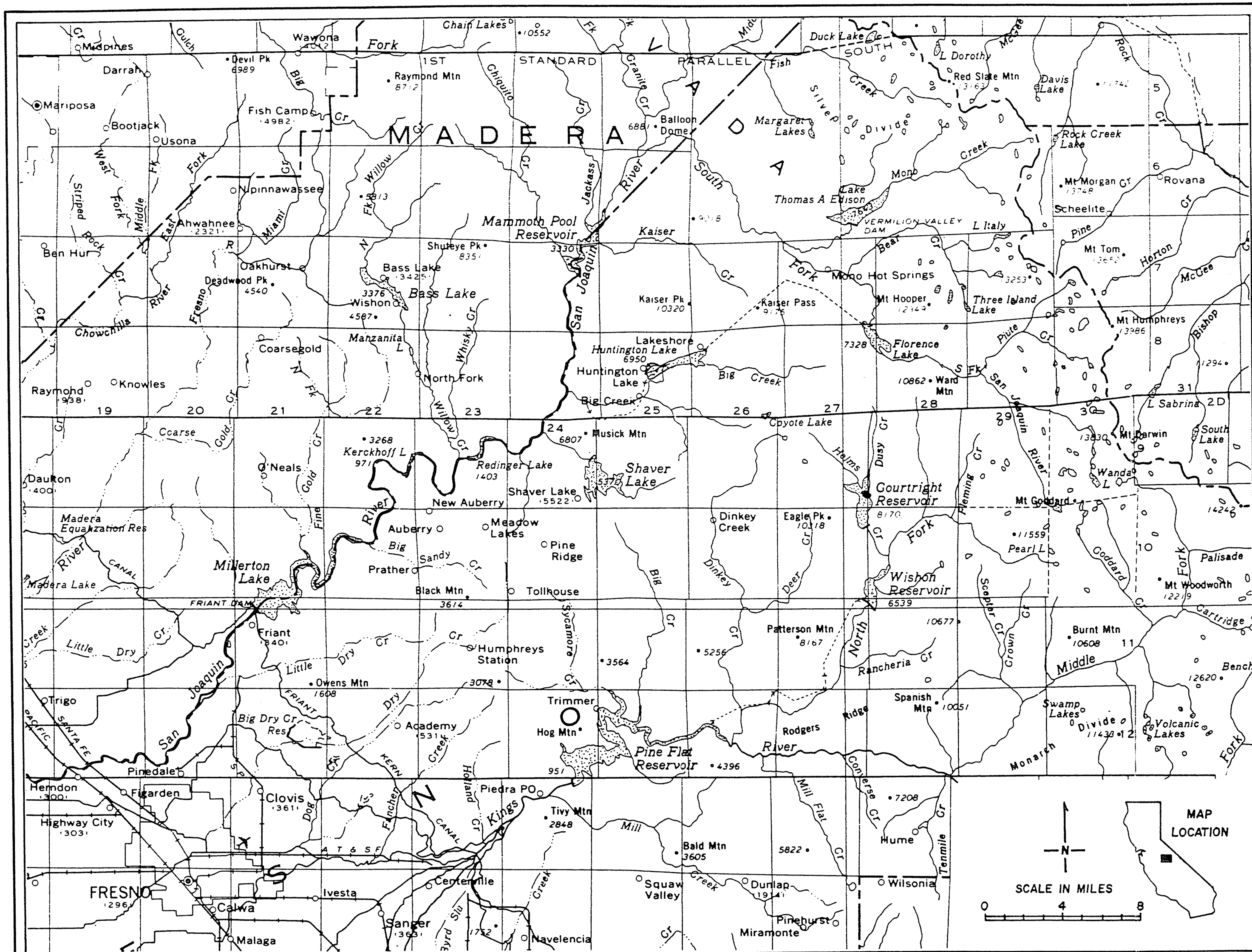
INTRODUCTION

THE SIERRA NEVADA MOUNTAINS AND THE BIG CREEK HYDROELECTRIC SYSTEM

The Sierra Nevada Mountain Range dominates central California; it is in fact the most impressive landform in a state blessed with a wonderful variety of spectacular landscapes. The Sierra Nevada consists of an uplifted granitic block—about 400 miles long and 70 miles wide—which rises to nearly 14,500 feet in elevation. The most formidable mountain barrier in the continental United States, this "range of light," as it is sometimes called, is tilted on its north–south axis, with the highest part of the chain in its southern portion. Yet, the water–laden air masses which sweep off the Pacific Ocean every winter usually come from the northwest and approach the lower, northern part of the Sierra first, dropping most of their rain and snow on the northern Sierra and adjacent mountain ranges and leaving much less moisture for the higher, steeper southern Sierra. The key function of the Sierra Nevada—as the gatherer of the water upon which most of California depends—is thus more often fulfilled in the northern Sierra than in its higher southern counterpart. In fact, the southern section of the mountain range averages only about one–half the rainfall of its northern extension.

The Big Creek/San Joaquin River section of the Sierra Nevada lies in this southern part of the range—nearly mid-way between Yosemite and Sequoia/Kings Canyon national parks (Map 1). Majestic peaks, beautiful lakes, and high mountain meadows crown this region, while thousands of feet below lie spectacular glaciated canyons. The steep topography of the region, together with its adequate (if not abundant) rainfall and mountain meadows, make it a prime natural location for large–scale hydroelectric power generation. The meadows provide good locations for water storage, and the landscape of steep ridges and deep canyons allow for high–head water power development. However, the final factor which made possible the actual development of this prime natural location was a cultural one—the vast and seemingly insatiable Los Angeles market. Los Angeles—one of the great metropolitan regions of the world—lies only a few hundred miles south of Big Creek.

This report, then, is the story of how the upper San Joaquin River was developed—and is still being developed—into one of the great hydroelectric workshops of the world. It is a large and impressive story, full of the struggle of men and women cooperating to bend nature's resources to humanity's needs. It is the story of the step–by–step fulfillment of one of the most ambitious engineering plans of the early twentieth century. The building of the Big Creek Hydroelectric System was also one of the world's most important engineering and technological achievements during the first third of this century—the creation of a system featuring "the hardest working water in the world."



MAP I —BIG CREEK DRAINAGE AND VICINITY— T.C.R. 1987

PART I

PRELUDES, PLANS, AND THE GREAT TRANSFORMATION: PREHISTORIC TIMES–1919

The first section of this epic of the Big Creek Hydroelectric System begins with a chapter on prehistoric and early historic times, and how the Indians and early settlers used this land. The second chapter documents initial plans for development of Big Creek—plans of a farsighted and ambitious engineer who eventually came to serve one of the greatest empire–builders California had ever seen. Chapter 3 recounts how this empire–builder took the engineer's plans and used them to industrialize the Big Creek region in the short space of a few years—a transformation which took millions of dollars and the work of thousands of men. By 1919, initial development of the Big Creek Hydroelectric System was complete.

CHAPTER 1

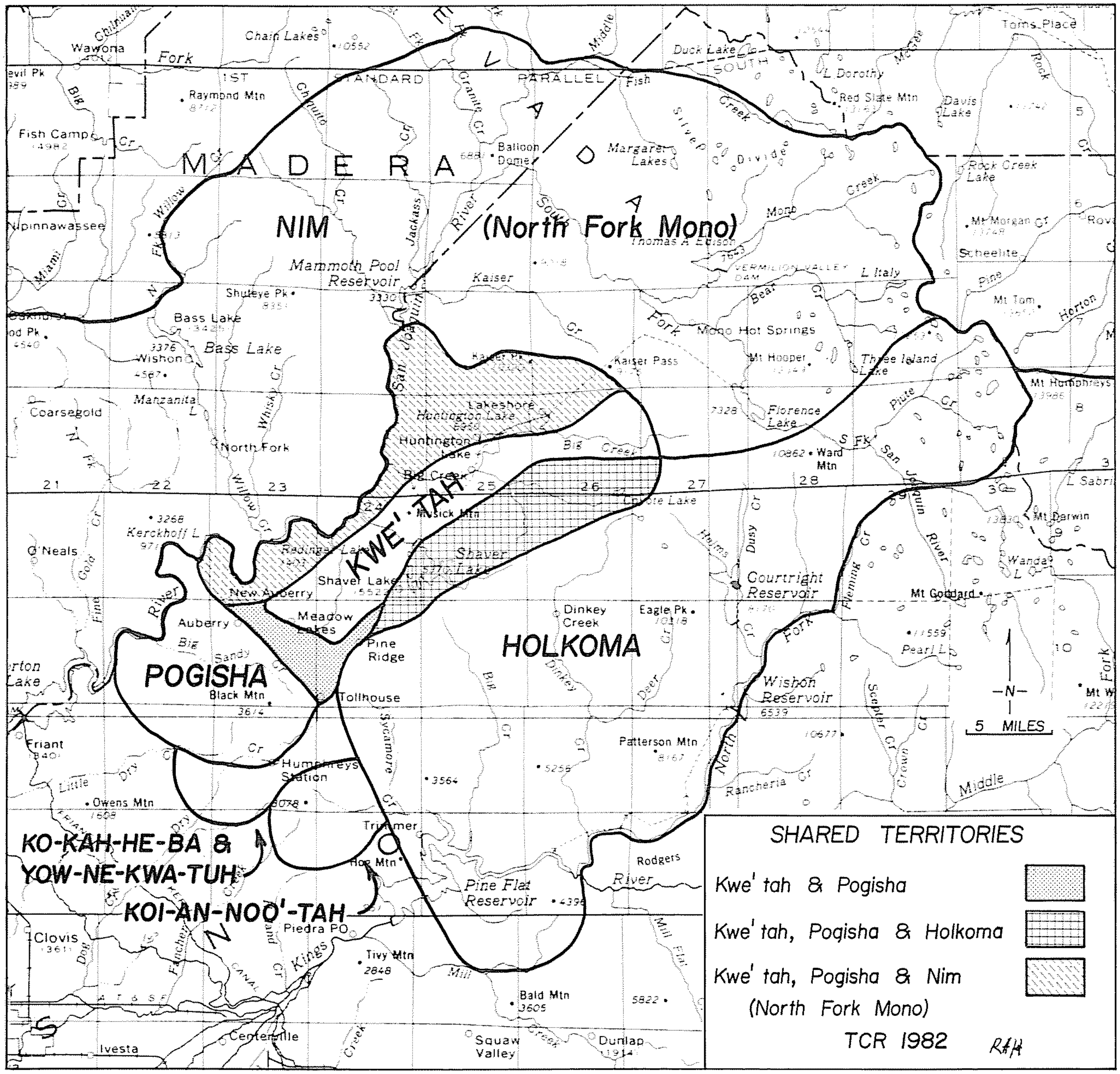
PRELUDES: PREHISTORIC AND EARLY HISTORIC ERAS

Since the Big Creek region is both highly developed and readily visited today, it is easy to forget that the area where Southern California Edison Company's massive hydroelectric project now stands was once a remote California frontier. During the pre-industrial era, the rugged mountains and difficult terrain acted as a natural barrier, restricting influences from and contact with the outside world. The peoples who inhabited the region around Big Creek during the prehistoric period were Native Americans—the Western Mono—who continued as the dominant population of the region until the late nineteenth century. Outsiders (Euro-Americans mainly, but also some Chinese) began to enter the area between the 1850s and early 1900s. Their arrival transformed this region—slowly at first, then more rapidly—from a place characterized by relative isolation and self-sufficiency to one whose main aspects were, as they are today, dependency on the outside world and its industrialism. This chapter will focus both on the process of change and its agents—the bearers of change. Interesting transitional steps, especially the largely self-sufficient world of men like Joseph Kinsman (1826–1916) and his Indian wife and family during the 1870s and 1880s, will also be a key theme. The slow process of building bridges to the outside world—the construction of trails and roads—will be another important focus. Finally, the real precursors of Big Creek hydroelectric development—the National Forest with its exertion of federal control, and the lumber business with its advancing industrialization—will be final themes leading to the next chapter.

The Mono and the Gold Rush, 1850s–1860s

During prehistoric times, the people who inhabited the Big Creek region (defined as that area lying within the watershed of Big Creek and the South Fork of the San Joaquin River westward to the foothills of the Sierra Nevada [Map 2]) were the Western Mono people. Traditionally, the Big Creek area has been the territory of two bands of Western Mono, separated by the San Joaquin River. North of the river, the Northfork Mono occupied the area from the Fresno River and Bass Lake south to just west of Kerckhoff Reservoir, east up the San Joaquin to Big Creek, and continuing northeasterly to the summit on a line north of Huntington and Florence lakes. South of the river, the Posgisa (made up of several smaller Mono groups) territory reached as far south as Pine Ridge, included the Auberry region to the west, and extended northeast along the river, across Italian Bar and Big Creek, and on to the summit (including Huntington and Florence lakes) (TCR 1985:14–16).

Living in the remote Big Creek area, the Western Mono people remained fairly isolated from the influences of Spanish and Mexican colonization during the pre-gold rush years. The pre-contact Mono lifeway was characterized by a hunting and gathering subsistence strategy, together with considerable trade with groups in the San Joaquin Valley and across the Sierra crest in Owens and Long valleys. The Mono possessed an intimate and detailed knowledge of the opportunities (and dangers) presented by the natural environment. The yearly cycle for any of the many small residential groups may have included fishing for salmon on the San Joaquin River,



MAP 2 —MONO TERRITORIES (Pre-contact)— C. Hart Merriam establishing summer camps at very high elevations, and extended trading and social visits with the Owens Valley Paiute peoples—groups to the east of the Sierra Nevada who are historically, culturally, and linguistically close to the Western Mono. Unlike the later immigrants, the Mono did not view the Sierra Nevada as a barrier; rather, the many east-west trails and passes were conduits of interaction.

The Mono are thought by many to have come to the western slope of the Sierra as recently as 600 years ago from a homeland in the western Great Basin. Their villages and camps were based loosely on extended families, with many residential shifts between villages for any of a number of economic and social reasons. It is this flexibility and adaptability which led to the pre-contact success of the Mono, and may have been an important factor in their success (relative to many other California Indian groups) in the post-contact period.

Compared to people living in coastal California or in the rapidly industrializing parts of the United States during this period, the Western Mono were relatively self-sufficient. While they did engage in significant trade, especially compared to other Indian groups, they still satisfied their basic needs—food, clothing, and shelter—largely from their own territory.

As was the case for so much of California, the Gold Rush of 1848 stands as a temporal boundary line between the prehistory and early history of the Big Creek region. The fact that only a few locations here were rich in gold had important implications for the future, for it meant that, unlike many other places in California, the characteristically self-sufficient Native American culture, economy, and society was not completely overwhelmed and destroyed by massive numbers of gold-hungry outsiders during the decade of the 1850s. The mining centers in the Big Creek region during and after the Gold Rush consisted of the Coarse Gold and Fine Gold areas to the west, on Kaiser Creek to the north, and along the main San Joaquin River. During the 1850s, miners from just about every national origin poured into this mining area, and by 1853, placer mining on the upper San Joaquin River reportedly stretched as far as the Kaiser-Chiquito drainage, with the entire Fine Gold Gulch marked by claims from one end to the other (English 1985a:1; Putney 1951:3).

Beginning in 1851, Joseph M. Kinsman, who later settled in the Big Creek area, prospected the vicinities of Coarse Gold and Fine Gold Gulch with his brother Oliver. In an interview published in the *Madera County Magazine* of February 1915, Kinsman recalled what life was like in this early gold mining region:

> Those were the days when the mountains of Madera County gave up their gold. In 1851 Broughton took out $160,000, from a digging where Krohn's store now stands at Coarse Gold. One pan below there yielded forty ounces of pure gold. The mines at Fine Gold, Hildreth, and Grub Gulch at this time all gave rich reward to the miners [Madera County Magazine 1915:19].

Kinsman's gold rush odyssey was identical to so many others during this era. Born on February 7, 1828, in Boston, Massachusetts, Kinsman came to California in 1849, lured by the hope of instant riches. He came to San Francisco by ship, working for awhile as a longshoreman in that city; but after earning a few dollars he decided to go out and make his fortune mining gold. Kinsman first headed for Mormon Island near Sacramento, but when that failed to bring him riches he wandered southward, eventually reaching the San Joaquin River. After mining for some time at Mariposa, he made his way to the mining area at Coarse Gold. Kinsman was a typical "49er" in the sense that he did not get rich quick in the gold fields, but later had to resort to a more traditional method of survival—farming.

By the mid-1850s, mining had become less profitable at Coarse Gold and Fine Gold Gulch, resulting in changes in the population distribution, occupational patterns, and ethnic make-up of the area. Many of the Euro-American miners who had worked the area since the early 1850s sold or abandoned their claims and went off in search of more productive mining locations. Two of these miners, Guiseppe Raggio and Guome Gambrone, along with a company of fellow Italian miners, made their way along the San Joaquin River to a location known as Mechanics Bar. For a short time, mining at Mechanics Bar paid off, and Raggio and Gambrone set up a trading post to supply their countrymen. By 1857, mining had become less successful, and the Italians decided to sell their claim to a company of Chinese miners. It is not known exactly how long Ah Chee and Company remained in the Big Creek area, but the vicinity where the Chinese worked was already known as Italian Bar for the men who had formerly mined there (English 1985b:1; TCR 1985:37–38). This pattern was typical of the Gold Rush: Chinese miners often took over abandoned Euro-American mining claims (Putney 1951:6). The U.S. Population Census of 1860 reported over 50 Chinese miners working in the Coarse Gold and Fine Gold Gulch area, compared with only 20 white miners in the same general location (U.S. Census Office 1860:17–19). Many of these Chinese miners worked in companies, complete with their own cooks and, occasionally, a merchant who brought them supplies. Experts in the use of rockers, the Chinese were able to continue to profit from mines which others had deemed hopeless.

The takeover of mining on the San Joaquin River and in the Coarse Gold/Fine Gold area by the Chinese thus marked the final stage of successful gold mining in the Big Creek region. Insubstantial deposits of gold meant that gold mining as an occupation would soon be over. The Chinese, as poor immigrants discriminated against in the larger society, typically had fewer occupational choices than Euro-Americans. As a result, they usually stayed at mining the longest, eking out a bare living from marginal deposits years after others had left the mining areas or turned to other occupations. The presence of large numbers of Chinese miners in or nearby the Big Creek region in the 1860 census was a sure sign that the mining era was almost over (U.S. Census Office 1860:17–19).

The decline of gold deposits in the Big Creek region meant that former miners either had to leave the area or find another means of making a living. Many left, and the population of the area declined, but most of those who stayed turned to agriculture. While most farming and stock-raising efforts focused on the better land in the San Joaquin Valley, there were those who—because of poverty or love of the mountains or desire for isolation or some other reason—decided to move into the remote mountains to establish subsistence farmsteads. Here they encountered intact Mono villages, and adapted to a relatively self-sufficient way of life.

Valley Farming and Mountain Community, 1850s–1890s

Typically, early agriculture in and around the Big Creek region took two forms: commercial stockraising in favored foothill and valley locations; and relatively self-sufficient farming in the foothill and mountain areas. Both types used the nearby mountainous regions: the commercial farmers used them as pasturage areas and the mountain farmers used them for a much wider range of economic pursuits. The trend toward agriculture began as early as the mid-1850s when, as Joseph Kinsman put it:

> Settlement developed toward the valley, and the settlers turned their attention to farming, cattle grazing and sheep raising. Jonathan Rea brought the first sheep from Mexico in 1855. Arnold settled on the Daulton Ranch in 1856. Jerry Brown located at the Weakley Ranch and John Newton below Buchanan Hollow in the same year [Madera County Magazine 1915:19].

Many of the settlers of whom Kinsman wrote established farmsteads not far from the mining communities in the Coarse Gold/Fine Gold Gulch area. Most of these settlers raised stock—cattle, sheep, and hogs. Men like Henry Daulton and Jonathan Rea owned large flocks of sheep and thousands of valuable acres of range land (Winchell 1933:47).

At the same time that the commercially oriented agriculturalists were becoming established, smaller, self-sufficient farmers were also acquiring land (often through the provisions of the 1862 Homestead Act) and settling down. Due to the shortage of women from their own culture (the Gold Rush had been a mainly male phenomena) these ex-miner/farmers often married Indian women, and these couples established families. Intermarriage facilitated the blending of cultures, economic strategies, and approaches to the environment and natural world—in short, some aspects of the life style of the Native-Americans became part of the settlers' lives. During the 1860s-1890s period, the Big Creek region saw a number of examples of this phenomena—so much so that it can aptly be said that a mountain community was formed during those years. This community had two main centers, Kinsman Flat and Jose Basin, each area having a number of families whose members cooperated with each other and intermarried. Since much better data is available on the Kinsman Flat people, the focus here will be on life in this region, with the understanding that life in Jose Basin was probably similar.

While the Mono had been impacted by the arrival and activities of the gold seekers of the 1850s, the remoteness and comparative lack of gold in the area had left these Native Americans with enough privacy and productive territory to survive and maintain their culture and many of their lifeways. They continued to live in traditional areas, such as the flats and basins above the San Joaquin River. Yet, due to Euro-American land hunger and the failure of various schemes to provide adequate reservations for the Indians, they did not have a legal right to what was in reality their own land. Even if a Western Mono family had "occupied and cultivated a plot for a generation, legally they were only 'squatters' who could be removed at any time" (TCR 1985:25).

It was this environment and social situation that Joseph Kinsman and other former miners found when they moved into the mountains east of Coarse Gold in the 1860s and 1870s. Joseph himself settled here in the mid-1870s, having spent at least part of the 1860s and early 1870s at his brother Oliver's 150-acre Fine Gold Gulch homestead (Madera County Magazine 1915:18-19; Winchell n.d.:n.p.). At that time, Oliver was married to an Indian woman and starting a family (U.S. Census Office

1870). By 1875, Joseph Kinsman was ready to settle down on his own, so he made his way into the Big Creek area to a location above the San Joaquin River canyon and settled near a Mono Indian camp. At this location (S29, T8S, R24E), which Kinsman called "Chiquita Ridge" (now known as Kinsman Flat), he built a substantial, comfortable house (Winchell n.d.:n.p.). As Kinsman would later describe it, "I left Coarse Gold . . . and came up here on Chiquita Ridge among the mountains where plums, gooseberries, huckleberries, wild grapes and other fruits grow in abundance" (Madera County Magazine 1915:19). That same year Kinsman, at age 49, married, either formally or informally, an eighteen-year-old Indian girl named Mary. Over the next eleven years, Mary bore him three children: Mary (1875), Joseph Jr. (1878), and Annie (1886) (Kinsman 1876-1894; U.S. Census Office 1900b:7).

Not far from the Kinsman place to the north, another Euro-American settler, Jesse Blakely Ross, had already established a homestead in Section 8, Township 8 South, Range 24 East. Born in Missouri in 1835, Ross, together with his brother Calvin, came in the early 1850s to what is now Madera County in search of gold. About 1858, Ross tired of mining and decided to settle in the Big Creek area, just west of a Mono village. Establishing a camp at this site, Ross planted over five acres of apple trees on his homestead. About 1877, he built a house on his property and married a local Indian girl named Mary Waspi, who later (in 1885) left Ross and returned to her people (Putney 1951:11-12; TCR 1985:42).

Little is known about a third Euro-American settler in the Big Creek area, Thomas Brown, who homesteaded sometime before 1888 southwest of Kinsman and Ross in Section 10, Township 9 South, Range 23 East. Born in Norway in 1831, Brown was naturalized in Alpine County in 1866 (TCR 1985:42). Like his fellow Euro-American settlers, Brown built his home just south of a Mono Indian camp.

The relationship between the settlers and the neighboring Mono communities is not altogether clear, although a number of characteristic factors do seem apparent. The economic exploitation of Indian communities as "cheap labor" was common in late nineteenth-century California, and certainly this may have influenced, to some degree, the settlement and economic development choices made by men such as Ross and Kinsman. Kinsman's diary and primary data retrieved from descendants of these marriages indicate that the settlers' lifestyles assumed many of the basic elements of traditional Mono life. Some descendants have stated that their white fathers had, at the time of their marriages, become almost incorporated into existing Indian communities (TCR Field Data 1985-1986).

With increasing pressure by Whites to settle and develop traditional Mono land, members of the surviving Mono communities became virtual aliens or refugees in their own homeland. In the early post-gold-rush era, true refugee settlements are known to have been created in safe, out-of-the-way places (TCR/ACRS 1984). In later years, affiliations with the white settlers may have provided a "safe harbor" in the face of increasing pressure from the white communities. In some cases, however, communities are known to have maintained a relatively traditional lifestyle well into the twentieth century—even after the establishment of federal trust-land rancherias. In such cases, the livelihood of the community may have been supplemented by the wage labor of male members of the group who frequently worked as loggers, sawyers, construction laborers, ranch hands, or herders. These communities seem to have been able to persist without the marriages and other liaisons with Euro-American settlers.

While the diary kept by Kinsman is not without an occasional ethnic slur, it is, for the most part, complimentary in its assessment of Native Americans and the relationship between Indians and Whites. According to Kinsman, the two groups worked cooperatively, exchanged fairly, and assisted each other without hesitation. He writes of Indians working for or with Whites in such cooperative endeavors as building a wagon road near Jesse Ross's home, gathering corn at Kinsman's farm, and tending to J. R. Jones' sheep. Kinsman also explains that Indians and Whites did favors for one another, such as finding each other's lost animals, or tending one another's wounds.

As far as exchange between Native and Euro-Americans, Kinsman tells of Indians trading their ranges for sheep or offering fish or meat in exchange for some small amount of money. Native Americans were obviously getting the short end of these exchanges, and Euro-Americans were undoubtedly pleased with the relationship. The Mono could see the obvious trends, but they were basically powerless to resist an alien culture which was numerically greater and technologically far superior. Farmers and ranchers were fencing Indian land, plowing it, pasturing herds of livestock on it, and feeding acorns to their hogs. Mono access to the very resources needed for their survival was being restricted, or the resources were being destroyed. As late as 1870, Native Americans were reportedly considering violent rebellion as a solution to their dilemma. As the *Fresno Expositer* stated the situation on September 14, 1870:

> For several days past rumors have been flying about the Fresno and Mono Indians, assisted by the Pah Utes, were about to commence hostilities against the whites. . . . The Indians have many grievances to complain of, and that they should be incited to seek revenge does not seem improbable. They depend, in great measure, for their sustenance upon the grass seeds and acorns which they gather in the mountains. This season cattle and hogs have been driven thither in great numbers, and as a consequence they have been robbed of their grass seeds and acorns. In some instances, we are told, white men have forbidden them, under any circumstances, gathering acorns at different points in the mountains, as they wish to keep them to feed their hogs upon. Some Indians had small gardens of corn and mellons, these were broken into by cattle and hogs and completely destroyed, so, naturally enough, the "poor Lo's" [a pejorative term for Indians] seeing starvation staring them in the face, have undoubtedly made some harsh threats [as cited in TCR 1982:27].

In contact with Euro-American settlers and sheep herders, the Western Mono were forced to develop a new lifestyle--one which incorporated traditional activities and some aspects of the white economy. Mono men often participated more closely than women in the local wage economy, working as laborers on farms and sheep herders in the field. Mono women were generally able to carry on "the traditional gathering of 'wild foods' in addition to overseeing the cultivation and harvest of introduced, domesticated plants." As a result of this gender division, many men interacted more regularly with Whites and learned some English, while women usually spoke only Mono (TCR Field Data 1984/1985, as cited in TCR 1985:24).

Whatever the effects of the relationship between Euro-Americans and Western Mono living and working in the Big Creek area, it is apparent that by the 1870s the two groups formed a mixed community. In close contact with one another, the settlers and the Mono retained many of their respective ways, but adopted some new practices more in keeping with their communal life. Although paternalistic in nature due to the power differences, lasting friendships were apparently established between these two groups of people. Of one such friendship, Kinsman writes on May 11, 1884, "About 9 p.m. old Johnson, an Indian, passed his checks and went to the good hunting ground. He was a great friend of the whites" (Kinsman 1876–1894:n.p.).

Life and Work in the Big Creek Region

The Kinsman diary and census records give us an unusually detailed picture of the nature of life and work in the Big Creek region's mixed community during the late nineteenth century. Here, Mono people lived alongside the few white men and their families in the context of Euro-American domination. They practiced a somewhat self-sufficient lifestyle, developing a variety of subsistence skills as a result. Key characteristics of this lifestyle included food-raising and gathering, barter instead of trade through the medium of money, and cooperative work.

A typical trade made between Euro-Americans living in the Big Creek area involved the cooperative exchange of labor. Although settlers possessed a range of work skills, they were not always able to perform these successfully on their own. To survive in the isolated Big Creek area, settlers relied not only on their own diverse labor skills but on the diverse abilities of their neighbors. While one man on his own did not have the means or capacity to be completely independent, the Big Creek community as a whole was largely self-reliant.

For the most part, the Euro-Americans living in and around the Big Creek area were not simply farmers, ranchers, or miners. Rather, they were generally skilled in all three areas, and perhaps in others as well. They were capable of performing whichever job task seemed most necessary, reasonable, or productive at the time. In the case of Joseph Kinsman, the 1880 U.S. Population Census listed his occupation as farmer, but his diary revealed that he participated in many other fields of work (U.S. Census Office 1880b:88). Throughout the 1870s, for example, Kinsman wrote sporadically of his usually unsuccessful attempts at gold prospecting; and in 1887, he finally established a quartz mine, from which he stated he was "taking out some fine looking rock . . ." (Kinsman 1876–1894:n.p.). Kinsman also wrote, in May 1884, of attempting to raise hogs and of taking them to Whisky Creek for sale. He reports having a "Hell of a time getting them across the creek" (Kinsman 1876–1894:n.p.). In addition to farming activities, which included cultivating a variety of fruits and vegetables as well as raising poultry, Kinsman also spent a good deal of time hunting and fishing to supplement his food supply (Kinsman 1876–1894:n.p.).

While Kinsman participated in a number of different job tasks on his own, he also lent support to his neighbors' endeavors. In return for Ross's help gathering corn, Kinsman would help Ross dig potatoes. Kinsman also sometimes assisted the local sheep herders, traveling with them to the higher mountain meadows and later returning to their camps to help shear the sheep. When his brother Oliver needed assistance setting up his camp, Kinsman traveled up to Fine Gold Gulch to lend a hand. He also gave aid to a local Indian by plowing one of his fields (Kinsman 1876–1894:n.p.).

Like Kinsman, Jesse Ross is listed as a farmer in the 1880 U.S. Population Census, and he, too, was involved in other activities. By 1877, Ross and his brother

Calvin had obtained squatters' rights to almost all of what is today known as Pechinpah Mountain. In the summer, the Ross brothers maintained a camp on this mountain, where they made shakes from sugar pine trees. In the winter, Jesse Ross would return to his homestead in the Big Creek area and tend his farm. Ross continued to carry on this dual existence until 1885, when the Pechinpah brothers of Sonoma County took up the squatters' rights on the Ross brothers' summer camp (Putney 1951:10).

By 1880, Ross had established a fairly well developed homestead and farm at his winter home. He had some 160 acres of tilled land, and his farm alone was valued at $1000, not counting the value of farm equipment and livestock. Ross owned three horses and a barnyard full of chickens, and cultivated two acres of potatoes and over five acres of apple trees. Despite these assets, the 1880 U.S. Agricultural Census estimated the value of all his 1879 farm production at a mere 68 dollars, indicating the basic subsistence level of Ross's farm (U.S. Census Office 1880a:7).

While Kinsman and Ross were certainly not the only inhabitants of the Big Creek area participating in a number of different job occupations, it is difficult to find additional documentation of such diversity. One indication, however, is found in the amazing variety of occupations listed for the inhabitants of the area in the 1880 U.S. Population Census. As might be expected, the majority of inhabitants were listed as farmers, with lesser numbers of miners and stock raisers. In addition to these expected job tasks, others participated in such diverse activities as carpentry, engineering, lumbering, surveying, blacksmithing, and teamstering; and one Chinese man was employed as a cook for one of the stock raisers (U.S. Census Office 1880b:88). By the 1880s, the Big Creek area's inhabitants comprised a close-knit community of workers capable of performing a number of different job skills successfully.

Barter was another aspect of this self-sufficient life. As people outside the mainstream, the community of the Big Creek region relied heavily on the system of direct trading. Kinsman wrote in his diary that often, in exchange for spending the night at his homestead, sheep herders would give him a "fine mutton" (Kinsman 1876–1894:n.p.). Kinsman mentioned on numerous occasions obtaining supplies from friends, including such items as garden seeds and plants from John Dunlap who lived near Fresno Flats (Oakhurst); flour from a neighbor named Cohan; potatoes from rancher Thomas Winkleman near Crane Valley; and a mule from J. N. Walker (Kinsman 1876–1894:n.p.). In exchange for such supplies, Kinsman would often help out at the neighbor's homestead or ranch.

Many Indians in the region lived in a very similar way to the Euro-American agriculturalist. The Norris family at Kinsman Flat may be taken as representative. Information on this family exists for the turn of the century period, and details on their lives during this era appeared in a previous TCR report:

> . . . The family consisted of Jack Norris, his wife, their five children, his wife's mother, and a widowed female relative (probably his cousin) and her child. The main dwelling was a frame house . . . with a large kitchen where they could all eat together. Other structures in the yard included a storehouse, hog pens, a barn, and several acorn granaries. The grandmother's log cabin, where they had lived previously, was across the gulch on a nearby hill. With his own horses, Norris plowed a field for

wheat. After the grain was cut, it was spread on a large canvas; the children rode the horses over the wheat to thresh it, and then the women winnowed it with their baskets. Mono women from the other families on the flat came to help with the job, and were paid in sacks of grain as well as with meals while they worked.

On their 200 acres, the Norrises also had a substantial and productive garden which was watered by gravity flow from the nearby spring. The garden produced radishes, carrots, corn, cucumbers, green beans, tomatoes, several kinds of squash, and delicious potatoes, which were everyone's favorite when they were "new." The children did much of the garden tending. Many of these vegetables were kept in the storehouse for winter use. In addition, there was an orchard with pears and apples.

The Norris family also raised hogs. Jack Norris gave each of his children a piglet to raise for the year, and the child received the money when the pig was grown and sold in North Fork. The children helped drive the pigs over Cascadel to North Fork for sale. It was important to get the pigs started on the drive early in the morning before the temperature rose, because if they got too hot they would go lie down and hide in the bushes, refusing to move. In addition, the Norrises had horses which roamed freely around the homestead, and the children became good riders at an early age.

The women, often with the help of the children, gathered many "wild foods" such as acorns, grey pine nuts, manzanita, sourberries, wild onions, and mushrooms. A *paha* [bedrock mortar locality] exists some hundred yards from the house, and the adult women regularly prepared acorn here for the family. The *paha* was enclosed by a screened structure with a door and slanting shingle roof. This sheltered the women as they worked, and also helped keep the mortar holes clean. Between the cultivated foods, the traditional Mono plant resources, the hogs they raised, and the fish and game supplied by Jack, the family needed very few supplies from the "outside" world. Consultants have emphasized that they always had meat from the plentiful deer, and it was easy to "run down to the river" for fish. The only commercial supplies regularly sought were rice, flour, beans, and sugar [TCR Field Data as cited in TCR 1985:25–27].

Transportation and Agricultural Change

During the entire 1860s–1890s period, there was a quantitative increase in commercial agriculture in the San Joaquin Valley to the west of the Big Creek region. Commercial agriculture, at least in its larger and purer forms, was very different from self-sufficient agriculture, for it focused its main efforts on producing for the outside world—the market. Commercial agriculture used money as a medium, shunning barter and cooperative work. The early form that commercial agriculture took was animal husbandry, especially sheep, but also some cattle-raising. As the numbers of sheep and cattle grew, so did the desire to graze these animals in the nearby mountains. The sheep herders, of many different ethnic origins, became a frequent sight in the mountains around Big Creek and throughout the Sierra Nevada. One of the most successful of these sheep men was Henry C. Daulton, already mentioned in connection with the Coarse Gold and Fine Gold Gulch area settlers. By 1865, Daulton owned some 18,000 acres of ranch land, and used the passageway through the Big Creek region (past Kinsman's homestead) to take his sheep to higher country. Daulton had numerous employees, including some Mexicans, Portuguese, and Indians (Kinsman 1876–1894:n.p.). Less affluent herders, such as J. R. Jones, also traveled through the Big Creek area with their sheep, as did a handful of cattle grazers such as Taylor and Logan (Kinsman 1876–1894:n.p.).

The sheep and cattle herders used and undoubtedly expanded the system of trails through the Big Creek region. Many of these originally were prehistoric and historic Native American trails, but it is possible that some new routes were created by the increased use of the mountains. Importantly, many of the new trails opened during the early historic period were pioneered by the Mono to accommodate their adoption of the horse and the corresponding need for milder ascents and descents. Some of these trails became crude wagon roads, and by the early 1880s a number of such transportation routes existed, connecting settlers with one another and with necessary mail and supply outposts. From Kinsman's home, trails led north to Jesse Ross's place, east to the San Joaquin River, south to the Indian camp and beyond, and west to Brown's Place (North Fork) (TCR 1985:41). As has already been discussed, foothill sheep herders traveling in the summer months to grazing meadows also helped establish trails in the area. One such trail passed directly through Hookers Cove near Kinsman's homestead (TCR 1985:43).

The existence of improved transportation encouraged the establishment of general stores, which encouraged local people (including the farmers) to purchase manufactured goods (e.g., clothes, shoes, tools), processed foods (flour, sugar, coffee), and other items. By the 1870s, such outposts had been established just outside the Big Creek area, providing not only supplies and mail but news and information to local settlers. During the 1860s and 1870s, Milton Brown ran a store and a ranch near present-day North Fork which supplied both settlers and traveling sheep herders. "Brown's Place," as the store was known, also served as the area's voting headquarters, and in later years the name "Browns" was retained for the North Fork voting precinct (Putney 1951:12). In his diary, Kinsman detailed his many treks to Brown's Place for supplies, and occasionally for an evening meal. Supplying the remote Big Creek area was no easy task, and on one of his trips to Brown's, Kinsman reported finding no supplies and "6–8 men waiting for the wagon to come in." Two days later he returned to find "no wagon yet" (Kinsman 1876–1894:n.p.). If Brown's Place was short on supplies, it was not, according to Kinsman, short on news and information. At Brown's, Kinsman heard of an outbreak of smallpox in Fresno and of an Indian fight with General Crook (Kinsman 1876–1894:n.p.). In 1878, Brown sold out to Charley Striven, who continued to run the store into the 1880s (Kinsman 1876–1894:n.p.; U.S. Census Office 1880b:88). Fresno Flats (Oakhurst) was another outpost for picking up information, supplies, and mail.

Purchasing supplies at the region's store was a change for the Indians and early Euro-American settlers in the mountains. As is frequently the case historically, the change was gradual, and it is difficult to pinpoint exactly when a quantitative change in the purchase of outside goods (and type of production needed to pay for those goods) became a qualitative change in the type of socio-economic system and lifeways. It is clear, however, that by the 1890s both new arrivals and old settlers were gradually becoming engaged in commercial farming activities. Accounts of this era in the Big Creek region indicate how the fact of better transportation was impacting and changing the socio-economic nature of this region. In his diary entries of the 1880s, Kinsman began to report that quite a few "strangers" were coming in and camping near his homestead. While it is not clear whether or not these strangers planned to settle permanently in the area, it is fairly certain that they were not sheep or cattle men. In fact, Kinsman mentioned on July 30, 1890, that "a young lady came to the summer camp" (Kinsman 1876–1894:n.p.).

One "stranger" who did settle in the Big Creek area during this period was Frank J. Fuller. Born in New York in 1851, Fuller was first mentioned in the late 1880s when he and a partner were prospecting for gold along the San Joaquin River (Kinsman 1876–1894:n.p.). He eventually married a half–Indian girl named Margaret (Maggie) Kirby, who was the daughter of James Kirby, an Irish miner living near Fine Gold Gulch. She was also a close friend of Kinsman's daughter Mary (Kinsman 1876–1894:n.p.; U.S. Census Office 1880b:88). Fuller settled somewhere below Kinsman's homestead and became closely associated with Joseph and Oliver Kinsman and Jesse Ross. For awhile Fuller worked at Ross' farm, pruning apple trees. The 1900 U.S. Population Census recorded him as a farmer living next to Kinsman, stating that he and Maggie had four children—two girls and two boys (U.S. Census Office 1900b:7).

Another Euro–American settler who came into the Big Creek area during this period was George Francis (Frank) Hallock. Born in New York in 1864, Hallock migrated to California in 1891. That same year he came to the Big Creek area where he met and married Julia Belle Ross, daughter of Jesse and Mary Waspi. Like Fuller, Hallock quickly became friends with Kinsman and his family, often staying at the Kinsman place or socializing with Kinsman's children, Mary and Joseph Jr. (Kinsman 1876–1894:n.p.). Hallock was described as "a short heavyset man, schooled in law and . . . several years the senior of Julia" (Foster 1961:2). After his marriage, Hallock settled on the Ross place and took over the supervision of the farm and orchards.

It was under Hallock's direction that the Ross farm expanded into a much larger and more commercial operation. In the 1890s, Hallock and Ross engaged in wheat farming and in a rather extensive production of pink beans. During this period, some 30 to 40 tons of beans were harvested annually and sold in Fresno (Foster 1961:3). For the harvest, Hallock reportedly hired many Native American women living nearby. Later, he planted additional apple trees, producing and drying apples by the ton and delivering them in wooden boxes to the Fresno market. Distance and road conditions prohibited the marketing of fresh apples (Foster 1961:3).

In 1899, Jesse Ross passed away leaving his farm to his daughter Julia. Julia died of a kidney infection three years after her father's death, leaving the farm to her husband. Hallock continued to operate the farm until 1910 when it was purchased by Samuel L. Hogue (Foster 1961:3).

At the same time that mountain farmers were becoming more commercially oriented (such as in raising pink beans and drying apples for export), sheep herding was also expanding as new concerns entered the area and old operations grew. One traveler in the Stevenson Creek vicinity reported in June of 1887 the extent of sheep–herding activities:

> During the summer months, these mountains that are below the perpetual snow line are thronged with shepherds who come from both

> states [California and Nevada], who have flocks varying from five to fifteen thousand each, in charge of two men and five or six dogs.
>
> These men move about from glade to glade, and erect for themselves little log cabins which are most useful to tourists who occupy them [Anonymous 1887:5].

Contributing to these throngs of shepherds were the employees of Miller and Lux, a large non-local grazing corporation which began using the Big Creek area in the 1880s (O'Neal 1952:12). In May, 1892, Joseph Kinsman reported in his diary on the exploits of Henry Miller, of Miller and Lux, who camped at Hookers Cove on his way to the high country with four bands of sheep. The day after Miller left for the mountains, Kinsman noted that he returned with two of the bands of sheep because of lack of feed (Kinsman 1876–1894:n.p.). While Henry Daulton's sheep-herding operations remained one of the largest in the Big Creek area, non-local concerns like Miller and Lux certainly made herding more difficult.

It is not surprising that, as sheep-herding activities became more extensive, they were also more competitive—especially given the fact that, until 1893, the use of grazing ranges in the Sierra Nevada Mountains went unregulated. Theodore S. Solomons, a charter member of the Sierra Club who explored the Big Creek area in 1894, described the way the sheep herders maintained control of mountain "ranges":

> The sheepherders have the whole western slope of the mountains divided off into 'ranges', which are subject to barter and sale as though they were personal possessions and not the property of the government. They know all the pasture grounds, have made rude trails thereto and built log bridges over all the larger streams [Solomons 1896:481 (as cited in Moore 1981:3)].

By the 1890s, sheep men of the Big Creek area had established the kind of control which Solomons describes. Each sheep herder's range lands were more or less respected by others, and migrant sheep herders were discouraged and at times run out of the area. There were even reports that migrant sheep men were shot at or not allowed access to the local trails and bridges (O'Neal 1952:11).

In the late 1880s and 1890s, with more Euro-American settlers and sheep herders living and working in the Big Creek area, the paternalistic relationship between Whites and Indians began to break down. The increased competition for use of the land by both farmers and sheep herders led to problems between the Western Mono, who wanted to continue their traditional land use, and Euro-Americans, who wanted to cultivate or use the land for grazing. The passage by the United States Congress of the General Allotment Act (Dawes Severalty Act) in 1887 permitted Indians such as the Western Mono, who did not live on reservations, to file for and receive up to one quarter section of land in the public domain (TCR 1978:112). Although this act was restrictive and resulted in few changes for the Western Mono, it did allow some 30 Mono and Yokuts families to receive land allotments in or near the Big Creek area from 1891 to 1905, including such areas as Township 8 South, Range 25 East; and Township 9 South, Range 23 East, Mt. Diablo Meridian (TCR 1978:113). Euro-American settlers of the Big Creek area could easily have perceived this act as threatening.

The breakdown in the relationship between the Mono and the Euro-American settlers is especially evident in the case of old time residents, such as Kinsman and Ross. By the 1890s, Kinsman makes few, if any, references in his diary to the activities of Native Americans, while his earlier writings are full of details about local Indians. It is not clear whether they had moved away from Kinsman Flat or whether Kinsman just lost touch with the native community (Kinsman 1876-1894). Ross, too, seems to have stopped communicating with Mono in his area—although not entirely by choice. According to an interview with Gene Tully (a forest ranger ca. 1905-1912), Ross's daughter had planned to marry a local Mono before she married Frank Hallock in 1891. However, Ross refused to allow the marriage. As a result, many of the nearby Mono were insulted and moved away, depriving Ross of his labor force (English 1980).

The mountain community was gradually transformed during the late 1880s and throughout the decade of the 1890s. Better transportation systems and rapid industrialization in other parts of California brought increasing impacts to the Big Creek region. These impacts began a revolution which would lead to development of a large-scale hydroelectric system during the period after 1911. The final section of this chapter reviews how better transportation and the industrialization of key sections of California led to the end of the self-sufficient world of the Mono and mountain farmers, and opened the way to the hydroelectric era.

Outside Dependency and New Industrialization, 1880s-1900s

As transportation was gradually improved during the last two decades of the nineteenth century, self-sufficiency declined and the Big Creek region became more dependent on and more controlled by the outside world. This greater outside dependency took two forms: activities of the lumber industry; and increased regulation of National Forest land-use by the federal government. The causes of both these changes were complex, and perhaps best understood as part of the process of industrialization which California and the western United States were undergoing during this period.

Industrialization is a dynamic, if step-by-step process. Older forms of transforming nature, relying on muscle power, give way to newer forms which rely on inorganic power sources (especially steam, but also water power, petroleum and gasoline-powered engines, and manufactured or natural gas). Slower, muscle-powered transportation and communication systems are superseded by faster methods using more complex technology. Narrow trade networks and self-sufficiency are replaced by broad trade networks and interdependency. A faster work pace, specialization, and factory work situations take over from slower, more diverse individual working situations. Individualistic modes of thought and action among workers give way to collective modes demanding unionization. Finally, based on all the above factors, there is an increase in size, complexity of operation, bureaucracy, and centralization of social power and authority.

Industrialization, by its very nature, is specialized and interdependent, giving rise to dominant centers and dependent areas. In California and the West during the late nineteenth century, this center was the City of San Francisco, with its factories, iron foundries, and control of investment capital. The industrial products of San Francisco and lesser centers radiated to rural parts of California by railroad (itself an industrial artifact *par excellence*). From rural California, the products of the land---such as wheat, wine, meat, lumber, silver, and gold---flowed back to San Francisco and other cities to be consumed or coined into money. The production of lumber and agricultural products are of special concern here, for these were the commodities which so greatly influenced development of the Big Creek region during the late nineteenth and early twentieth century.

Lumber Industry, 1860s–1920s

The lumber industry in the Big Creek region dates back to the mid-1860s. The low level of industrialization in California at that time meant that the technology and markets needed for large-scale logging and sawmilling activities were not yet in existence. Therefore, only very small mills, cutting small amounts of timber for the limited local market, operated during this period and for the next few decades. One expert in this field described these small mills as few in number and cutting only for local consumption. Many of them were wild-cat mills, trespassing upon public land, whose cut usually ranged from 2000 to 15,000 feet per day. Logging for these concerns was crude and quite wasteful. Only small areas around each mill were logged, and the timber was usually snaked into the mill by oxen or horses. Most of the logging was concentrated on the best sugar and yellow pine of medium size, since the small machinery did not permit the handling of large trees. It was common practice to use only the clear portions of the trunks and to discard the rest of the tree. The lumber was hauled by wagon to mining camps and other local communities (Smith 1914:5).

However, to successfully log timber, cut it, and deliver the lumber---even in small amounts---required wagon roads into the mountains. This early road-building effort by the lumbermen proved to be a very important contribution to developments in later years.

Construction was started on the wagon road up the Tollhouse (Pine Ridge) grade about 1866, and small sawmills began operating at that time along Pine Ridge. In the winter of 1866/1867, John Humphrey and Mose Mock decided to move their mill from Bear Creek in Mariposa County, where it had been located since the 1850s, to Pine Ridge. When they arrived at Tollhouse the wagon road was only partially completed, so they were forced to delay their plans. By spring, 1867, the road had been completed as far as the saddle Widow Waits, and Humphrey and Mock decided to haul their mill as far as the road would take them, then across country to a site near what is now the small community of Pine Ridge (SE 1/4 Sec. 9, T10S/R24E, MDM). Operating a double-circular steam mill, Humphrey and Mock could cut about 12,000 feet per day. Logging was accomplished with oxen and log wagons. The two men continued to operate this mill until the fall of 1872 (Hurt 1941:30).

Throughout the 1870s, new mills were put in operation around Pine Ridge, as well as Ockenden. In the spring of 1873, Humphrey and Mock moved their mill to Bransford Meadow, just east of their original site. They remained at this location until 1878, when they moved to Kentuck Flat (near their original site) until it, too, was cut out in 1880. In 1874, Humphrey and Mock built a second mill at Hoxey Meadow (near Ockenden) which they promptly sold to Henry Glass and M. J. Donahoo in 1875. Glass and Donahoo ran the mill until 1882. Another mill which began its operation in 1874 was named the Flint Lock, a steam-powered, up-and-down mill built by C. G. Davis and D. C. Clark, located south of Ockenden and east of Pine Ridge. The mill was not successful, and was soon taken over by a man named Morgan (Hurt 1941:32).

In the 1880s, smaller mills began operating along Stevenson Creek. One of the first lumbermen in the area was John Bacon who, on January 21, 1884, purchased 160 acres near the north shore of present-day Shaver Lake (Sec. 19, T9S/R25E, MDM) (TCR 1978:26). Between 1884 and 1890, many others followed Bacon's move, and most of the timberland in the north end of Stevenson Meadow was acquired by small-scale lumber concerns (TCR 1978:26).

In 1888, several slightly larger logging operations were established in the present-day Shaver Lake area. Humphrey and Mock of Pine Ridge and Ockenden built a mill at what was then Swanson Meadow (Sec. 25, T9S/R24E, MDM). Using a double-circular steam mill, Humphrey and Mock cut about 26,000,000 feet by 1892 and logged over 110 acres. To move the logs, they used oxen and horse teams and heavy log wagons (Hurt 1941:31). In 1888 a man by the name of Bennett moved his double-circular steam mill from Rush Creek to Stevenson Meadow (Sec. 19, T9S/R25E, MDM). Bennett's mill operated until 1900, with John Sage as mill wright. During that time about 7,000,000 feet were cut, and 300 acres were logged using oxen and horse teams (Hurt 1941:34). Also in 1888, the Musick family (H. L. Musick and brother Charles W.) began operating a double-circular steam mill in the vicinity of the present town of Shaver Lake (Sec. 35, T9S/R24E, MDM). The Musick mill operated for two years before it burned down. During its operation, the mill cut as much as 50,000 feet per day. Again, logging was done with oxen and horse teams and heavy log wagons (Hurt 1941:35).

The primary difficulty of early lumber operations in the lower Big Creek area had to do with transportation. A traveler who passed through the area in the summer of 1887 discussed this problem in some detail in his diary:

> The reason why this valuable land is not taken up under the pre-emption laws or purchased of the Government at two and a half dollars an acre is the difficulty of getting the timber to market. It takes a teamster with ten horses and two wagons, one coupled behind the other, four days to get to Fresno, and four days for the return journey empty. The most he can take is from four to five thousand feet at a time and for which he receives ten dollars a thousand, which means from forty to fifty dollars the trip. This lumber is purchased at the mills in the mountains at eight dollars a thousand, and is retailed by the lumber yards in Fresno, at $25 a thousand. Not one per cent of the lumber used in the county is brought from the mountains in consequence of the scarcity of teams to haul it, and the difficulty of competing with Oregon lumber which is brought a thousand miles by rail [Anonymous 1887:6].

As these early activities of the lumber industry in the Big Creek region illustrate, the lumber business was only partly industrialized during the 1860s–1880s. Although mills were powered by steam, transportation of both logs and finished lumber was by muscle power—a fact which severely restricted the output of the lumber industry. This handicap was to change during the 1890s with the advent and early development of the Fresno Flume and Lumber Company. This company soon brought up-to-date logging technology into the forest around what was later to be known as Shaver Lake—an industrial technology using donkey engines, a short railroad with locomotives, and a large, modern sawmill. The donkey engine (an upright steam engine with an attached drum which used wire rope and steam power to haul heavy logs through the woods to a landing) is a primary example of the industrialization process in western forests.

The Fresno Flume and Irrigation Company was organized in the late 1880s and incorporated in 1891 as the successor company to a smaller concern controlled by Captain H. D. Colson, R. B. Butler, C. W. Musick, Joseph P. Vincent, and others (Fresno Morning Republican, December 6, 1912:1). The company hired a young Fresno engineer by the name of John S. Eastwood—a man destined to leave a lasting mark on the area—as their chief engineer, and put him to work building levees and working on land reclamation (TCR 1978:27).

About 1890, two events occurred which helped to firmly establish the Fresno Flume and Irrigation Company. First, C. B. Shaver, a lumberman from Grand Rapids, Michigan, arrived in the Big Creek area and decided to invest in the Fresno Company. Shaver put up some $30,000 of his own money and later brought in men, like Lewis P. Swift, who also invested in the company (Fresno Morning Republican, December 6, 1912:2). Second, the company completed a granite and concrete dam across Stevenson Creek, just upstream from where the present Southern California Edison dam now stands. Near the dam, at the lower end of the meadow, the company built the largest mill ever put into operation in the Big Creek area (Hurt 1941:35; TCR 1978:27). The new lake formed by the damming of the creek was named Shaver Lake in honor of the company's largest investor.

Money was not the only thing that Shaver brought to the Fresno Flume and Irrigation Company: he also brought a knowledge of modern lumbering techniques as practiced in the East. Originally, the Fresno Flume and Irrigation Company operated much like the smaller concerns of the area. All lumber was hauled by team to Fresno over the Tollhouse grade, and the company used a double-circular steam mill which could cut about 90,000 feet of lumber per day (Fresno Morning Republican, December 6, 1912:4; Hurt 1941:35). It was Shaver's idea to dam up Stevenson Creek and construct a flume which would use the creek water to carry lumber from Shaver Lake to Clovis—some 40 miles away. In 1891, work began on the flume, and by 1894, the V-shaped, five-foot-wide flume was completed at a cost of $200,000 (Huber 1912:3; Rose n.d.:B1). In addition to carrying lumber, the new flume brought valuable irrigation water which was used by farmers on the west side of Clovis (Huber 1912:4).

Within the first ten years of its existence, the Fresno Flume and Irrigation Company greatly expanded, taking over many of the smaller concerns in the area, increasing the number of its employees, and incorporating new technologies into its logging practices. C. G. Davis, who in 1893 had opened a small mill near the northern arm of present-day Shaver Lake (Sec. 13, T9S/R24E, MDM), was bought out by the Fresno Flume and Irrigation Company about 1895 (Hurt 1941:31). By 1897, the flume company controlled some 12,000 acres of timber, principally pine, in the Shaver Lake area (Fresno—Past and Present 1972:1). This acreage had increased to about 25,000 in 1908 (Smith 1908:1). In addition to the outright takeover of local logging concerns, Fresno Flume and Irrigation also bought the cut of most of the smaller mills still operating in the area (Hurt 1941:35).

While expanding its holdings, the Fresno Flume and Irrigation Company also increased the size and scope of its work force. In 1897, the company had about a hundred men employed in mills and yards, and, except during the winter season, work went on both day and night—thanks to newly installed electric lights (Fresno—Past and Present 1972:1–2). Just three years later, United States Census records revealed far more employees working for the flume company in many different areas. Information from these census records show that there were at least 111 employees living in company-run housing, just over 50 employees living in privately run boarding houses, 40 or so men at work in the woods, and an unknown number of married men living in the vicinity with their families but also working for Fresno Flume and Irrigation Company. The overwhelming majority of these employees were White, age 18 to 40, and single, although a handful of Chinese were also employed. Most of these men listed their occupations as lumbermen or laborers. Other occupations included bookkeeper, clerk, physician, carpenter, pullyman, machinist, blacksmith, saw filer, sawyer, engineer, spooltender, woodsman, edgeman, waiter, cook, and dishwasher. The Chinese employees worked only as cooks and dishwashers (U.S. Census Office 1900a:10–11, 14, 15).

Along with increasing its acreage and work force, the Fresno Flume and Irrigation Company also incorporated new techniques into logging practices. As early as 1897, the company began using donkey engines and wooden chutes. The trees were felled by hand and pulled into a wooden chute by donkey engine. From there, the logs were hauled to the lake by an endless cable (operated by steam) and from there they were floated to the sawmill (Fresno—Past and Present 1972:1). Sometime around 1907, Fresno Flume and Irrigation purchased two locomotives and built a standard-gauge logging railroad running southeastward from Shaver Lake for about 12 miles. The railroad and larger donkey engines were used to dump logs in the east end of the lake, where they were floated from the dump to the sawmill (Adams 1961:n.p.; Fresno—Past and Present 1972:1; Hurt 1941:35). The donkey engines and railroad proved to be much more efficient than earlier logging practices.

The Fresno Flume and Irrigation Company remained one of the largest mills in the Big Creek area throughout the early years of the twentieth century. By the time the company was sold to Southern California Edison in 1919, it had cut over 450,000,000 board-feet of timber and purchased nearly as much from smaller mills in the area (Hurt 1941:35). The construction of the San Joaquin and Eastern Railroad, which began in 1911, meant easier transportation. New logging concerns came into the area, including a few shingle mills and shake camps, but none was as large as the Fresno Flume and Lumber Company.

San Joaquin Valley Agriculture and the Sierra National Forest

Stimulated by high foreign and domestic demand and the arrival of modern industrial transportation in the form of the Southern Pacific Railroad, the years between 1880 and 1900 were boom years for Fresno County agriculture. Whereas there were only 926 farms in the county in 1880, by 1900 there were 3290—an increase of over 350 percent. Other measures of expansion were even more spectacular. The value of farm land and farm buildings increased from 4.4 million dollars in 1880 to 37.3 million in 1900 (about 850%). The value of farm productions increased from just under one million dollars in 1879 to about 6.7 million in 1899 (about 670%) (U.S. Census Office 1883:106, 1902:268). As a result of this boom, Fresno County was, by 1900, already among the top three agricultural counties in California, ranking first in value of livestock, second in value of agricultural products, and third in value of farm land (U.S. Census Office 1902:268–269).

Since the San Joaquin Valley plains were naturally dry, much of this expanded production and land value was the result of irrigation practices making use of water diverted from Sierra Nevada streams. Farmers, therefore, became very nervous about the activities of the sheep herders and lumbermen in the higher mountains—for they feared that overgrazing and poor timberland practices would ruin the watershed upon which they depended for their prosperity. Fresno County agriculturalists realized that the owner of the land—the federal government—had to be pressured to protect this mountain environment. So on November 12, 1889, citizens from Fresno County and neighboring counties sent a petition to the United States Congress stating their concerns and recommending the preservation of the resources of the Sierra Nevada Mountains. The petition explained:

> It was fully established that the inroads of the timber speculators in the lower mountain regions and the almost numberless *bands* of sheep in the higher regions were playing sad havoc with the watersheds on which these counties depend. The sheep destroy the undergrowth which prevents a too rapid melting of the snows. The herders through carelessness and *design*, are frequent cause of the most disastrous fires, which sweep over vast areas, destroying the undergrowth—burning the leaves and brush and grasses from the mountain sides, thereby causing floods and such dimunition of the snows that the supply is inadequate when most needed for Irrigation [U.S. National Archives 1889].

The petition went on to state that "it is *absolutely* necessary that certain lands . . . should be forever withheld from entry or sale and the United States provide a proper means of policing and protecting the lands so reserved." Among the areas the petitioners wanted to protect were Township 8 South, Ranges 23–30 East; Township 9 South, Ranges 24–31 East; and Township 10 South, Ranges 25–31 East, Mt. Diablo Meridian—in effect, the entire Big Creek area.

Fresno County farmers were not alone in their concerns about the destruction of the Sierra Nevada's resources. For some time, conservationists and preservationists had been putting pressure on Washington legislators to establish a program to protect natural resources throughout the United States. As a result, in 1891, President Benjamin Harrison signed the Forest Reserve Act which provided that forest reserves could be set aside from any part of the public domain. That same year, a federal representative, B. F. Allen, was sent to California to investigate conditions east of the San Joaquin Valley and make recommendations for a reserve. Finding many of the complaints of Fresno County farmers to be valid, Allen agreed that sheep herding was destructive and recommended the creation of a forest reserve. On February 14, 1893, President Harrison followed Allen's advice by proclaiming the establishment of the Sierra Forest Reserve, which included the watershed of the upper San Joaquin (TCR 1978:15–16).

The response of the people living and working in the Big Creek area to this imposition of outside controls on the forest land was not overly enthusiastic. Especially troublesome for sheep herders working in the Big Creek area was the decision by the U.S. Forest Service to exclude all sheep from the Sierra Reserve in an effort to prevent further damage to the watershed and allow regeneration. "At first, the sheep men defied the federal order and continued to graze their flocks in the Reserve" (TCR 1978:16). Sheep herders joined with residents of the Big Creek area, including Jesse Ross, in signing a petition asking that certain lands (including T8S/R24E and T9S/R24E, MDM) be withdrawn from the Sierra Reserve because they contained "a large amount of good agricultural land . . . and even more good grazing land" (U.S. National Archives 1893). According to these petitioners there was "no reason for so reserving said townships, in order to keep the snow from melting rapidly,—for the reason that snow does not often fall there, and hardly ever lies on the ground more than two days ata [*sic*] time" (U.S. National Archives 1893). Many of the foothill and valley-based ranchers fought the sheep-herding restrictions in court, but eventually lost their cases (TCR 1985:44).

With sheep herding prohibited in the upper Big Creek area except on lands held privately through homesteads or Indian allotments, many of the ranchers who had used the area as a passageway to the high country turned to cattle raising. Ranching was permitted by the Forest Service as it was found to be less damaging to the land. Miller and Lux, the large grazing corporation that used the Big Creek area, switched its operation away from sheep and, beginning about 1897, ran some 3000 cattle through Big Creek into the higher areas (O'Neal 1952:12; USDA FS, Sierra National Forest 1942:[2]). Jim Thompson was another rancher who turned from sheep to cattle. Thompson was the first known user of what was later called the Kaiser Allotment, which lies on the south side of Kaiser Crest from Potter Pass Trail on the east to the San Joaquin River on the west—that is, most of the Big Creek area (USDA FS, Sierra National Forest n.d.:[2]). Captain Logan, an earlier partner in Logan and Taylor, expanded his cattle-grazing activities in the Big Creek area. Beginning in 1895, Logan and his new partner, Thomas Brown, ran 150 cattle directly past Jesse Ross's farm and on to the high country (USDA FS, Sierra National Forest 1942:[2]).

A description of the route many of these cattlemen took through the Big Creek area and the country they encountered is provided by John O'Neal in his article, "Two Blades of Grass Where Thousands Grew Before." O'Neal writes of when he first ran cattle through the area beginning in 1900, taking 125 of his father's cattle up to Jackass Meadow:

> During the first three years that I took cattle into the mountains we trailed them by way of North Fork. Leaving home the first days trailing took us to Pomona Dick's place this side of Bill Ellis's ranch near North Fork where the cattle were confined to a fenced field overnight. The second day we traveled past North Fork, Cascadel and then along the old road past Joe Kinsman's to the Jesse Ross place later called the Halloch [*sic*] place . . . and is now called the Hogue Ranch. Here the cattle were turned loose in the forest for the night.
>
> The forest was then so open and abundant with feed that the cattle did not scatter far and little difficulty was encountered the next morning in rounding up for the third day's trailing [O'Neal 1952:12–13].

O'Neal's article not only describes the cattle drive, but it is highly critical of the way stockmen were blamed for exploitation of the forests.

By the turn of the century, imposition of governmental control on the Big Creek area's forests had resulted in a changeover from sheep herding to cattle herding under more strict regulation. After 1902, the Forest Service began requiring grazing permits for use of the mountain ranges by cattlemen, and restricted the season to the period between mid–June and mid–September (TCR 1985:44). In 1905, jurisdiction over Forest Reserves was transferred from the Department of the Interior to the Department of Agriculture, and the Sierra Forest Reserve became the Sierra National Forest. At this point, the forests were staffed with professional Forest Service personnel who were responsible for monitoring such activities as timber conservation, pest control, grazing, fire fighting, and Indian allotments (TCR 1978:17, 1985:44). By 1906, through the work of full–time Forest Service personnel, prohibitions against sheep were largely in force in the Big Creek area. In 1908, the Sierra National Forest was divided into the Sequoia, Inyo, Mono, Stanislaus, and Sierra national forests (the latter encompassing the Big Creek area), all of which are still in existence today.

Conclusion: Legacy of the Prehistoric and Early Historic Eras

Successive eras of the past lie on each other somewhat like the geological strata of a mountain range. Each period is to varying degrees intertwined with what has come before, and in turn leaves some legacy for the future. The prehistoric and early historic eras in the Big Creek region left two types of legacies. First, there are the cultural resources of these periods—the physical remains of both the relatively self–sufficient society of the Mono and the mountain farming communities, as well as the sheep and cattle camps, lumber camps and sawmills of later years. Second, both eras contributed in fundamental ways to what came later: The Indians, Euro–American settlers, lumbermen, and sheep and cattle herders established a network of trails and roads which came to serve the hydroelectric developers. In addition, during the historic period, the regulatory framework provided by establishment of the Sierra National Forest was very important, for it provided a design within which to work out rights and duties of those who were to occupy and use any part of the public domain. The next subject of this study involves some of the prime users of these public lands. It is the story of an ambitious group of industrial developers—the men and women who created the Big Creek Hydroelectric System.

CHAPTER 2

PLANS: THE EMPIRE BUILDERS AND THE ENGINEER, 1893–1911

Big Creek was first recognized as having great hydroelectric potential during the decade of the 1890s. The man who first saw this potential was then an obscure engineer named John S. Eastwood. Eastwood, who had both vision and a high level of engineering skill, was soon able to lay out plans for development of the Big Creek Hydroelectric System. He was also successful in interesting a hard-headed, empire-building capitalist, Henry E. Huntington, in his plans. Between 1902 and 1911, this odd couple and their associates, William G. Kerckhoff and Allan C. Balch, laid the groundwork for eventual development of Big Creek. These four men were the central figures in early planning of the Big Creek development.

Eastwood

John S. Eastwood was an ambitious, creative, and pioneering engineer who at an early date recognized the great potential of hydroelectric power (Plate 1). His background and training made him an independent and somewhat iconoclastic engineer, a man with unusually high goals and the intelligence and drive to bring them to fruition. He was born in Scott County, Minnesota, in 1857, of Dutch emigrant parents. Eastwood's grandfather was the Royal Dutch Engineer, Arent Van Oosterhout, who was responsible for construction of many of Holland's dikes. While Eastwood followed his grandfather's engineering and water management interests, he chose not to retain the Oosterhout name but instead used the literal English translation, Eastwood (Whitney 1969:41).

Following college graduation, Eastwood's career began simply with a summer job working for a Minneapolis civil engineer. Soon, however, he was offered and accepted a job as assistant construction engineer on the Pacific extension of the Minneapolis and St. Louis Railroad. In 1883, after five years with the railroad, Eastwood realized that he worked best unsupervised. He set out for California and settled in Fresno, where he established a private engineering firm (Whitney 1969:41).

Eastwood's engineering talents were soon in demand, as Fresno was fast becoming California's "garden spot" for growth and development. To the east, the growing southern Sierra timber industry employed him to build logging railroads, flumes, and log-pond dams; closer to home, the City of Fresno engaged him to survey routes and superintend street construction. Fresnans quickly recognized Eastwood's skills and made him their first city engineer in 1885, although he still retained the right to maintain a private practice (Whitney 1969:41; Rose 1985:B1, B4).

In the 1880s and 1890s, the Fresno region was booming. At the same time, good sources of power for the area—and for most of California for that matter—were lacking. California's coal production was insignificant in relation to demand, wood was readily available only in mountainous areas, and oil had not yet been discovered in adequate quantities. In these circumstances, hydroelectric power

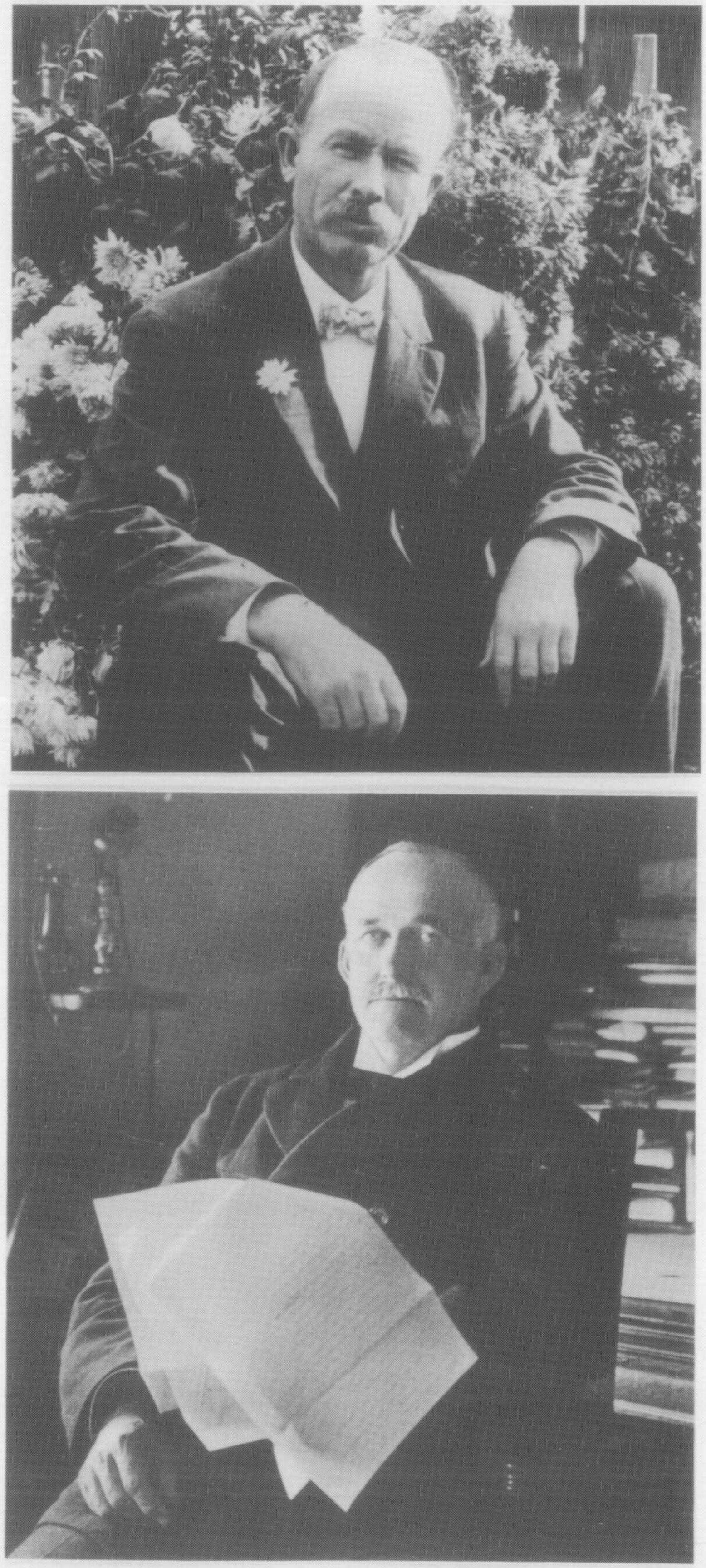


Plate 1 John S. Eastwood (SCE n.d.);
Henry E. Huntington (California State Library n.d.).

was a natural for the Fresno area and much of California. In addition, many of the technological problems needed to make hydroelectric power a reliable source of energy had already been solved; for example, water turbines were highly developed by 1890 (Hughes 1983:263–264). In the 1880s and 1890s, long-distance transmission of electrical power was a problem which remained to be solved, but many engineers world-wide were working on it.

As the potential inherent in hydroelectrical development became apparent in the early 1890s, John S. Eastwood was in an excellent position to capitalize on it. As early as the mid-1880s, Eastwood began to explore the Sierra Nevada Mountains east of Fresno (Redinger 1949:4). By 1893, Eastwood was familiar with the two best areas for hydroelectric development on the upper San Joaquin River and its main tributaries, the Big Creek and Willow Creek drainages of the San Joaquin River watershed. In the summer of 1893, Eastwood, with his wife and brother, went on a camping trip into the Big Creek country. During this trip, he rode out onto the ridge between Stevenson Creek and Big Creek, and spoke to his brother of creating a massive power project in that area. Later, Eastwood remarked to his wife about that day, "I went to the end of the rainbow . . . and found my pot of gold" (Welch n.d.:3).

Although John Eastwood had his eye on Big Creek as the site of a mammoth hydroelectric power development from at least as early as 1893, the massive potential of the project dwarfed both possible sources of financing and possible places where such power might be consumed. So Eastwood decided to focus on the second of the two potential hydroelectric generating locations: the confluence of Willow Creek and the San Joaquin River. Soon he was able to interest John Seymour, President of the Fresno Water Company, in a proposal to build a hydroelectric plant to supply electricity to Fresno. In January, 1894, Eastwood and Seymour became partners, but it was only when an outside source of capital was found that the project got off the ground. Financing was offered early in 1895 by the Municipal Investment Company of Chicago (Fresno Republican 1902:81; IRI/TCR 1985:115). With Seymour as president and Eastwood as vice-president and chief engineer, the San Joaquin Electrical Company was incorporated on April 2, 1895, with a capitalization of $800,000. Other directors of the new company were O. J. Woodward, Treasurer; L. L. Cory, Attorney; J. M. Collier, Secretary; M. R. Madary; and James Porteous (Fresno Repulbican 1902:8; IRI/TCR 1985:115–116). Funds for plant construction were provided by an $800,000 bond, and the new company soon gained control of the Fresno Water Company for a sum of $185,000 (Coleman 1952:186; IRI/TCR 1985:116).

Eastwood's plan was to divert the North Fork of the San Joaquin River (later called Willow Creek) at a point where it began its rapid drop into the San Joaquin River canyon—that is, in Madera County at Crane Valley, 37 miles northeast of Fresno. The proposed plant's head (i.e., the vertical distance the water falls from where it enters the penstock to where it hits the water wheel) was to be over 1400 feet—a height far exceeding any other hydroelectric power plant in the world at that time. Indeed, many skeptics thought such a head was too high for safe operation, and they also pointed out that Eastwood's proposed 37-mile transmission system to convey the power was unheard of among hydroelectric systems anywhere in the world (IRI/TCR 1985:116).

Certainly, it was a challenge to Eastwood's engineering prowess to design the technical aspects of a plant that was able to harness a 1410-foot head and control a power transmission system over 37 miles in length. "In those days," Eastwood stated, "everything was experimental and everybody connected with the business was a novice" (Fowler 1923:456). Nevertheless, Eastwood remained undaunted, and his triumph became apparent at the new plant's opening ceremonies. Curious guests and members of the general public assembled at the Fresno substation to view what they assumed would be a peaceful demonstration. The motor began to roar and there was a blast of air through the duct. As the blast gained strength, a huge cloud of dust, dirt, shavings, and various debris burst forth as well. The guests, assuming that a dangerous explosion was underway, beat a hasty retreat toward the exit. It took some minutes of reassurance to convince the frightened observers that the operation was merely an impressive, but harmless, display of power (Fowler 1923:456; IRI/TCR 1985:121).

Another even more frightening display took place in 1896 at the powerhouse below Reservoir Mountain at Corrine Lake. Here, George P. Low recorded a graphic picture of the starting of the water wheels:

> One of the first surprises experienced by the visitor to the powerhouse of the San Joaquin Electric Company results from standing him opposite the wheel house of one of the Pelton wheels within the pit while the attendant in the station starts up the equipment, and the nerves of the visitor must be strong if they can restrain him from fleeing terror-stricken from the heavy "cannonading" that accompanies the starting of the plant. He is, of course, aware that the installation is operated under a higher head of water than any other electric transmission plant in the world, but he is not prepared for an outburst resembling that of artillery, and his first thought will be that something is wrong—that the enormous receiver beside him is breaking away, and that but a moment stands between him and eternity, but he finds his distress a source of amusement to the station hands, and his chagrin secures satisfaction in the determination that he will get someone else in the same predicament, and "have the laugh on him." In truth he has received his first lesson of the terrific energy represented in a column of water which throws the gauge to above 600 pounds, and the rattle as of the "machine guns" is readily explained by the fact that while idle the chamber of the nozzle is filled with air, and upon opening the gate, the water rushes in, filling the lower portion of the nozzle first, then compressing the air in the upper part, and in the churning of the air that follows, bubble after bubble of air compressed to over 600 pounds per square inch is released, forming a discharge of pneumatic musketry that, reverberating through the canyons, bears tidings to the ranchers even six miles distant of the starting of the water wheels [Low 1896:79].

John Eastwood had silenced his critics; the new plant was a thundering success.

While the operation of this plant was a technological triumph, it did not bring the founders of San Joaquin Electric Company the financial success they had envisioned. A series of mechanical problems (compounded by the incompetence of a German engineer and actions of their gas company competitor, Fulton G. Berry) led to the company's downfall. In 1899 it was forced into bankruptcy, with Seymour and Eastwood losing heavily. Seymour, acting as receiver, struggled to keep the enterprise afloat, only to have it acquired in December 1902 by Allan C. Balch and William G. Kerckhoff, who reorganized it as the San Joaquin Power Company.

Although Eastwood was "eliminated from any financial interest . . . he was grateful to Balch and Kerckhoff for snatching it from oblivion" (Whitney 1969:43). Today, Eastwood's original location is being used by Pacific Gas and Electric Company's A. G. Wishon Powerhouse.

Excluded from influence over the future of his first hydroelectric development, Eastwood turned his attention to the Big Creek region. In 1900, he took several trips into the mountains, surveying the area extensively. In the same year, Eastwood formalized his plans for the Big Creek region, deciding on two separate and distinct projects. The first of these projects, Mammoth Pool, was to use the waters flowing in the main San Joaquin River at Mammoth Pool and in the lower end of Big Creek, whereas the Eastwood project was to use both the waters of the upper reaches of Big and Pitman creeks and the waters flowing in the San Joaquin River below the mouth of Big Creek (SCE 1917b:2).

While keeping his plans a secret, Eastwood set about securing water rights for his Mammoth Pool project. In August 1900, he posted a water appropriation notice which claimed 25,000 inches of the waters of the San Joaquin River to be diverted (in Sec. 15, T7S/R24E, MDM) for power purposes. This was soon followed by other notices which were posted along Big Creek, Pitman Creek, and the San Joaquin River (SCE 1917b:2).

To develop his interest in the Mammoth Pool project, Eastwood formed the Mammoth Electric Company, and on October 12, 1900, deeded the new company's water rights for the Mammoth Pool project. In exchange for his interests, Eastwood received a one-tenth interest in the new company. In 1901, the Mammoth Electric Company reorganized under the name of Mammoth Power Company. Eastwood continued to convey other water rights to the new power company as they were obtained.

However, this plan for development of Mammoth Pool did not come to fruition for 60 years—probably because (in typically ambitious Eastwood fashion) its scope was so vast that costs were projected at 10 million dollars. In 1901, this amount of capital was impossible to raise; furthermore, Eastwood planned to transmit power from the Mammoth project to San Francisco (Eastwood 1901:1–20), but there were other, more efficient hydroelectric generation sites more convenient to the Bay Area. Unknown to Eastwood at the time, the key to the destiny of Big Creek development lay to the south—in the rapidly growing Los Angeles area. Already in the years 1901 and 1902, the empire builders of the southern metropolis were organizing themselves, and soon they would be willing to consider the visionary plans of John S. Eastwood.

Huntington

Henry E. Huntington was, as Charles Whitney described, born "with an outsize instinct for acquisition" in Oneonta, New York, in 1850 (Whitney 1969:45). Huntington's start in the business world came from his uncle, Collis P. Huntington, mastermind consolidator of the Southern Pacific Railway. Impressed with the younger Huntington's initiative in the hardware and lumber industries, Collis made Henry the superintendent of construction for the Huntington lines, then being built from Louisville to New Orleans. However, Henry was not content to be known only as the nephew of Collis P. Huntington. He quickly made a name for himself in the railroad industry, and, as McGroarty commented, "from that point [ca. 1880] no consecutive account could be given of his rapidly accumulating interests as a railroad builder and financier" (McGroarty 1923:365).

In 1901, after being thwarted in his desire to ascend to the Southern Pacific Railroad presidency, Huntington sold the $50 million worth of Southern Pacific stock he had inherited from his uncle, and headed for Los Angeles to create an empire (Johnston 1965:10). Early on, Huntington realized the potential of Los Angeles, remarking, "I am a foresighted man, and I believe that Los Angeles is destined to become the most important city in this country if not in the world" (Crump 1962:11). Soon Huntington had grand plans for development of the Los Angeles area in particular, and southern California in general. A key element of these plans involved construction of an electric railroad system in the Los Angeles basin—a system which could be extended throughout southern California and even the rest of the state. But transportation was only part of Huntington's plans: he also wanted to purchase and develop huge blocks of real estate—land which would greatly increase in value once it became accessible by railroad. Finally, Huntington created or purchased public utilities—gas and electric systems especially—which could be extended to his new land developments. The gradual implementation of Huntington's plans during the first decade of this century created a vertically integrated empire of real estate developments, electric railroad transportation, and public utilities, which made Henry E. Huntington the most important man in southern California. Due to the fact that the empire he was creating had a great need for electric power (both for his railroad system and his public utility business), Huntington soon had a special interest in further development of electric power potential in southern California. This interest brought him in contact with electrical engineers and other developers of electrical power. Two such men, soon to become Huntington's allies, were William G. Kerckhoff and Allan C. Balch.

Kerckhoff

William G. Kerckhoff was born in Terre Haute, Indiana, in 1856. His early years were spent at the gymnasium at Lingen, Hanover, where his father had been educated. Kerchhoff's first business training was acquired in his father's wholesale saddlery-hardware establishment. Following this training, he set off on a trip to California, which he would later remark was the turning point of his life. Upon returning from this trip, he convinced his family to move to California; and in 1878 he moved to Los Angeles, with his family following the next year.

Soon after their arrival, Kerckhoff and his father became interested in a lumber company (later known as Kerckhoff-Cuzner Mill and Lumber), with the younger Kerckhoff acting as company president. It was this enterprise that provided Kerckhoff the financial resources and important business connections necessary for his later entrepreneurial endeavors. Through his dealings in the lumber industry, Kerckhoff took an interest in the San Gabriel Valley Rapid Transit Railway connecting Los Angeles, Pasadena, and Monrovia. The railway was eventually purchased by the Southern Pacific Railway, whose directors included Henry E. Huntington. The sale brought Kerckhoff not only financial gains, but introduced him to Huntington, a man whose career would be intertwined with his for the next decade and a half (Hunt 1932:148).

Kerckhoff's first attempt to put water to commercial use was in a water-powered cold storage plant using water from the Azusa River. This enterprise united him with such businessmen as M. Dodsworth, M. G. Eshman, Abe Haas (wholesale merchant), Kaspare Cohn (banker), and Henry W. O'Melveny (lawyer), who would subsequently join him in filing for the water rights of the San Gabriel River. In 1896, Kerckhoff was joined by Allan C. Balch, an electrical engineer, in the formation of the San Gabriel Electric Company. By 1898, Kerckhoff, Balch, and associates had successfully completed a hydroelectric power plant on the San Gabriel River (O'Melveny 1941).

Balch

Allan C. Balch, born in 1864 at Valley Falls, New York, became interested in electricity and engineering at a young age. After graduating from Cornell with degrees in electrical and mechanical engineering, Balch decided to go west where greater opportunities could be found. By 1891, Balch was managing the Union Power Company of Portland (a steam plant powered by slabs from a sawmill) which supplied light and power for the operation of the city's street railways (Fowler 1923:540; Los Angeles Examiner 1912:27).

In 1896, convinced that further advances could and would be made in transmission of electric energy, Balch sold his interest in the company and moved to Los Angeles. There, he became one of the founders of Sierra Power Company, Mentone Power Company, and San Gabriel Electric Company. It was Balch's involvement in the latter company that brought him into contact with William Kerckhoff and Henry Huntington—two principal participants in future development of the Big Creek area.

Pacific Light and Power Company, 1902

Huntington, Kerckhoff, and Balch were natural allies. Huntington's electric railroad lines needed good and inexpensive sources of electricity. Kerckhoff and Balch's San Gabriel Electric Company had a hydroelectric plant on the San Gabriel River, and they were planning another, even larger development on the Kern River over 100 miles north of Los Angeles. In 1901 and 1902 Huntington, Kerckhoff, and Balch formalized their community of interest by joining together to create the Pacific Light and Power Company. However, the original aim in creation of this new company was far grander than a simple consolidation of Huntington/Kerckhoff/Balch interests.

As is often the case with a new industry established in competitive conditions, there were a number of small or medium-sized electric utility companies established in the Los Angeles area during the 1890s and around the turn of the century. Since this type of business is a natural monopoly (that is, most efficiently operated by one large company), mergers were inevitable. The only real question was, who would come out on top in the struggle to succeed? With this in mind, Kerckhoff and Huntington, in cooperation with prominent California financier I. W. Hellman (President of the Union Trust Company of San Francisco), planned to consolidate all the major electric companies in the Los Angeles area. As Kerckhoff stated in a letter to Hellman in January, 1902: "You will remember that while in San Francisco I spoke to you of the matter of consolidating the various companies here . . ." (Kerckhoff 1902a:1).

With this goal in mind, Kerckhoff had opened negotiations with Edison Electric Company and Los Angeles Electric Company. He found that Edison drove too hard a bargain (it "over-values its plant," as Kerckhoff put it) and was ready to give up the original aim, but ". . . after talking the matter over with Mr. Huntington, have concluded to continue negotiations with the Los Angeles Co. . . ." (Kerckhoff 1902a:1).

Although the ultimate aim was never forsaken, nothing immediately came of these negotiations. When Pacific Light and Power Company was incorporated in March of 1902, it included only properties already controlled by Huntington, Kerckhoff, and Balch; namely, the San Gabriel Electric Company's hydroelectric facilities and the Los Angeles Electric Railroad Company's electric power generation plant (Kerckhoff 1902b). Details for the merger were worked out by Kerckhoff's lawyer, H. W. O'Melveny (O'Melveny, February 21, 1902). Stock in the new company was divided between Huntington and his associates (including Hellman) (51%) and Kerckhoff and his associates (49%) (Kerckhoff 1902c). The seven-man board of directors of the new company reflected this stock division, with Huntington and allies holding four seats, and Kerckhoff, Balch and O'Melveny the remaining three (Pacific Light and Power Company 1902). Huntington actually controlled Pacific Light and Power Company through the Los Angeles Railroad, which formally held the 51 percent stock ownership. Huntington in turn owned 55 percent of the Los Angeles Railroad Company, the other 45 percent being owned by the Southern Pacific Railroad (Clay 1966:271; Fowler 1923:540). The minority involvement of the Southern Pacific Railroad in Pacific Light and Power Company, both through the Los Angeles Railroad and Henry E. Huntington himself (Huntington remained on the Board of Directors of Southern Pacific into the 1920s), was destined to have an influence on development of the Big Creek System (Crump 1962:179).

The aim of Pacific Light and Power Company was twofold: to supply Huntington's electric railroads with inexpensive electric power, and "sooner or later" to take over all existing electric power companies in the Los Angeles area (Kerckhoff 1902b:1). Progress was made on both of these goals during the few months immediately following creation of Pacific Light and Power Company. In a long letter to Huntington dated October 23, 1902, Kerckhoff discussed in some detail his ideas about how to force other companies in the Los Angeles area either to open up their territory to Pacific Light and Power generation or merge with Pacific Light and Power. In view of Pacific Light and Power Company's later merger with Edison Electric/Southern California Edison, Kerckhoff's comments on the Edison Company are especially interesting. Since rate wars and other risks were involved, Kerckhoff was unusually blunt in discussing the problem posed by Edison, and its possible solution:

> In regard to our relations with the Edison Company. As you are aware, we have not touched the Pasadena business, nor any business in the San Bernardino and Redlands districts. I think we ought to force a division of the Pasadena business, which is large and still growing. We have an agreement with this company as to the division of territory outside of Los Angeles, which agreement is subject to cancellation at the desire of either party. However, when we enter the territories of the

> Edison Company which not only include Pasadena, but such towns as Santa Ana and the intervening territory, we shall probably open up the entire proposition in Southern California, and precipitate a fight along the line, not only in the outlying territories, but also in Los Angeles. I have thought that if this should happen and a fight properly prosecuted that with the revenue this company has not subject to attack, that the situation could easily be brought about in which the Edison Company's property and the Los Angeles Lighting Company's property could be purchased at reasonable rates. Of course, this is a condition of affairs which we would not undertake to create without the fullest understanding with you on the subject [Kerckhoff 1902d:2].

Kerckhoff closed his letter with the statement that very good profits would be possible if Pacific Light and Power could take over the entire electric business of the Los Angeles area (Kerckhoff 1902d:5). Kerckhoff's plan to force Edison to either agree to a merger or open up its territory to penetration was apparently never implemented, perhaps because Pacific Light and Power Company's sources of electric power supply were inadequate. The efforts of Pacific Light and Power were instead focused in another direction—toward the development of new hydroelectric power facilities in the southern Sierra. This involved, among other things, contracting for the services of John S. Eastwood.

The Empire Builders Look to the Southern Sierra

There was only one possible source for those who wanted to expand the available supply of inexpensive electrical power available in the Los Angeles area during the first decade of the twentieth century: the mighty Sierra Nevada Mountains. Only here were the needed water supply and reservoir and powerhouse sites necessary for efficient large-scale electrical generation. The leaders of Pacific Light and Power initially focused on the Kern River watershed, building the large Borel power plant on this river in 1902-1904 (Downing et al. n.d.:597; Kerckhoff 1902e). No later than the summer of 1902, however, Kerckhoff, Balch, and Huntington recognized that long-range needs of both their companies—and the Los Angeles area—demanded more power than the Kern River could ever give. There was also the possibility that Huntington or the Southern Pacific itself might build an electric railroad through the San Joaquin Valley, a line which would need large amounts of electric power (Crump 1965:53). For these reasons, Kerckhoff and Balch, acting as allies of Huntington, purchased the San Joaquin Electric Company during the second half of 1902 (O'Melveny, August 8, 1902, December 8, 1902). As vice president and chief engineer of San Joaquin Electric, John S. Eastwood came into direct contact with Kerckhoff and Balch—an ideal opportunity to present his Big Creek plans to them. Evidently Eastwood's ideas were appreciated, for in July 1902 he was hired to work for Kerckhoff and Balch. Eastwood's job, which was to last for the next eight years, was to do all preliminary planning needed to begin work on a gigantic hydroelectric project in the Big Creek region (Reppy 1936:1; SCE 1917b:7). This included securing water rights and making surveys for hydroelectric facilities such as dams, tunnels, penstock lines, and power plant sites.

Kerckhoff and Balch immediately sent Eastwood into the Big Creek region to begin his work. By early October 1902, he reported to his employers:

> It gives me great pleasure to inform you that I have completed the survey for a tunnel line to the junction of Pitman and Big Creeks and I can place before you the most remarkable power project yet presented [Coleman 1952:189].

In December of 1902, Eastwood began filing large water claims in the Big Creek region, one for 100,000 miners inches (Fresno Morning Republican, December 10, 1902). In this and later work Eastwood, while working directly under Balch and Kerckhoff, was ultimately working for Huntington, and his major reports were sent to Huntington. This ultimate source of control was recognized at an early date by the *Fresno Republican*:

> Those in a position to know are of the opinion that the fine hand of H. E. Huntington is clearly discernible in the numerous water claims that have been filed on likely producing points in the mountain water shed to the east of the San Joaquin Valley. . . . The locator of the water privileges [J. S. Eastwood] is not, however making admissions in this direction . . . [Fresno Republican n.d.].

Water filings continued during spring and summer of 1903, and, by August of 1903, 410,000 miners inches of water had been claimed (Welch n.d.).

Eastwood's Original Plan, August 1903

During 1902 and 1903, John Eastwood spent much time in the Big Creek region, living in a log cabin at the meadow near where Huntington Lake Lodge later stood. After a year of work surveying the Big Creek development, Eastwood was ready to issue a report detailing his plans for one of the largest hydroelectric projects the world had ever seen. The report was given to Kerckhoff and Balch, who soon passed it on to Henry E. Huntington. Writing on Pacific Light and Power stationery in a letter dated August 10, 1903, Kerckhoff introduced Eastwood's report as follows:

> As you are aware, we have a number of water rights on the San Joaquin River, some of which are now being surveyed and held by our engineer, J. S. Eastwood. Applications for all these have been made in the Department of the Interior and I hope will soon be granted. As far as our filings are concerned, they are all in first class legal shape, and as far as we know there are no conflicting rights, either for the water or for the land.
>
> I enclose statement of the various powers by Mr. Eastwood. You will undoubtedly think on reading this over that Mr. Eastwood is making a tremendous over-estimate as to the amount of power. However, I am satisfied that his estimates are reasonable ones as I have had the matter checked up by Mr. Olmsted, an entirely disinterested engineer [Kerckhoff 1903:1].

The crux of the matter was, however, whether the Huntington electric railroad system needed even part of such a huge hydroelectric system in 1903, or—given the lack of demand for all of Big Creek's great potential power—if a steam power plant would be cheaper and more efficient. Huntington decided that the answer to this question favored the steam plant, so the development of Big Creek would have to wait. Nevertheless, Eastwood's 1903 plan was the basis for much of what was to follow. His report outlined the location of Huntington Lake (then called "Big Creek Basin reservoir") and three power plant sites; it also pointed out that Shaver Lake could be used to store additional water, and that the System could be built in stages as more power was needed over time. Eastwood's initial plan, called "Engineer's Report," was thus a remarkable document—one worth quoting at some length:

ENGINEER'S REPORT.
BIG CREEK POWER PLANTS.

In making this preliminary report I will ask that it be borne in mind in extenuation of its apparent incompleteness, that owing to the limited time, the preliminary engineering surveys of plant No. 1 only are made while those for No's 2 and 3 are not made at all, the data on the latter, given herewith, being based on reconnaisances [*sic*] only, will therefore be subject to revision in conformity with the results of the actual surveys, but in the main will agree closely with the final results.

It is my purpose to give you merely an outline of the project, showing the principal features of each part of the general plan, so arranged that the main features may be comprehended at a glance.

The general plan consists of a scheme for using the waters of Big Creek of the San Joaquin and its tributaries, the principal portion of which is to consist of waters stored in Big Creek Basin reservoir.

BIG CREEK DRAINAGE AREA.

The water shed of Big Creek, and its principal branch, Pittman Creek, consists of a plateau region lying to the north of the divide between Kings River and the San Joaquin, and extends from the abrupt western edge of the canon of the south fork of the San Joaquin westerly to the brink of the canon of the main San Joaquin river, and is surrounded by a rim or almost continuous series of mountain peaks, culminating in Mount Keyser, 10300 feet high, on the north rim, and the divide between the south fork of the San Joaquin and Big Creek to the east, from 9,000 to 11,000 feet high and the main divide between Kings River and San Joaquin waters on the south, from 9,000 to 12,000 feet high. From this rim all the creeks and water courses, except Pittman creek, converge into Big Creek Basin at an elevation of 6,800 feet above the sea level at its lowest point. . . . The area of Big Creek drainage basin is about 90 square miles, taken from the map of the Government surveys, and of Pittman Creek above the point of diversion, 25 square miles, making a total area of about 115 square miles. As the elevation and position on the range is such that the precipitation is the maximum for this latitude, while the natural storage in meadows and soil is subject to little evaporation owing to its high altitude, this basin will furnish a very large annual run off, as, owing to the solid condition of the underlying rock there can be no appreciable seepage, and the evaporation being light, the run off will be a large percentage of the precipitation. While the percentage of run off will vary directly with the volume of precipitation, the true basis of water supply, takin [*sic*] in the following calculations, is the condition existing on a dry year. On this water shed the lowest annual precipitation will rarely fall below 60 inches, with a run off of 24 inches, or 147, 200 acre-feet per annum. . . .

TOTAL POWER ON BIG CREEK.

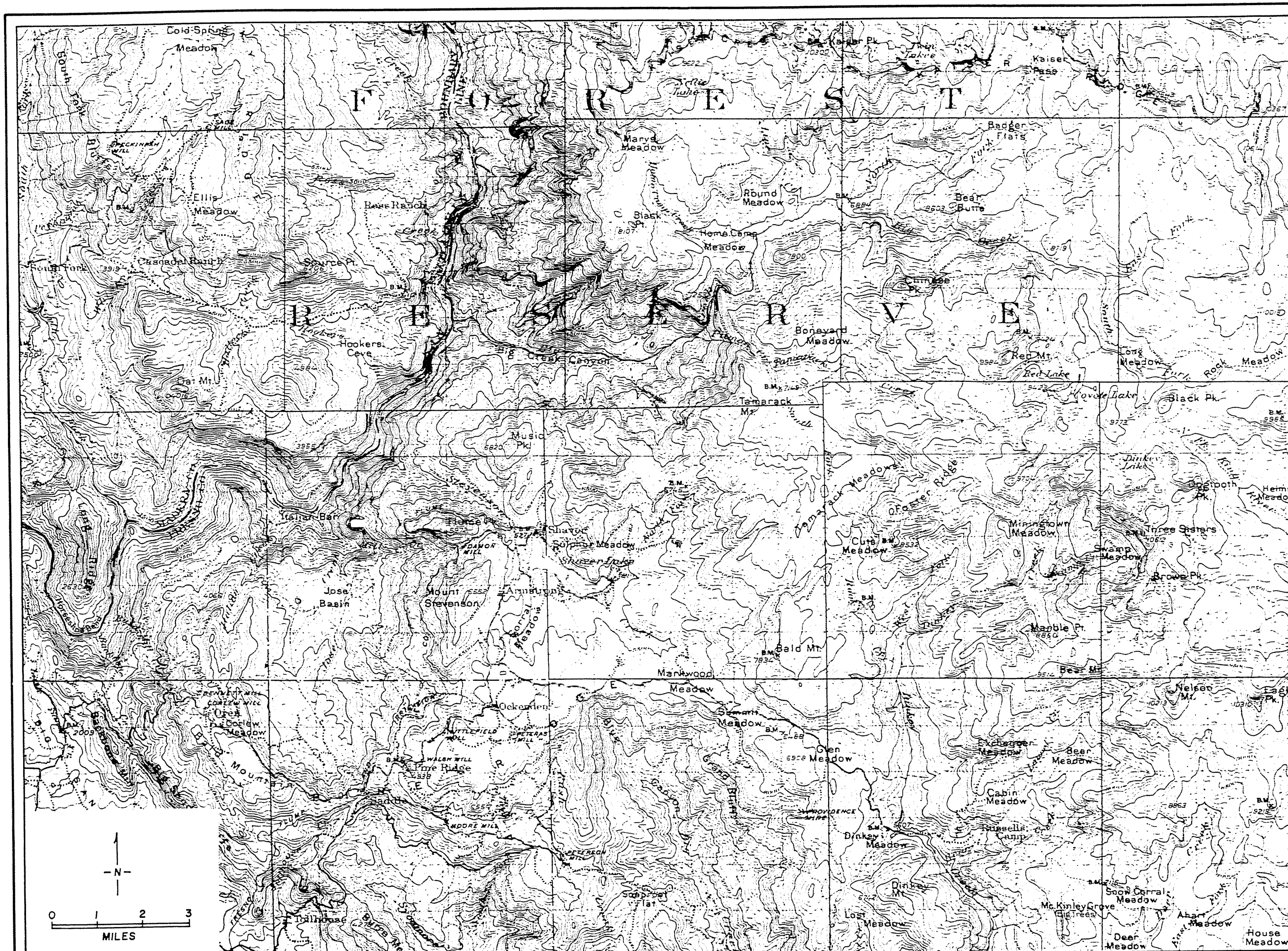
The total fall from the surface of the water in the reservoir to the water in the main San Joaquin River at Italian bar, the site of plant No. 3, if [*sic*] 5,550 feet, to be used in three falls, allowing for losses between plants, for grade and high water, deducting 270 feet for all, the net fall is 5,280 feet effective, which with an equivalent of 300 second-feet of water, at 80% efficiency is about 142,560 horse power. The two lower plants, having a combined effective fall of 3,230 feet, could each be supplied with 100 second-feet additional from a reservoir of Shaver Lake, making the equivelent [*sic*] of 450 second-feet, under a fall of 3,230 feet, or an output of about 130,000 horse power from the lower plants at 80% efficiency, or a grand total possible in the three Big Creek plants of 185,000 horse power.

While on the subject, I wish to note the power possibilities on the main San Joaquin river, in order to keep the data together. From the junction of the upper north fork, at an altitude of 5,000 feet at a point where most of the permanent flow is in the river, to a point on the main river at Big Creek plant No. 3, the effective fall if [*sic*] 3,200 feet. The water supply, using the few reservoir sites examined, and there are many more, would be 600 second-feet, or an output at 80% efficiency of about 172,800 horse power, in two falls with about 30 miles of conduit in all, or a grand total on both streams of 358,965 horse power.

The attractive feature most apparent, outside of the fact, that any one of the plants can be installed very cheaply, is that they can be installed progressively, without the slightest interruption of previously built works, in the case of all the plants, besides each of them is of a size most economical to build and operate.

After the completion of the reservoir dams, and Pittman creek ditch, the cost of which should be charged to each of the plants in proportion to the power output of each, the second and third sites can be utilized by boring the tunnel and pressure line for either without in any way interrupting the service of plant No. 1. . . [Eastwood 1903:1-5].

Map 3 (Big Creek Region in 1904) illustrates the Big Creek drainage area and surrounding country during the period of Eastwood's survey. This map (based on the U.S. Geological Survey's Kaiser Quadrangle map of 1904) shows the steepness of topography around Big Creek, as well as the area'a lack of development. Eastwood's cabin was at what he called "Big Creek Basin," labeled on Map 3 as "Home Camp Meadow" (this name probably came from the earlier presence of a sheep or cattle camp at this location).



MAP 3 -BIG CREEK REGION 1904- U.S.G.S. Kaiser Quadrangle

Interregnum: Big Creek Development on Hold, 1903–1909

As was so often the case with Eastwood's ambitious plans, his 1903 proposal for development of Big Creek was ahead of its time. The demand for electric power was not yet sufficiently advanced in Los Angeles to justify such a grand-scale development, nor was there any other market close enough to Big Creek to justify the large expenditures necessary to complete even the first phase of the project. So, several years following the 1903 submission of Eastwood's first plan were slow ones—a kind of interregnum in the project's history. During these years, however, necessary groundwork was laid for full-scale development: gaining needed permits from the federal government (owner of the land); building roads needed for access to the area; making agreements with other private interests with claims on the water; and refining developmental plans that Eastwood had already begun. Meanwhile, John S. Eastwood continued to be the central figure in this period of Big Creek's history.

During the entire 1902–1910 period, Eastwood worked on the Big Creek development under an agreement with Allan C. Balch. As an officer in both San Joaquin Power Company and Pacific Light and Power Company, Balch directly represented Huntington and Kerckhoff's interests in this relationship, as well as his own. The agreement reportedly provided only for reimbursement of Eastwood's expenses while planning work continued. If and when the project was actually built, Eastwood would then receive a ten percent interest in the corporation which built it (Whitney 1972:22–23). Working under this agreement, Eastwood continued his efforts both in the field and at the drafting board. Between 1903 and 1906 he continued to file water rights claims, and prepared and filed four maps with the U.S. Department of the Interior covering powerhouse numbers 1, 2, 3 and 4 (Trowbridge 1949:10–18; Ward 1918:2). Government approval followed quickly (Trowbridge 1954:1–3).

The next step was negotiation of an agreement between Miller and Lux (the giant land and livestock combine which had vast landholdings in the San Joaquin Valley and downstream water rights to much of the water to be used for the Big Creek project) and Eastwood, Kerckhoff, Balch, and Huntington. This agreement was difficult to achieve, and the fact that it was concluded without expensive litigation indicates the influence of Huntington's personal connections with top officers of the Miller and Lux combine. Kerckhoff's lawyer, Henry W. O'Melveny, suggested as early as mid-1904 that Huntington and Kerckhoff should meet with Lloyd Tevis and Mr. Nickel of Miller and Lux to settle the question of water rights (and hydroelectric power in general) short of the law courts (O'Melveny 1904). This was apparently done, because an amiable agreement was reached between the two parties in August of 1906 (Miller and Lux, Incorporated, et al. and John S. Eastwood et al. 1906). The core of this and subsequent agreements was that dams to be built on the San Joaquin River and its tributaries to impound water for hydroelectric generation could not be filled except when the river was flowing above a specified level. As the original agreement stated: ". . . in the event the parties of the second part shall at any time be storing water in a reservoir on Big creek and there shall cease to be three thousand (3000) cubic feet per second of water flowing at such point of measurement, they will immediately cease to store water in any reservoir on said Big creek" (Miller and Lux, Incorporated, et al. and John S. Eastwood et al. 1906:7).

The next step in efforts to lay the groundwork for Big Creek development involved road building. As late as 1905, the nearest road in the region was a lumber industry road which terminated near the town of Shaver (near Shaver Lake). Beginning in late 1905 or early 1906, road construction to link Shaver with Big Creek Basin (the future site of Huntington Lake) was ongoing. Before the first road was completed, however, the need for a second was determined—this one to avoid the steep grades to Shaver located in the Toll House region. Therefore, about October 1908, construction of a second road was begun, from Auberry to Camp No. 1. This road followed the San Joaquin River and Big Creek to an intersection with the first road near today's location of Powerhouse No. 1. These roads were based on permits granted John S. Eastwood by the Department of the Interior in 1903 and 1904, and both were completed in 1911 (Redinger 1949:19; Ward 1918:3).

By 1907, the Sierra National Forest controlled the permit-granting process for the Big Creek region. The new Forest Supervisor, Charles H. Shinn, took a critical stance toward the hydroelectric entrepreneurs so active on his Forest. As could be expected from an intelligent and progressive-minded public servant during the presidency of Theodore Roosevelt, Shinn's conception of proper use of national forests differed from the Eastwood-Huntington view. Shinn saw the hydroelectrical entrepreneurs as greedy capitalists who wanted to lock up the Forest's resources for themselves by putting up fences and keeping the public out. As Shinn put it in a 1907 letter to Chief Forester Gifford Pinchot:

> . . . they have surveyed and estimated all the power in this Forest, and have filed on most of it. They expect to reservoir and use the whole water-shed of the Sierra Nevadas, with as little payment as possible, and with no attention to the broader demands of higher civilization for outdoor life. My personal relations with the managers are excellent, but we deal with men of entirely primitive capitalistic instincts and training. It is one chain: Wishon and Eastwood, Frank Short and Senator Gallinger, Huntington and Harriman (agents, attorneys, principals, etc.). To one and all of them the entire modern Rooseveltian theory of public utilities is lunacy, ignorance and diabolism [Shinn 1907:1–2].

Shinn recommended that the Forest Service should cancel all old permits issued by the Department of the Interior and require Eastwood et al. to apply for new permits with higher payments to the Forest as well as stiffer requirements and restrictions (Shinn 1907:2). This recommendation for new permits was implemented, but in late 1909 Eastwood was successful in getting a new comprehensive permit from the Forest Service (Trowbridge 1949:19–20).

Creation of Pacific Light and Power Corporation and Final Plans for Big Creek Development, 1909–1911

During 1909 and 1910 a series of decisions were made—mainly by Huntington and Kerckhoff—which brought together the main elements needed to finally begin construction of the first phase of Big Creek development. The first of these decisions was to bring in several outside consultants to check all of Eastwood's estimates of cost and electric power potential of Big Creek. Due to the tremendous costs involved, Huntington and Kerckhoff wanted to be absolutely certain that development would pay for itself over time.

The first outside authority to be consulted was the east coast engineering consulting firm, J. G. White and Company. They were apparently hired in 1908 or early 1909 to estimate the cost of building the first two Big Creek power plants. Their report, which was completed by mid-May, 1909, estimated total cost of the two power plants at about 12.34 million dollars, including conduits, tunnels, buildings, hydraulic and electrical equipment, engineering fees and a transmission line (Storrow and White 1909). Faced with this magnitude of expenditure, Huntington wanted to be sure the electric output would be worth the cost, so he brought in the chief engineer of the Southern Pacific Railroad to provide yet another opinion on the project.

There seem to have been at least three reasons for involving the Southern Pacific. One reason was that Huntington had made his early career with the Southern Pacific; he had been its vice president and still served on its board of directors; therefore, he probably knew and trusted the judgment of its engineers. A second reason was that the Southern Pacific was a part owner of Pacific Light and Power Company—a prime candidate for developing the Big Creek System. Finally, in 1909, there was still some question about whether effective demand for power in Los Angeles was strong enough to justify the Big Creek development. The Southern Pacific was viewed as a potential large-scale consumer of electric power, especially if it converted some or all of its main-line rail routes to electric power. Kerckhoff mentioned this possibility in a September 1910 letter to William F. Herrin, Chief Counsel of Southern Pacific, adding that the Big Creek development was centrally located for provision of electric power to a possible Southern Pacific electric railroad through the central valley (Kerckhoff 1910a:2).

In the summer of 1909, William Hood, Chief Engineer of the Southern Pacific Railroad, assigned two of his engineers, Mr. Gaytes and Mr. Curtis, to study the Big Creek project and issue a report. The study was completed in October 1909. Unlike the J. G. White report, which focused only on the costs involved, the Hood report focused on both output and cost. The statement of the Southern Pacific engineers must have hit Eastwood, Balch, and Kerckhoff hard, because it concluded that the project would probably be a losing proposition, depending on various assumptions about electric rates, number of powerhouses built, depreciation, interest on loans to build the System, and repairs, operation, and maintenance costs (Kerckhoff 1910b:1–2). This report was in direct contradiction to the conclusions of Eastwood, Balch, and Kerckhoff over the previous seven years. Since part of Hood's conclusions were based on estimates of how much water was available in the Big Creek watershed each year, Balch and Kerckhoff had a concrete weir built on Big Creek to measure water flows. This weir was in operation at least from December 13, 1909, until July 31, 1910. Measurements showed that the water flow figures in the Hood report were too low and that a Big Creek development would be profitable. Hood's figures on depreciation and the cost of alternate sources of power in Los Angeles (basically electricity produced by a steam power plant) were also challenged as being incorrect by Kerckhoff and Balch (Kerckhoff 1910b).

While the controversy over cost and potential output of Big Creek development was being debated, other decisions were being made as if the Big Creek project was going forward. These decisions were corporate and financial ones, and at this level of decision-making, Henry E. Huntington was the supreme arbiter. Huntington, with Kerckhoff as his junior partner, still had the goal of consolidating all southern California electric companies into one giant combine. By 1909 they had added gas companies to their holdings, and wanted to consolidate the gas industry as well. To do this they needed capital, so in early 1909 they made an agreement with N. W. Halsey and Company, New York bankers, to market stocks and bonds for a new and much larger company. This new corporation, formed in early 1910, was the Pacific Light and Power Corporation, superseding the Pacific Light and Power Company (Fowler 1923:540; Huntington, Kerckhoff and Halsey 1909:1–4). A prospectus issued in 1909 in connection with sale of the stocks and bonds of the new Pacific Light and Power Corporation stresses the important role Big Creek development would have in the future of this corporation, pointing out that the demand for Big Creek power already existed (Anonymous n.d.:14).

While Huntington did want outside investors to help finance the acquisitions planned by the new corporation, he wanted complete personal control over the new Pacific Light and Power Corporation. Toward this end, in 1910 he decided to eliminate Southern Pacific Railroad's role in the new corporation. The original Pacific Light and Power Company had been jointly owned by Huntington and associates, the Southern Pacific, and Kerckhoff and associates. The Southern Pacific influence was exercised through a 45 percent ownership of the Los Angeles Railroad Company, which held 51 percent of Pacific Light and Power's stock. Now Huntington sought to eliminate this influence through trading one of his electric lines in Los Angeles, the Pacific Electric, to the Southern Pacific in exchange for their 45 percent control of the Los Angeles Railroad Company. This agreement was completed in May of 1910 (Crump 1962:89). Henceforth, Huntington held absolute control over Pacific Light and Power Corporation.

The last steps on the long road to beginning construction on the Big Creek development involved acquisition of the water rights and permits which had been acquired by Eastwood over the 1902–1910 years, and arrangments for the financing needed to begin. Soon after Pacific Light and Power Corporation was created, Balch exercised his option on Eastwood's plans, water rights, and the government permits which he held to develop the Big Creek System. These were transferred to Pacific Light and Power Corporation in February 1910 and October 1910 respectively (Trowbridge 1949:19–22). In exchange, Eastwood received ten percent of Pacific Light and Power Corporation's stock, and his connection with the Big Creek project was discontinued as of December 1, 1910 (Whitney 1972:1). This stock gave Eastwood no control over the corporation's affairs, however, and events soon to follow showed how such control was crucially important.

The last step on this unusually long road leading to initial development of Big Creek was to generate the large-scale capital needed for just the first phase. This effort began soon after a final decision was made to develop the System—a decision which came soon after the September 13, 1910, letter from Kerckhoff to Huntington. This letter concluded with the following strong argument to move foward with development:

> . . . I would say that the Big Creek power is the cheapest and most available in California today; it is centrally situated, and would be of the utmost importance to the Southern Pacific. In addition to this, our rights are all under laws as they exist now and are well secured. . . . In order to preserve our rights, however, we must begin work this fall and prosecute the work in good faith, with due diligence. The work required this fall and winter need not be very much, but it must be such that it cannot be questioned by anyone [Kerckhoff 1910b:2].

Late 1910 and the entire year of 1911 were devoted to working out financial arrangements needed to begin work. In October and November of 1910, the decision was made for Pacific Light and Power to create a bonded indebtedness by assessing stockholders a set amount per share (O'Melveny, October 17, 1910, November 3, 1910). This was an old Huntington technique to drive out people without large amounts of capital, often forcing them to sell their stock (cheaply) to him. As a man without large amounts of capital, John S. Eastwood was powerless to resist this scheme and gradually had to sell off his stock to pay the assessments. In the end he was left with nothing. Eastwood's niece later wrote that this resulted in ". . . complete monetary loss of all his work of a lifetime up to 1912 to Henry E. Huntington. . . ." (Welch n.d.:2). Soon, Kerckhoff and Balch also sold most of their stock to Huntington (O'Melveny, February 7, 1911). By mid-1912, and probably much before this date, Huntington held the overwhelming majority of the stock of Pacific Light and Power Corporation. A list of Pacific Light and Power stockholders dated May 22, 1912, showed that Huntington personally controlled the following percentages of stock (Pacific Light and Power Corporation 1912):

First Preferred	-	79.8%
Second Preferred	-	82.1%
Common Stock	-	49.6%

The second largest stockholder was Kerckhoff, who held only 6.8 percent of First Preferred and 12 percent of Second Preferred (Pacific Light and Power Corporation 1912).

In October and November of 1911, a final agreement was reached with a syndicate of New York bankers which made 10 million dollars available for the initial phase of construction on the Big Creek Hydroelectric System (Pacific Light and Power Corporation 1911; O'Melveny, February 7, 1911). After many years of waiting, work could begin at last on the first phase of what was eventually to be the largest and most important hydroelectric system in California.

CHAPTER 3

THE GREAT TRANSFORMATION: INITIAL CONSTRUCTION AND ITS AFTERMATH, 1911–1919

Although there had been years of surveys and detailed planning for a hydroelectric development at Big Creek, by late 1911 only road construction had actually been completed. This slow pace of development was soon to change, however, as forces were being put in motion which would—within the short span of a few years—create one of the great hydroelectric workshops of the world. The results of this massive construction effort were two of the world's most powerful hydroelectric generating plants and a 56-mile railroad linking Big Creek to the outside world. Thus, during the 1911–1914 period, industrialization came to the Big Creek region on a scale almost unimaginable a few years earlier. Once these years of rapid construction were over, the area settled down, with a much smaller population and less frantic work pace. Soon after completion of the two plants, World War I broke out and Big Creek construction—like large-scale construction projects worldwide—was largely put on hold. During the war, Southern California Edison and Pacific Light and Power Corporation merged, and when the war was over in late 1918, development capital again became available. With the demand for electric power rising in Los Angeles and capital once again obtainable, large-scale construction could begin again.

Beginnings: Late 1911 to Early 1912

The beginning of construction in 1911–1912 marked the end of a planning process which had spanned almost a decade. During those years, the demand for electric power in Los Angeles had skyrocketed as its population grew rapidly and Huntington's electric railroad lines spread across the landscape. This demand had been met for a time by the joint use of Pacific Light and Power's hydroelectric plants and its steam electric plant at Redondo. By 1911, however, it was evident that much more power was needed—and soon. The cost of power from the Redondo steam plant ($4.00 per 1000 kw.) was much higher than the cost of the same amount of power from the company's existing hydroelectric facilities ($0.91 per 1000 kw.), making the building of the Big Creek System financially attractive (Sibley 1912:154). It was soon decided that initially only two of the seven prospective power plants would be built: these were Powerhouse No. 1 and Powerhouse No. 2, the most attractive, cost-effective components of the project. In order to build these two plants, however, an immense amount of construction work had to be done. This work involved three dams at Big Creek Basin, two tunnels, two powerhouse buildings and their equipment, one long flow line, four high pressure penstocks, and a double circuit high voltage transmission line 248 miles long. Due to the long delay in starting the project, construction had to be rushed. Since this rush work required an engineering and construction organization much larger than even Pacific Light and Power Corporation could command, corporation leaders decided to employ the east coast firm of Stone and Webster Construction Company to undertake the job on a percentage basis. In November 1911, a contract was signed with Stone and Webster to build the three dams needed to create Huntington Lake reservoir in Big Creek Basin (to be filled to one-half its ultimate capacity), powerhouses No. 1 and No. 2, and the necessary forebays and tunnels "along the lines planned in the rough by John S. Eastwood for his Eastwood Project" (SCE 1917b:9; Ward 1918:3).

One of the initial decisions which had to be made—a decision which would have very important ramifications—was whether to follow Eastwood's original plan of creating Huntington Lake using earthen dams. Neither Pacific Light and Power Corporation nor Stone and Webster Construction Company favored the construction of this type of dam. Instead, the two parties agreed to substitute Cyclopean masonry dams with gravity sections (SCE 1917b:10). Preliminary surveys were then made to determine the most practical method of transporting into the Big Creek area the equipment and supplies necessary to build such dams. At first, 12- and 14-team wagons were considered for hauling, but this idea soon proved too time-consuming and expensive for handling both heavy equipment and the immense amount of concrete needed to build masonry dams. With teams ruled out, Pacific Light and Power Corporation decided the best method of transportation would be a railroad. This decision was not surprising, since Henry E. Huntington (an old railroad man) controlled Pacific Light and Power. In December 1911, the corporation sent a reconnaissance party into the vicinity of Friant, a terminus of the Southern Pacific line, to locate "the best route through the foothills to reach Auberry" (Redinger 1949:11). On January 26, 1912, Pacific Light and Power signed a second contract with Stone and Webster Construction Company for building a railroad stretching from Friant (later known as El Prado, 25 miles northeast of Fresno) to Big Creek (Johnston 1965:16).

Initially, secrecy about Pacific Light and Power's control of this railroad was maintained, and even the newspapers were deceived about its origins and real purpose. In mid-November 1911, newspaper articles stated that the railroad was being built by New Jersey timber and mining men. Quoting A. G. Wishon, manager of Kerckhoff and Balch's San Joaquin Light and Power Corporation, and Charles A. Lee, attorney for those who incorporated the railroad, the article went on to say that the line was not being built for Big Creek development. Lee, who stated that Shaver Lake was the final destination of the railroad, was quoted as follows:

> The construction of the road has no wide significance. . . . There is an abundance of timber land and mining territory about the lake, and the road is intended for no other purpose than opening up the country adjoining the lake. As soon as it is completed, a sawmill will be erected at the water terminal of the road and work on the mining properties will be begun [Fresno Morning Republican, November 19, 1911:32].

The reason for secrecy and related deception was probably the desire of the developers to obtain rights-of-way cheaply and without extensive delays. If it were widely known that Huntington and Pacific Light and Power Company were in charge, prices for rights-of-way might skyrocket.

The aura of secrecy continued to surround the project even after the newspapers were informed, early in 1912, that construction of a railroad into the mountains past Shaver Lake would be completed by Stone and Webster Construction Company for Pacific Light and Power Corporation. As the *Fresno Morning Republican* (January 28, 1912:1) explained, "Although it has been known since the first of December that the power company was preparing to build this road, the time for beginning construction work was kept secret, nor was any definite announcement made at [*sic*] to the route that was to be chosen." While Pacific Light and Power Corporation's contract with Stone and Webster clearly covered construction of a railroad from El Prado all the way to Big Creek (SCE 1917b:11), newspaper articles from early 1912 indicate that the railroad to Big Creek would only go as far as Pinnell's Station, 30 miles from Clovis (Fresno Morning Republican, January 28, 1912:1, January 29, 1912:12, January 30, 1912:3). From Pinnell's, the remainder of the distance would be traversed using a wagon road. The length of the railroad remained a mystery until February, when the *Fresno Morning Republican* reported that Stone and Webster's engineers were making surveys to determine how the wagon road could be developed into a railroad grade (Fresno Morning Republican, February 4, 1912:3).

Working On the Railroad

In early February, 1912, planning and organization were at last completed, and ground was broken to begin construction of the San Joaquin and Eastern Railroad. J. M. Thebo, chief engineer of the Stone and Webster Company, was placed in charge of the railroad's construction, which was scheduled for completion in three or four months (Fresno Morning Republican, February 6, 1912:9). Pressed for time, railroad workers began on several fronts at once. Construction crews were set up in camps about five miles apart, while survey parties hastened to finish their plans, barely keeping ahead of construction. Initially unable to obtain all needed rights-of-way, company officials worked frantically to secure the land as work progressed (Fresno Morning Republican, February 13, 1912:7). Railroad supplies, locomotives, and rolling stock were purchased as quickly as possible and kept ready in order to start operations at any time (Fresno Morning Republican, February 21, 1912:7). By late February 1912, construction was in full swing:

> . . . Three miles of grading has already been completed on the railroad which is being built to Big Creek. The grading work is near Auberry and with 500 men at work, a total of five miles will be ready by March 1. The laying of steel will probably begin early in March, according to representatives of the Stone-Webster construction firm, which is building the road. Steel and other equipment is already on the way.
>
> Construction work is being rushed as the road goes through very rough country, the progress already made is regarded as being unusual. There are five railroad camps on the right of way near Auberry and five hundred men are employed. Fully three hundred head of horses are being used in the construction work. The right of way swarms with men and grading teams and cuts are dug and canyons filled in short order.
>
> Not only is the grading and other construction work being rushed and promises early completion, but rolling stock is already being secured. A locomotive built to climb mountain grades and capable of drawing heavy trains into the heart of the mountains, has been purchased. Negotiations are also under hand for the purchase of other rolling stock and necessary adjuncts. These railroad supplies are purchased early with a view of having everything ready to start operations as soon as the grading and laying of steel has been completed.

> Surveying crews are at work along the right of way making final surveys and cross sectioning the line. Preliminary surveys were made a long time ago and it is now necessary to make permanent surveys. With the grading crews are competent construction engineers supervising the construction work and overseeing the building of bridges and culverts [Fresno Morning Republican, February 21, 1912:7].

The incorporation of the San Joaquin and Eastern Railroad Company in March 1912 had little impact on progress of the railroad's construction. Stone and Webster's crews continued to rush to meet their deadlines, while Pacific Light and Power Corporation kept finances afloat through their related company, the San Joaquin and Eastern. With only four miles of track laid, the new railroad company installed an engine with 12 flat cars to transport materials to workmen farther up grade (Fresno Morning Republican, March 27, 1912:7). To save on time and money, wherever possible Stone and Webster's crews used the old wagon road grade as the railroad's route, but this decision also had its problems. The government required that the wagon road be replaced with a "road as good as the present road," so the company had to build a new wagon road alongside the railroad (Fresno Morning Republican, March 11, 1912:5). In discussing progress of the San Joaquin and Eastern, a Fresno newspaper could report by April 1912 that 1800 men were at work in over 17 camps, with 12 miles of track complete and a third locomotive on its way (Fresno Morning Republican, April 3, 1912:16, April 19, 1912:7).

Due to the rush nature of the job, work on the railroad went on 10 hours a day, seven days a week. Crewmen numbered as many as 1200 at a time, although the average was only 800 (Johnston 1965:18). Most of these men were paid 27 cents an hour for the hard, manual labor involved in building this railroad. Such modern equipment as bulldozers were still unknown, so construction crews had to rely on simple construction techniques. As David Redinger described this work in *The Story of Big Creek*:

> There was nothing available for such construction in the way of the modern equipment we have today . . . consequently, all work had to be done by team and scraper, wheelbarrows, and hand drilling. . . . All drilling for blasting . . . was done by hand, with the well-known single and double-jack methods. The former is done by one man holding his own drill with one hand and wielding the sledge with the other. The latter method involves two men, one holding the drill with one or both hands while the sledge hammer is slung by the other man [Redinger 1949:12].

The final push for completion involved work in the higher mountains, where curves were sharper, grades steeper, and canyons more precipitous. By late May 1912, grading was finished all the way to Big Creek and the completed section of the railroad line extended to Auberry—near the half way point (completion of the road was expected by mid-July.) Six locomotives were being used on the completed section, including two big 60-ton geared Shay engines (Plate 2). These locomotives, built by the Shay Company of Lima, Ohio, were to be used on the steep, upper part of the railroad line, where more power was needed (Fresno Morning Republican, May 23, 1912:1). On the lower part of the line, below Auberry, standard rod engines were used (Sievers 1956:11).

As the *Fresno Morning Republican* reported in late June, 1912:

> About ten miles of the Big Creek railroad remain to be completed, according to an announcement made yesterday from the offices of the Stone & Webster Construction Company. The track crews are laying ties and steel now at the rate of a mile a day and by the first of the month or before the Fourth of July at the latest, the company expects to have construction completed. The track is almost up to Stevenson Creek now and by today or tomorrow it is expected that it will have passed that point.
>
> Although the road will be completed by the first of July, it is not the intention to open it for traffic before the 15th of July. Everything will be done this summer to discourage passenger traffic over the new road and two reasons are given for this.
>
> The heavy freight traffic that is to go over the road for the completion of the big power plant at Big Creek, it is said, will utilize the road practically all of the time and the running of passenger trains, it is said will greatly hinder the movement of this material.
>
> The second reason given for the discouragement of passenger traffic is the dangerous character of the road at the present time. While it has been built with every safety precaution, the fact that it is in the mountains, that the grades and fills are not solid and that it is not known where the weak points are, make passenger traffic exceedingly dangerous, say the officials. Until the operating department has had opportunity to watch the road and go over it carefully to locate all the weak places, and in fact until all the fills and grades have become solid, the officials assert that they will do all they can to keep passenger traffic off.
>
> They realize that under the law they are required to carry passengers but will not prepare for any more than are absolutely obliged to go up. It is understood that the passenger rate will be on a basis of 10 cents a mile or $5.50 to Big Creek, a distance of 55 miles [Fresno Morning Republican, June 22, 1912:24].

The San Joaquin and Eastern Railroad was at last completed on July 12, 1912, with 56 miles of difficult railroad construction accomplished in only about 165 days (Fresno Morning Republican, July 13, 1912:14; Sievers 1956:7). This was said to be "a world's record for the construction of 56 miles of standard gauge railway over the roughest type of mountain country" (Arthur and Meyer 1924:1). Called the "Crookedest Railroad" in the world, the newly completed line climbed up 255 steep grades, wound around 1073 difficult curves, and rumbled over 43 wooden trestles for a distance of 55.92 miles (Plate 3). Beginning at El Prado, the railroad headed in a northeasterly direction on a 1.4 percent rise for the first five and one-half miles. The grades were increasingly steeper for the next 33 miles, with a maximum grade of 2.4 percent. Above Auberry, the railroad traversed grades as steep as 5.2 percent and curves of 60 degrees before stopping at its final destination, Cascada (later known as Big Creek). One particularly spectacular piece of engineering and construction work was the trestle built across a granite cliff near the end of the line. This trestle was later described by a railroad historian as follows:

Plate 2 Shay No. 103 at Cascada, January 7th, 1913 (SCE var. [b]:Album 2, No. 179).

Plate 3 San Joaquin and Eastern Railroad, 1920 (SCE var. [b]:Album 2, No. 112).

A spectacular piece of work was just about a mile below Power House No. 1—just about opposite the promontory on which Big Creek was situated. A nearly sheer wall of granite blocked progress at this point. A trestle was built around it and anchored with big iron bolts to the rock wall. While some posts reached to the rocks below, the trestle depended for its stability on these anchor bolts. It was quite a sight from the opposite side of the canyon to watch a train wind its way on this narrow shelf around the steep rock wall (Sievers 1956:7).

Early Construction, 1911–1912

While railroad construction was the main focus of Big Creek development during the first half of 1912, preliminary work was begun at Cascada, located at the confluence of Big Creek and Pitman Creek. This site became the headquarters camp for the whole Big Creek project, and today it is still the operations center and primary population nucleus of the development.

Construction of Cascada, later known as Big Creek, began in late 1911, soon after the access road was completed. The first settlement was on the south bank of Pitman Creek, but, late in 1911, the main camp was moved across Pitman and a short distance west. In December 1911, bunk houses were built at the new site and a mess hall was opened (Redinger 1949:20). A work force of men was soon brought in, and preliminary work on the dams, tunnels, penstocks, and powerhouses could begin.

Although construction was hampered by a lack of equipment and supplies as well as by winter weather typical of the high country, much progress was made while awaiting arrival of the railroad during the first half of 1912. A newspaper report in mid–March, 1912, reported that a hotel had already been built at Big Creek Basin (later Huntington Lake), the three Huntington Lake dam sites had been cleared of timber, the routes of tunnels and flumes had been laid out, and, within a few days, the blasting of water tunnels was expected to begin (Fresno Morning Republican, March 11, 1912:5). Between mid–March and completion of the railroad in mid–July, excavation started at the dam sites and an incline railroad was begun from the railroad terminus at Cascada (sometimes called Camp No. 2) to Big Creek Basin. This incline railroad was needed to haul men, equipment, and materials to the dam sites, tunnel locations, and camps (Fresno Morning Republican, July 3, 1912:3; July 19, 1912:16). These efforts were merely the preliminaries, however, for full–scale construction work could not begin until the railroad was completed and massive amounts of equipment, materials, and supplies brought in.

During the summer of 1912, rapid influx of the men and machinery of the industrial world quickly altered what had been a largely pre–industrial region. Muscle power gave way to steam and gasoline power, construction work was ongoing 24 hours a day, machine shops and repair facilities were built, population surged, and the sound of bird song gave way to the roar of powerful engines. The Big Creek region was being industrialized all at once in a frenzy of activity. During mid–July 1912, in the midst of this construction–related tumult, Huntington, Balch, and George C. Ward (one of Huntington's chief lieutenants) made a short inspection visit. The railroad had only just been finished. The newspaper report on the trip pointed out that it was one of the largest (if not the largest) construction projects in the United States, and that the incline railroad ("hoist") then in operation would be used to haul two locomotives to Big Creek Basin to aid in the Huntington Lake dam construction:

OFFICIALS PLEASED WITH BIG CREEK UNDERTAKING

H. E. Huntington, A. E. Balch and G. C. Ward Inspect Project

Largest in United States; Monster Hoist to Lift Engines

Satisfaction with the progress of the Big Creek power project was expressed by A. E. Balch of Los Angeles last night, who, together with H. E. Huntington and G. C. Ward made an inspection of the Big Creek railroad and other construction work yesterday and the day before. All three returned to Los Angeles last night on the 10:15 o'clock train after an informal conference with A. G. Wishon, manager of the San Joaquin Light & Power company.

Whether there would be further developments than the present Fresno and Eastern [the San Joaquin and Eastern] railroad and the big power plants that are planned, could not be stated at this early date, said Mr. Balch. It will be years yet before the power project is completed.

The undertaking on the creek is the largest, or at least one of the largest in the United States, said Balch. This is in length of transmission, in power and in voltage. Surveys have been completed for the line from Los Angeles to Big Creek, and construction of the steel tower line will soon begin.

The railroad officials were much pleased to be able to ride to the base of the basin over the new Fresno and Eastern railroad and from there by automobile to the top of the basin, where the dam will be constructed. The road was completed last Thursday. Balch took occasion to praise the Stone-Webster [Company] for their quick construction of the railroad, as he had not expected to find it completed by this time. The line is fifty-six miles long and cost a million to build.

To show the magnitude of the undertaking Mr. Balch mentioned that two locomotives would be lifted to the top of the basin by a hoist, and railroad accommodations would then continue for a few miles on top, for the transportation of materials for the dam and power plant. There is at present a hoist working on an incline, but heavier materials will now be shipped in, after the completion of the railroad, and it will be possible to lift the locomotives to the top. Materials, such as cement, will be hoisted to the top and sent on by rail. Only rails are lacking for the few [*sic*] line of road on top.

"We have fourteen hundred men at work there," said Balch, "and you can imagine how fast the work is progressing. It is an immense undertaking and will take some time to complete. It will cost $10,000,000."

After the construction of the power plants, the railroad will continue to be conducted, stated Mr. Balch. A passenger coach will be put on in a few days [Fresno Morning Republican, July 19, 1912:16].

Life in the Big Creek Camps, 1912–1913

Throughout the last months of 1912 and almost all of 1913, construction at Big Creek continued at a feverish pace. A central part of this construction effort was establishing the infrastructure needed to house, feed, and generally care for the army of workers hired to build this System. The support network that was ultimately created at Big Creek consisted of both formally established company camps and less structured, privately run hotels and businesses. As construction of the Big Creek System progressed, these institutions flourished, catering to needs of the workers.

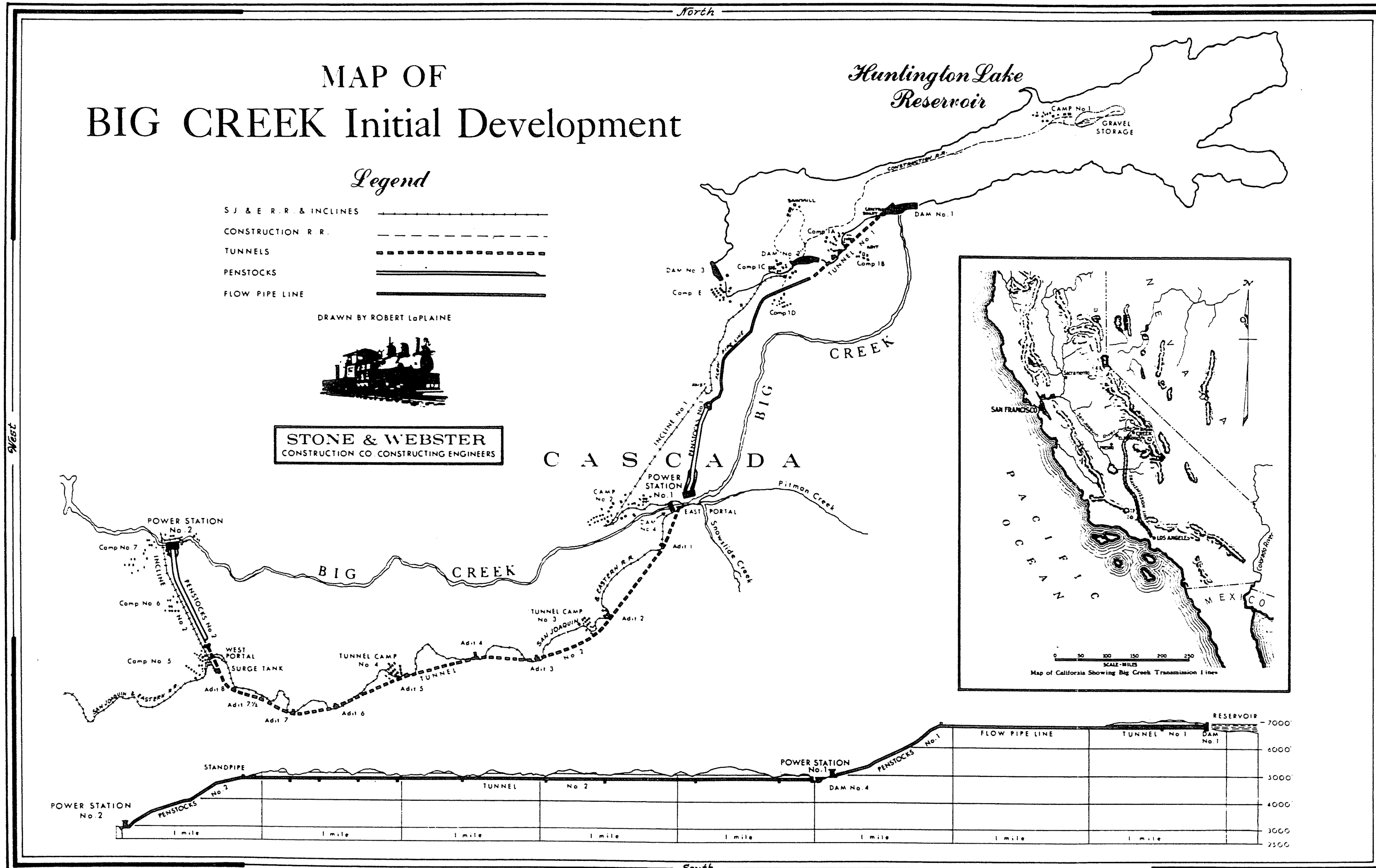
At the height of initial development, construction crews, numbering as many as 3500, were divided into 12 camps throughout the project area (SCE 1917b:13). Six of these camps were located at the Basin, and one at Cascada. The remaining five camps were located along the tunnel route to Powerhouse No. 2 (Map 4). The headquarters camp was at Cascada, the terminus of the railroad, which contained "field engineering and construction offices, a large railroad yard, warehouses, stables, stores, and accommodations for a thousand men" (Stone and Webster Construction Company 1913:[16]). In addition, Stone and Webster operated "a well equipped hospital with a resident surgeon and nurses," where sick and injured employees could be cared for (Farnsworth 1912:174).

Little more than a post office before construction began, Cascada soon became the center of activity. The first store in Cascada was built early in 1912 by Frank Alviso, who remained in Cascada for four years before selling out to Imhoff and Aggergaard. In August 1912, the Stone and Webster Construction Company built its first permanent structures, consisting of four residential cottages for top employees. In 1913, A. O. Smith of Clovis, with encouragement from Mr. Thebo, built a hotel to accommodate visitors to the area. Sometime later, several floored tents, or "rag houses," were erected opposite the hotel to handle overflow (Redinger 1949:26).

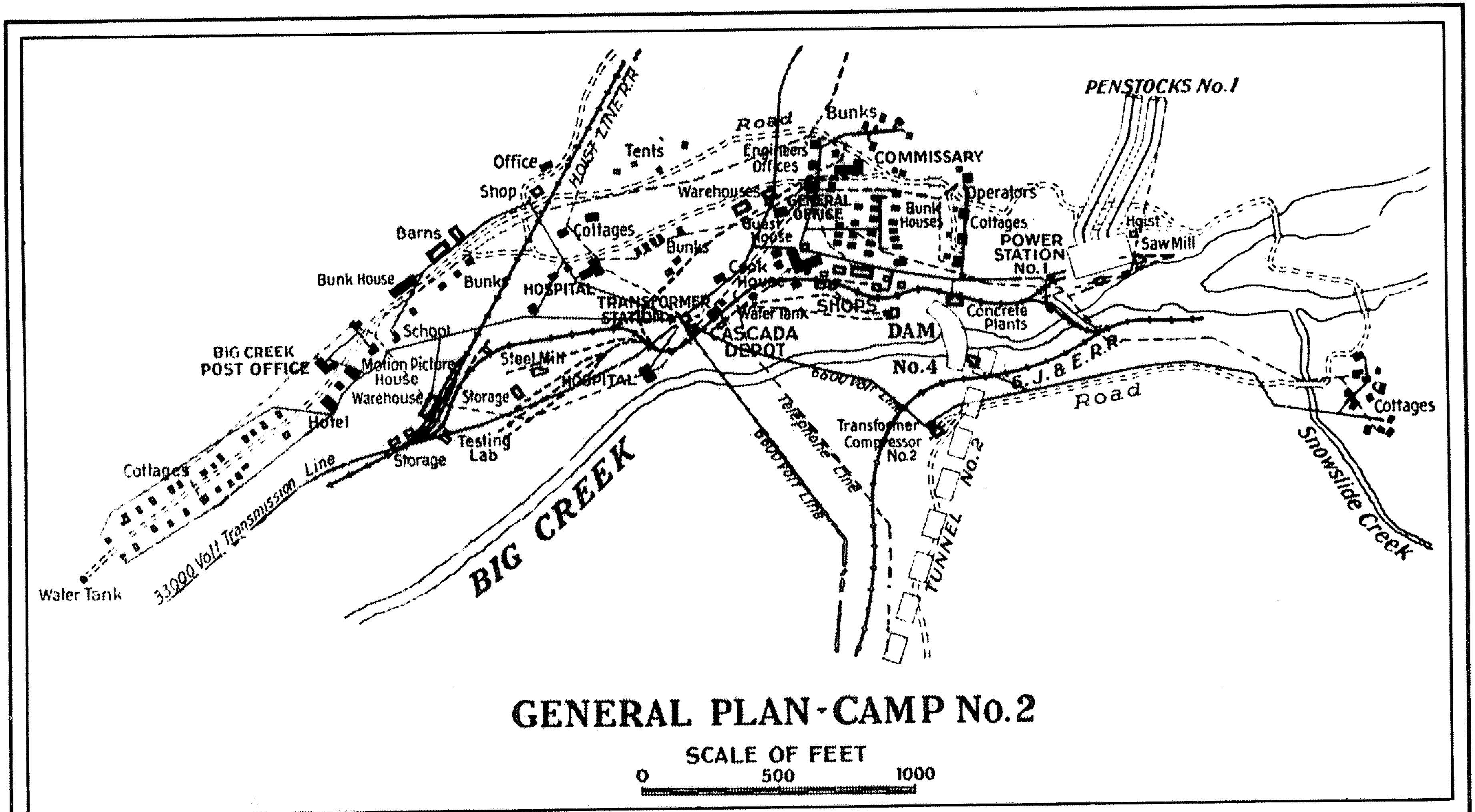
A 1914 map of Cascada (Camp No. 2) shows how well developed this headquarters camp was by this time (Map 5). It had a post office, railroad depot, shops, general office, warehouses, cook house, motion picture house, hotel, barns, saw mill, concrete plants, commissary (Plate 4), and a complement of various types of living quarters: cottages, bunk houses, a guest house, and tents (Pacific Light and Power Corporation 1914).

At Big Creek Basin, a high plateau surrounded by mountains through which the Big Creek stream ran, crews went to work clearing the way for the construction of a huge reservoir which would become Huntington Lake. Stone and Webster established a headquarters for Basin operations at Camp No. 1C, with additional camps numbered 1, 1A, 1B, 1D, and 1E (Map 4). While each of the two divisions was only supposed to accommodate 1000 men, the Basin apparently had close to 1500 men working in its camps at one time (Stone and Webster Construction Company 1913:[11]).

The remaining five camps were located along the tunnel and penstock line from Powerhouse No. 1 at Cascada to Powerhouse No. 2 in Big Creek canyon. These camps were temporary in nature, and the housing and furnishings were crude at best. Lodging consisted of tents on platforms and small, rough cabins (Plate 5).



MAP 4 Adapted From 1914 Pacific Light And Power Corporation Map (Johnston 1965:32)



MAP 5 -CASCADA HEADQUARTERS- (Pacific Light & Power Corp. 1914)

Plate 4 Commissary at Camp No. 2, 1912 or 1913 (SCE var. [b]:Album 3, No. 90).

Plate 5 Camp No. 7 from the north side of Big Creek, 1913 (SCE var. [b]:Album 3, No. 254).

Conditions inside these cabins were later vividly described by David H. Redinger, who arrived at Cascada on August 13, 1912:

> In those days men carried their own bed rolls, or "bindles," and were known as "construction stiffs." Another favorite term for one's bed roll in construction parlance was "crumb pile"—from "crumb," which the soldiers of the first World War called "cootie." "Crumb boss" was the name for a caretaker around bunk houses, since he had to "ride herd" over the occupants, many of whom in those days were quite apt to be pediculous [Redinger 1949:20–21].

For those men (like Redinger) who did not have their own bed roll, the "crumb boss" had another solution. As Redinger continues his story:

> After breakfast the "crumb boss" suggested I provide myself with a mattress, and directed me to the nearest barn, one-half mile distant, where I obtained a large armfull [*sic*] of straw. He then assigned me to a bunk, of which there were three tiers around the inside of the bunk house. It is strange how quickly straw can harden in a bed where the only springs are boards. Being a greenhorn, I was happy to have one of the bottom bunks. After the first night I learned why the uppers were so much more desirable—in a lower, every time the fellow above moved or turned over, one got chaff and dirt in his face. The old and reliable Sibley stove in the center of the room not only furnished too much or too little heat, depending upon the location of the bunk, but served too, as a drier for all the damp or wet clothing hanging around. Outside plumbing thrived in all its glory, and no one can fully appreciate how cold water can be until he tries to wash in an outside trough at six A.M., with the thermometer hovering between "zero" and "freezing," making no particular effort to go higher. At such times it wasn't much of a disappointment to find the water line frozen [Redinger 1949:21].

With thousands of men working at any one time, the Stone and Webster Construction Company was faced with the difficult task of providing for a large, hungry workforce. Luckily, local ranchers ran cattle through the area, and the company obtained more than a hundred head of beef steers to satisfy their employees' hunger (Sierra Ranger, October 1, 1912:19). At Cascada, the company served meals in a mess hall which had a seating capacity of 375. At times, the tables of this hall had to be set twice. The Basin had a mess hall which was almost as big as Cascada's, and there were smaller mess camps for the workers engaged in the tunneling operations (Fresno Morning Republican, August 14, 1912:12).

While Stone and Webster provided their construction crews with most of the bare necessities, many of the men needed "something to wash down" the often lonely life they led in the mountains, and were more than willing to go out of their way to tickle their palate with something a little stronger than the coffee served in the mess hall. Unfortunately, Fresno County had, sometime before, voted to support the "Wyllie local option law," creating a "dry" county in which the consumption and sale of liquor was illegal. Undaunted, workers purchased their liquor from bootleggers who traveled into the area from "wet" counties. In September 1912, the sheriff and district attorney of Fresno decided to crack down on a number of violators operating in the mountains near Shaver, and several men were arrested. Although no one from Stone and Webster was cited, it seems likely that bootleggers were also supplying workers in the Big Creek area (Fresno Morning Republican, September 21, 1912:20). Proof of such activities was reported in December when several bootleggers were caught attempting to sell alcohol to Stone and Webster employees:

> Two gallon jugs of whisky and three suit cases filled with bottled whisky were seized by the officers and will be held as evidence. The men were carrying liquor to Dry creek where it is alleged that they were going to sell it to the laborers at the Stone-Webster construction camp. They were hauling the liquor in a wagon [Fresno Morning Republican, December 12, 1912:24].

While little written evidence remains to document bootlegging activities, it seems likely that the laborers of Stone and Webster Construction Company provided a ready market for such illegal goods.

Dams and Tunnels, 1912–1913

As the infrastructure needed to successfully hasten construction was completed, actual work on the power system could be pushed forward. The first step was to complete the hydraulic system, because this—the dams in particular—had to be in place early enough to catch the rain and snow melt of the winter of 1912–1913. Otherwise, there would not be enough water to successfully run the two planned powerhouses during the next year. Three dams were needed to create a reservoir in Big Creek Basin. To build these dams, lumber (for forms especially), concrete, and gravel were necessary. A railroad was built in the Basin above the incline railroad (hoist) to facilitate construction, since this was the only means of transportation that could efficiently haul the immense amount of materials needed to build the dams. The incline railroad, which was used to connect the Basin with Cascada, conveyed the equipment and supplies needed for the job in the Basin. Operating with a cable and hoist which could pull loaded railroad cars up the steep slope, this incline railroad was described as follows in January 1913:

> The rise of 2,000 feet is made with a total length of 6,000 feet, and the hauling line is a steel cable, two inches in diameter, operated by an electric hoist. It has handled the entire equipment used in constructing the work in the Basin, including seven locomotives, three steam shovels and the machinery for the concrete plants. In addition to taking in the construction equipment, it hauls daily the cement used in the dams and the supplies for some 1,500 men who are employed in the Basin Camps [Stone and Webster Construction Company 1913:(11)].

A saw and planing mill was built on the railway near the dams, providing lumber for temporary structures of all kinds—especially the immense forms needed to hold wet concrete in place to form the dams. Logging was conducted using steam-powered donkey engines. Once the water level in the lake began to rise, these engines continued to operate while being floated on rafts (Plate 6). Logs were hauled by the railroad to the mill during early stages of construction; later they were floated to the mill site (Plate 7).

There was a good deposit of sand and gravel within Big Creek Basin. This deposit was excavated with Marion steam shovels and hauled by railroad to a gravel washer, where it was cleaned and sorted.

To build the three concrete dams, the sites had to be excavated, forms made, a concrete mixing plant constructed, and trestles built to carry wet concrete to the dam sites (Plate 8):

> Three solid concrete, gravity-type dams are being built at the west end of the Basin. For the initial development these dams will have an aggregate length of about 2,700 feet, and will contain about 120,000 yards of concrete. The storage reservoir formed will impound 38,000 acre feet of water, which for the ultimate development will be increased to 100,000 acre feet by raising the dams 50 feet. Concrete is placed from trestles, the mixers being located directly under the deck and receiving materials through overhead hoppers from material trains.
>
> During December, concrete was poured at an average rate of about 850 yards per day, the best run being 1,260 yards. The speed of construction of the dams as a whole was governed by the capacity of the railway to supply materials, and the form of mixing plant devised for the job permits the concentration of transportation facilities at any given point on the three dams, insuring completion of the structures in the time available [Stone and Webster Construction Company 1913:(13–14)].

Beside the three dams needed to close off Big Creek Basin to create Huntington Lake, another dam was required to function as the impoundment dam or forebay for Powerhouse No. 2. This was called Dam No. 4, constructed at Powerhouse No. 1 in 1913 (SCE 1923c:2).

Construction of the two tunnels needed for initial development also had to begin early, since their total length was four and three-quarters miles, and they would take some time to complete. The longest was Tunnel No. 2 between Powerhouse No. 1 and the ridge above Powerhouse No. 2—a distance of about four miles. In order to expedite work, the two portals (entrances at either end) were supplemented by nine separate adits (side entrances to a tunnel anywhere between the two portals). These provided a total of 20 headings (faces on the rock which was being drilled to create the tunnel) to work on. The bore, or size of the tunnel, was 14 feet, and five air drills with 16-man crews worked at each heading. Power for the drills was supplied by compressed air generated at three compressor plants which took in 7000 cubic feet of air per minute and delivered it to the headings at 100 pounds pressure (Stone and Webster Construction Company 1913:[17]). Work at a heading or face was, like mining, a dirty and sometimes dangerous form of employment. Plate 9 shows a tunnel crew working at a face in Tunnel No. 1 in late March 1913.

Plate 6 Logging with floating donkey engine, 1913 (SCE var. [b]:Album 2, No. 479).

Plate 7 Hauling logs to the sawmill, 1913 (SCE var. [b]:Album 2, No. 533).

Plate 8 Pouring concrete at Dam No. 1, 1913 (SCE var. [b]:Album 3, No. 430).

Plate 9 Work in Tunnel No. 1, 1913 (SCE var. [b]:Album 1, No. 298).

With the large number of headings, a constant problem was keeping tunnel crews driving in the proper direction and at the correct elevation. David H. Redinger's first job at Big Creek in 1912–1913 was to help the tunnel engineer keep tunnel crews on target. He later described this work as follows:

> Since there were so many headings, and as the work was on a twenty-four hour basis, our party at times would be "run ragged" because blasting would occur at any hour. It was our job to go in after each round was fired, to give direction and grade, or elevation, for drilling the next. Like a train crew, we were on a call basis.
>
> Along the tunnel "battle front" the thunderous report from each dynamite blast was terrific, and the echoes would reverberate through Big Creek Canyon, up and down, across and back, as though infuriated by the interference of the canyon walls. Zeus himself could not have done a better job.
>
> The pistol drill was used, as compared to the present much-improved hammer type drill. A blacksmith shop stood at the mouth of each adit for the sharpening of the drill steel, which was done by hand. Today, most sharpening is done with a mechanical sharpener operated with compressed air. Instead of having storage battery or trolley locomotives for hauling out blasted rock or muck, we used mules. It was amazing to observe the intelligence of these animals. They would function almost automatically—about the only need for a driver was to see that they did not head for the stable during a trip outside, instead of returning for another load. The cars were loaded by hand, as the present day mechanical loaders had not yet been developed [Redinger 1949:22].

Plate 10 shows one of these mules with its load at the mouth of Adit 3, Tunnel No. 2, August 5, 1912.

Tunnel No. 1, located in the Basin, was designed to carry water from Huntington Lake to a flow line pipe, which in turn led to the penstocks for Powerhouse No. 1. It was only about three-fourths of a mile long, and had only one adit and two portals, one of these being a shaft near Dam No. 1 (Map 4).

Working Conditions and the Great Strike, 1912–1913

The Stone and Webster Company apparently did not have any problem finding men who wanted to work on the Big Creek construction project. One story about a man who, although never hired, refused to be fired, illustrates how much people wanted to work on the project:

> **MAN WHO WOULDN'T BE FIRED HOLDS JOB HE NEVER RECEIVED**
>
> **Persistency of Laborer at Big Creek Lands Him on Payroll**
>
> This is the story of a man who was never hired, yet who would not be fired. He couldn't talk English or any other language known to the

foreman of the Stone–Webster construction gang at Big–Creek to which he attached himself, nor could any of his fellow workmen understand him. To make up for his lack of linguistic ability, however, he possessed a persistency and a singleness of purpose which was nothing short of marvelous, which brought him some bodily bruises and a near–arrest. Yet, as in most cases where man pursues one object whole–heartedly, the laborer gained his point, and he is today on the payroll of the company because all the officers of the company, and the special police combined could not fire him from his self–appointed job.

It should be mentioned in the beginning that the construction company when a laborer is hired labels him with a button upon which is a number by which he is known on the books of the company. A few days ago one of the foremen at the camp noticed that one of the men under him was not provided with a button, and he forthwith proceeded to question him. It was found, however, that the man could not speak a word of English, and furthermore, there was not a foreigner on the job who could talk his dialect, which was evidently that of a native of one of the Balkan states.

Without further ado the foreman sent the man off the job. However, the laborer held a firm determination to work for the Stone & Webster Company, and it was but a matter of a few hours until the foreman again discovered the unknown and the unintelligible with his pick and shovel busily engaged. Again he was led from the work, this time not too gently, and told in forcible pantomine language to "beat it."

Between the times of work and the times of being discharged the workman was showing up regularly for his meals. However, after the second warning to cease work he did not respond to the next meal call, and the foreman made up his mind that he had at last gotten rid of the too–willing worker. It was a vain hope, however, as during the afternoon he was again discovered diligently picking away in the midst of a gang of workmen.

In sheer desperation the foreman sent for the superintendent and asked for advice. Forcible ejection was resorted to, and the persistent laborer was hustled down the hill some hundreds of yards, not gently but forcibly, and with a sigh of relief the foreman saw his self–hired man disappear over a hill in the general direction of the lower levels.

But the next morning there was a workman without a button in the gang and he was working as though his life depended upon removing the mountain before night. The foreman looked at him and gasped: it was the man who would not be fired.

One of the special police officers was sent for and requested to arrest the laborer.

"What charge?" enquired the officer.

"Working" asserted the foreman.

"Nothing doing," declared the officer. "I am here to arrest law breakers and as far as I know working is not a crime. I can't spend the county's money in taking the fellow down to Fresno and have only the charge of "working" to lodge against him when I get him there."

The superintendent was asked for, and feeling the case hopeless he ordered a button placed on the man and his name entered on the books. The grin which spread over the laborer's face as the button was riveted on tight was the cause of some suspicion on the part of the superintendent, who is beginning to believe that the silent worker is as clever as he was persistent [Fresno Morning Republican, April 2, 1913:5].

The workers employed on the Big Creek construction project often faced difficult working conditions. Since work continued night and day (thanks to installation of large overhead electric lights), overtime work at straight time salary was apparently common. Workers were charged for their food, and, as discussed above, living conditions in camp were far from perfect. Outbreaks of deadly diseases such as typhoid were known to have occurred, affecting many employees (Fresno Morning Republican, October 11, 1913:9). Moreover, accidents occasionally killed or maimed a worker, and were dutifully reported in the *Fresno Morning Republican*:

> J. Mayer, aged about 35 years, was crushed to death under the weight of several tons of rock and dirt early yesterday morning at Big Creek. Mayer had been employed at the construction camp of the Stone and Webster company for about ten days and little is known of his relatives and former place of residence. News of the accident was telegraphed to Coroner Bean, who left for Big Creek at 9 o'clock yesterday morning. Up to a late hour last night, he had not returned.
>
> According to the telephone message received by the coroner, Mayer was the member of a construction gang in the Big Creek basin, which is the terminal of the Big Creek railroad. At the time of his death, the laborer was engaged in assisting a crew of workmen in the excavation of a site for a dam. Mayer was working in the pit and a huge derrick is used to lift a big steam shovel from the pit to the wall of the dam.
>
> While the shovel was being lifted the derrick became entangled in electric wires and the signal was given to lower the load.
>
> A warning was given, but evidently Mayer became excited and instead of running away from the descending shovel he ran directly under it and before the steam engine could be stopped the load of rock and earth had crushed the laborer to a pulp. Coroner Bean intended to conduct an inquest over the remains yesterday afternoon and will probably return to Fresno with the body this morning [Fresno Morning Republican, August 4, 1912:28].

A number of other accidental deaths took place, along with at least one suicide and a case of heart failure (Fresno Morning Republican, January 30, 1912:7, May 23, 1912:20, September 6, 1912:16, April 4, 1913:9, April 12, 1913:3, April 21, 1913:12).

The cumulative effect of these problems began to be felt by late 1912, when the desire to improve both living and working conditions was apparently widespread among the workers at Big Creek. Word of the discontent must have reached the outside world, because in December of 1912 the state labor commissioner, John P. McLaughlin, traveled to Big Creek to "investigate labor conditions" (Fresno Morning Republican, December 14, 1912:20).

In January 1913, trouble began at Camp No. 3, one of the tunnel camps (Plate 11). In *The Story of Big Creek*, David Redinger describes the incident:

> Men were complaining about the food. The climax was reached one night after supper when a group arrived at the mess hall carrying rope and

Plate 10 Work at Adit No. 3, Tunnel No. 2, in 1912 (SCE var. [b]:Album 5, No. 17).

Plate 11 View of Camp No. 3 in 1912 (SCE var. [b]:Album 9, No. 106).

> with "blood in their eyes," allegedly to hang the cook. Word had gone ahead that such a move was under way, and as the advance guard went in the front door, the chef went out the back and disappeared. He never did return to that area [Redinger 1949:26].

What Redinger fails to report in this lighthearted description of events is that the men who drove the cook from camp were promptly fired by Stone and Webster, touching off a strike that would temporarily shut down operations in the Big Creek area (Fresno Morning Republican, January 7, 1913:8). The strike was apparently led by the radical anarcho-syndicalist labor organization, the Industrial Workers of the World (IWW), which fused the vision of a worker-run economy and society with the tactics of strikes and sometimes sabotage.

On January 7, 1913(:8), the *Fresno Morning Republican* reported that "nearly 2,000 men, the majority said to be IWW's, went out on strike at Camp No. 3 of the Stone-Webster Construction Company at Big Creek Sunday morning. . . ." The article went on to say that strikers not only objected to paying 25 cents for inedible food, but wanted time-and-a-half pay for overtime, double pay for Sundays and holidays, hot and cold running water in their washrooms, less crowded sleeping quarters, and "other things of less importance." The strike soon spread throughout Stone and Webster's construction camps. At camps No. 2 and No. 4, workers demanded that a doctor be placed in attendance. Strikers in the Basin asked that a general hospital be established to care for the sick and injured (Fresno Morning Republican, January 11, 1913:20). After interviewing striker E. F. Lefferts, a reporter commented:

> He [Leffert] claims that men go into the mountains labouring under false ideas. He says that the men are charged a transportation rate of 10 cents per mile and that they are forced to ride in box cars; that there are no mattresses or even straw in bunks and 21 men are compelled to sleep in a room 12 by 18 with no ventilation. He says that the car fare is deducted from their wages before the laborers can buy warm clothing; that the employment agencies inform the laborers that the conditions are good at Big Creek and that the weather is ideal [Fresno Morning Republican, January 8, 1913:8].

The attitude of the Stone and Webster Construction Company toward striking workers was far from sympathetic. Its immediate reaction was to call in officers "for fear of trouble" (Fresno Morning Republican, January 7, 1913:8). Just three days after the strike began, the company announced that no concessions would be made to the strikers because their demands were "beyond reason" (Fresno Morning Republican, January 8, 1913:8). That same day, the company suspended work on the tunnel near Camp No. 3, claiming that this action would not be a problem "as they were ahead of their contract time." In an effort to rid themselves of strikers, Stone and Webster also closed down the mess halls (there was no other place to eat) and "made up" a train to carry the strikers back to Fresno (Fresno Morning Republican, January 8, 1913:8; Johnston 1965:42). The following day, after another walkout of workers, the company locked out its employees and informed the public that work would be suspended at Big Creek and the entire work force discharged. After firing nearly 2000 men, the company obviously intended to hire a whole new work force later in the winter (Fresno Morning Republican, January 9, 1913:20).

While Stone and Webster Company officials apparently made the decisions about how to respond to this strike, their attitude probably reflected Pacific Light and Power's position. It is unlikely, in fact, that Stone and Webster would have responded as they did without consulting the management of Pacific Light and Power. The hard-nosed attitude of the company to what were apparently legitimate grievances of the workers is traceable to Henry E. Huntington himself, who was, from an early date, very class conscious about the prerogatives of those who controlled capital vis-a-vis labor. In a September 1903 letter sent to David M. Parry, president of the National Association of Manufacturers, Huntington expressed strong opinions against both strikes and unions, calling these "oppression" against capital. He summarized his views as follows:

> If the danger to our institutions ever lay on the side of capital it has certainly shifted now to the side of labor. . . . Every successful resistance to the organized oppression of the Unions . . . is a strong upward step towards industrial contentment and happiness; every failure to stand firm is a long downward strike towards industrial anarchy [Huntington 1903:1–2].

Since Huntington held such a view, it was not surprising that almost 2000 men were fired and forced from the mountains. Those who worked on a job had, in Huntington's view, no right to any opinions about what occurred during that job—and he obviously meant to enforce his view. Luckily for Huntington and Stone and Webster Company, during the first week in January a heavy snow storm dropped four to five feet of snow on the Big Creek area. The storm cut off electric power coming into Big Creek and provided a convenient excuse to shut down the project (Redinger 1949:26–27). Once the weather improved, new employees were hired (along with some former ones), and soon the project was back to full strength and "on schedule" (Fresno Morning Republican, January 25, 1913:6). It is likely that any IWW men and those perceived as union men were excluded from the job.

Penstocks, Flow Lines, and Powerhouse Construction, 1912–1913

Construction of penstocks, flow lines, and two powerhouses were among the final tasks to be completed during initial construction at Big Creek. Other elements of the Hydroelectric System had to be in place before the pipes (which were to deliver the water) and powerhouses could be built. By the end of 1912, only the excavation for Powerhouse No. 1 had been started (Stone and Webster Construction Company 1913:[9]). During late winter and early spring of 1913, however, intensive work began on these final elements of the System. These were: a flow line 6600 feet long (consisting of 84-inch-diameter pipe); four penstock pipes (two for each powerhouse), each about one mile long; and two powerhouses with all their equipment (Map 4). Much of late winter and spring of 1913 were spent in excavating foundations for these pipe lines and powerhouses.

Plates 12 through 17 illustrate the various steps needed in construction of the penstock. Much of this work consisted of hand labor (blasting, drilling, and digging) with the use of powered rail cars and steam donkeys whenever possible. Plate 12 shows work being done on flow line excavation in late March 1913. Following a blast, men loaded loose rock on a small rail cart for transportation to a tailing pile. Plate 13 depicts a group of Mexican workers resting between drilling efforts on the penstock or flow line in February 1913. Plate 14 illustrates manual excavation of the penstock line for Powerhouse No. 2 in early March 1913. (Note the incline railroad running alongside the excavation.) Plate 15 portrays construction of the incline railroad needed to transport supplies, equipment, and penstock pipe along the route of the penstock for Powerhouse No. 2. Plates 16 and 17 illustrate how the penstocks were installed, with Plate 16 showing stockpiled pipe on the incline railroad near Camp No. 6 in mid-October, 1913. (Note the wood-fired donkey engine used to supply power to lift the pipe using a boom and cables.) Plate 17 illustrates the actual process of installing what was the last piece of pipe on the cliff above Powerhouse No. 1 in early October 1913. The penstock pipe used at Big Creek was high-pressure pipe fabricated in Germany and brought to Big Creek by ship and railroad. The process of installing it was described as follows by David Redinger:

> The high pressure pipe for the four units installed during the initial development--two in each of the two plants--was made in Germany. When it was laid, the work was started at the power house and the sections placed up-hill, the lines being kept full of water as they grew in length. The water allowed a lower and more even temperature to be maintained, and in warm weather would hold the pipe movement in the trench to a minimum. It is amazing how pipe lines will react to temperature changes--crawling around like snakes if care is not taken. The practice of providing expansion joints was adopted in later years, but since there are none in these older lines they were back-filled, that is, covered with earth. The lap-welding process for making the longitudinal seams had been developed and used extensively in Germany in the manufacture of pipe for such purposes. Two Germans were sent here by the factory, to remain during the installation of its product, to represent the manufacturer and be of possible assistance in laying the pipe [Redinger 1949:33].

While the flow lines and penstocks were being completed, work was initiated on the powerhouses themselves. Construction began first on Powerhouse No. 1; the concrete foundation for this building was reportedly poured in March 1913 (Redinger 1949:31). Plates 18 through 23 illustrate development of powerhouses 1 and 2 during the construction period of 1913. By late July 1913, as Plate 18 indicates, the building was almost ready for its roof, and Plate 19 shows how it appeared about the time of completion. Meanwhile, work on Powerhouse No. 2 was also progressing: Plate 20 shows the layout of this powerhouse in mid-May 1913, and Plate 21 depicts the process of pouring an upper floor in September 1913. Plate 22 indicates that, by mid-October 1913, Powerhouse No. 2 was approaching completion. Plate 23 illustrates the installation in Powerhouse No. 1 of two impulse water wheels and the generator core. Rotation of the generator within a magnetic field would convert mechanical energy into electrical energy.

Powerhouse No. 1 was ready to deliver power on October 14 and Powerhouse No. 2 on December 18, 1913 (Redinger 1949:32). Plate 24 shows how the two initial units at Powerhouse No. 1 appeared in late November, 1913.

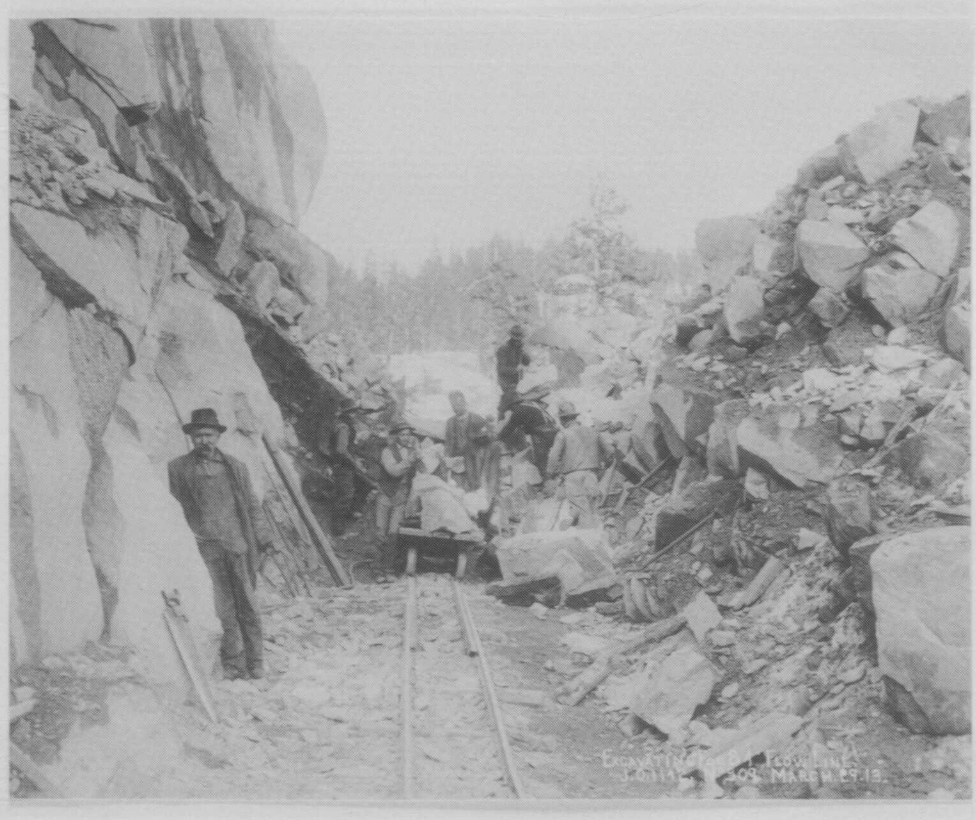


Plate 12 Excavating for the 84-inch flowline pipe, 1913 (SCE var. [b]:Album 5, No. 309).

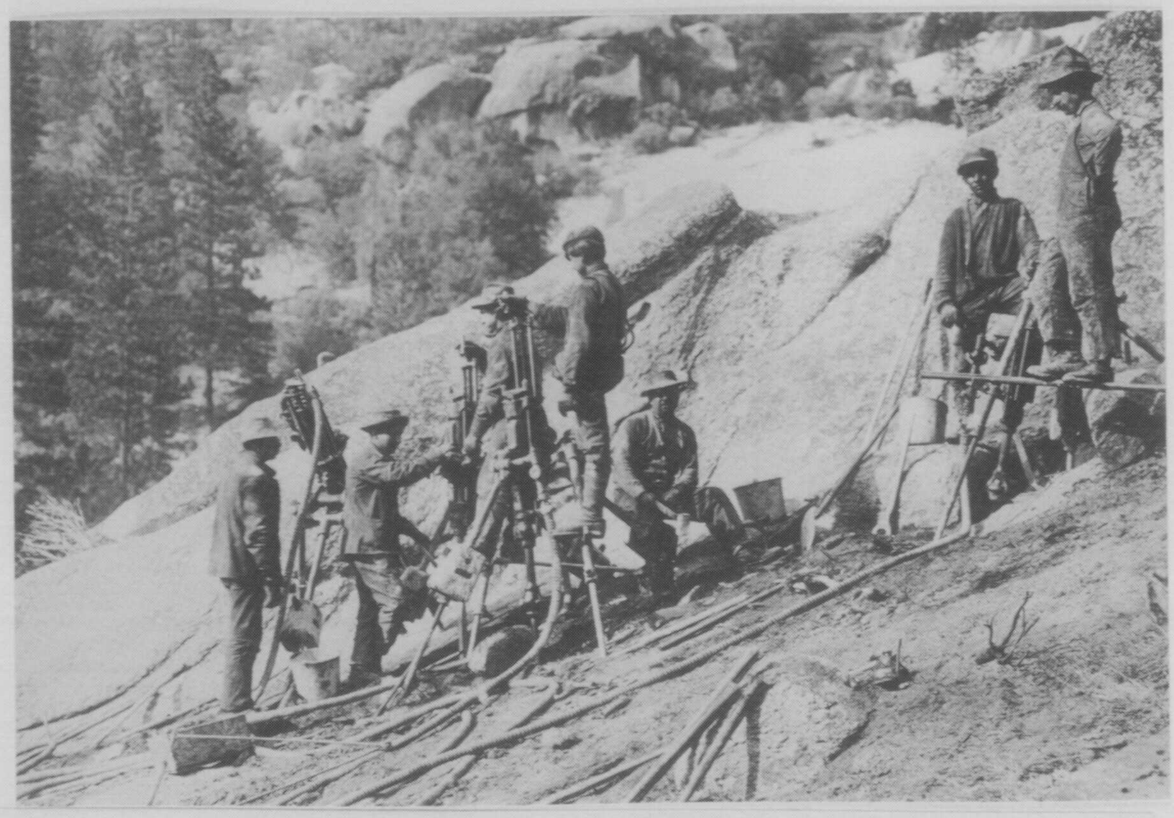


Plate 13 Drillers working on the flowline, 1913 (SCE var. [b]:Album 5, No. 244).

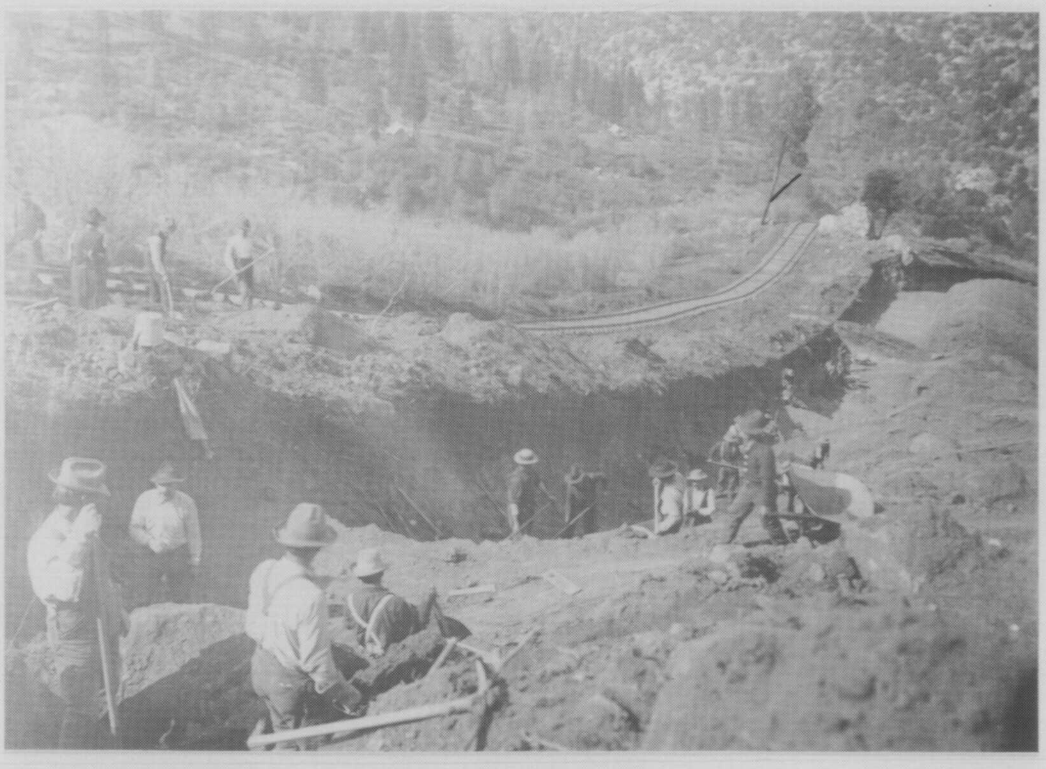


Plate 14 Hand excavation on the penstock line, 1913 (SCE var. [b]:Album 23, No. 252).

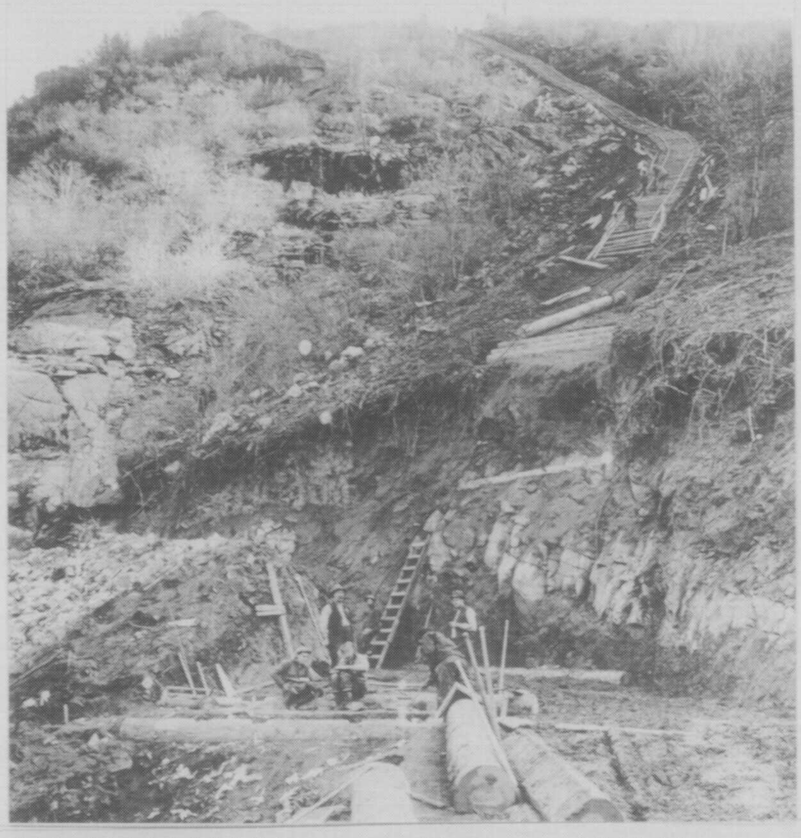


Plate 15 Construction of Incline Railroad No. 2, 1913 (SCE var. [b]:Album 5, No. 253).

Plate 16 Penstock stockpile at Camp No. 6, 1913 (SCE var. [b]:Album 5, No. 676).

Plate 17 Penstock Construction, Penstock No. 1, 1913 (SCE var. [b]:Album 5, No. 631).

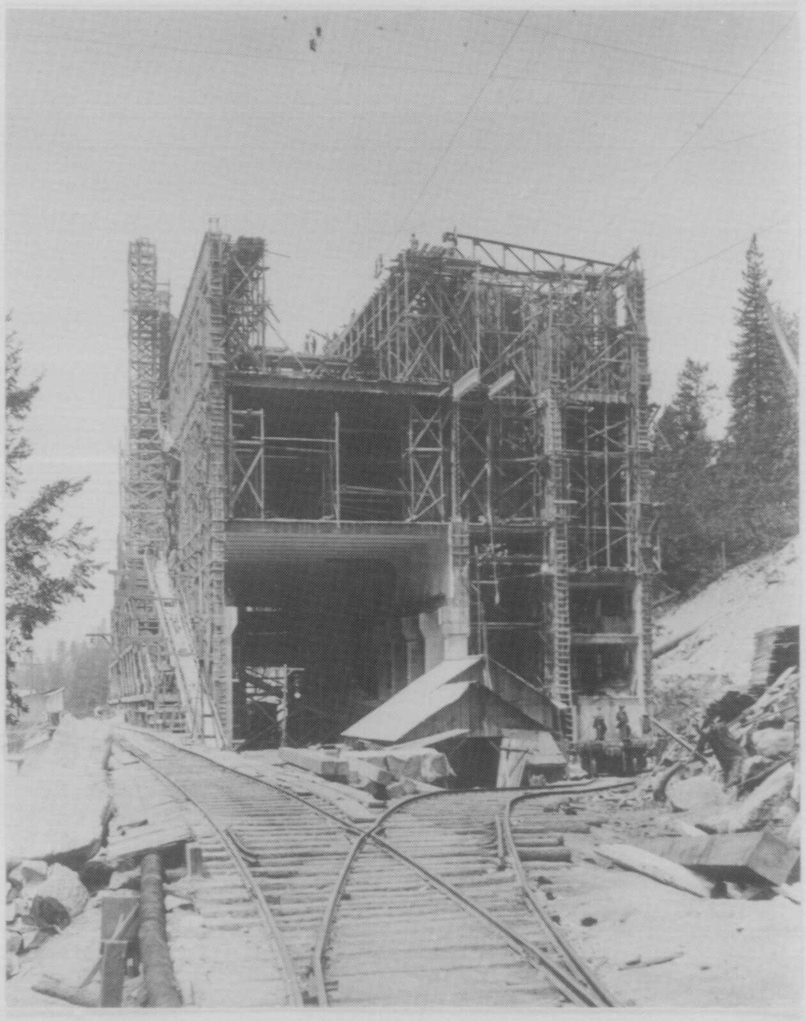


Plate 18 Construction at Powerhouse No. 1, July 1913 (SCE var. [b]:Album 6, No. 517).

Plate 19 Powerhouse No. 1 at completion in October 1913 (SCE var. [b]:Album 6, No. 692).

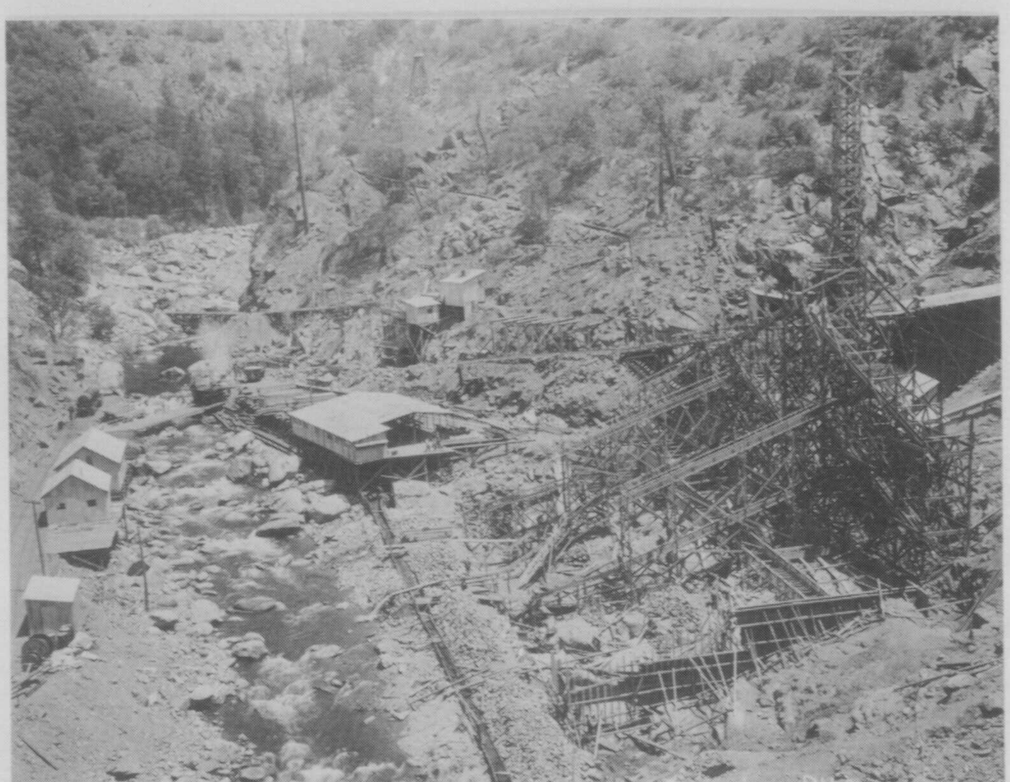


Plate 20 Construction at Powerhouse No. 2, May 1913 (SCE var. [b]:Album 1, No. 411).

Plate 21 Pouring an upper-story floor at Powerhouse No. 2 in September 1913 (SCE var. [b]:Album 1, No. 593).

Plate 22 Powerhouse No. 2 in October 1913 (SCE var. [b]:Album 1, No. 668).

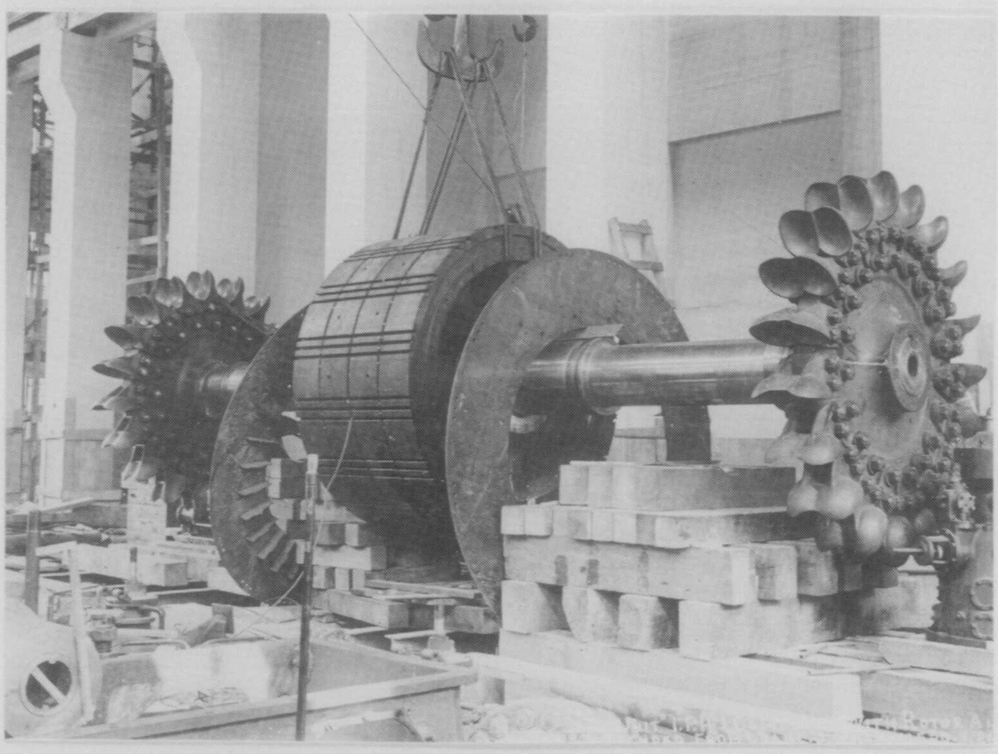


Plate 23 Installing Unit 1 in Powerhouse No. 1, July 1913 (SCE var. [b]:Album 6, No. 520).

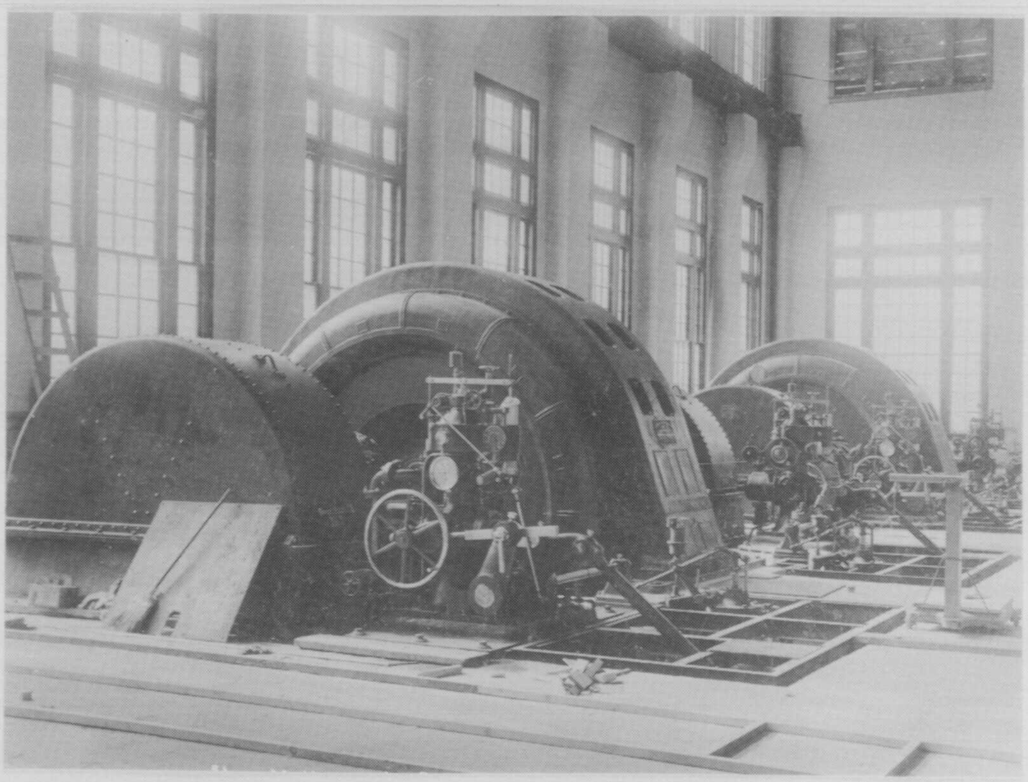


Plate 24 Units 1 and 2 in Powerhouse No. 1, November 1913 (SCE var. [b]:Album 1, No. 722).

Transmission Line Construction, 1912–1913

The final step in completing initial construction of the Big Creek Hydroelectric System was building the longest transmission line in the world. As with many other features of the Big Creek System, work on the transmission line began early. The route for the line was laid out in 1912, and most of the massive amount of steel and aluminum needed for a 241-mile-long line was purchased during that same year (Fresno Morning Republican, November 22, 1912:20). The work of erecting steel towers and stringing aluminum line began late in 1912 and continued until completion in November of 1913. Like much of the rest of Big Creek's initial development, the transmission line was a significant achievement for its era. Operating at the highest voltage (150,000) ever used up to that point in time, it incorporated huge amounts of materials. An article in the *Fresno Morning Republican* captured the spectacular nature of the line:

> **241 MILE POWER LINE**
>
> For miles stretching away on either side through the valley and over mountain peaks is the pathway of the transmission line, a line 241 miles long, such as in length has never been contemplated, carrying in its strands of steel and aluminum that constant current of 80,000 horsepower, alone sufficient to supply a region half the size of Southern California with all its lighting, all its transportation, and all its manufacturing power.
>
> This transmission line will carry a pressure of 150,000 volts, the largest known to go over the longest known line.
>
> To do this it was necessary to use an aluminum cable of seven strands of steel core, around which are placed fifty-four strands of aluminum.
>
> The 241 miles of aluminum cable, weighing eight million pounds, is supported by forty-eight million pounds of steel used in the towers [Fresno Morning Republican, November 2, 1913:15].

Initial Development Completed, December 1913

Completed at a cost of almost 14 million dollars, the initial development at Big Creek was, in the words of one editorial, ". . . the most remarkable . . . yet put into operation in this country or anywhere else" (Stone and Webster Public Service Journal, February 1914:112). This development was also innovative, causing *Electrical World* to comment:

> It is really gratifying to record the starting of this very notable development, for it is not only altogether remarkable in voltage and range, but its design displays a degree of resourcefulness very pleasing in these days of banal standardization when prescriptions per catalog are too often the order of the day. Now and then a chance like this is given to the engineer to make real progress, and fortunate is he to whom it falls. By such plants does the art advance and the community benefit.

Uncle Sam did well when he granted the permit for its construction [Electrical World, January 3, 1914, quoted in Stone and Webster Public Service Journal, February 1914:113].

What made the new System remarkable was its large scope and certain of its features, which were then world records. As a Pacific Light and Power Corporation publication expressed it in 1914:

The completion of the initial development at Big Creek for the Pacific Light & Power Corporation is noteworthy because it involves unusual natural conditions, unusual engineering problems and an unusual commercial accomplishment.

It is by far the largest high head development in this country. The most powerful impulse wheels ever built drive the largest electric generators of their type.

The transmission line is the longest "express" line in existence and will operate at the highest voltage ever used commercially. It carries power 240 miles from a remote spot in the mountains halfway between San Francisco and Los Angeles to commercial use in the latter city and adjacent territory.

A preliminary to the construction work proper was the building of a railroad 56 miles long to reach the site of the development. This road was finished and equipped in 157 days. The works covered so large an area that when the site was reached it was necessary to add 11 miles of construction railroad and equip it with 9 locomotives and 112 cars. It was necessary, also, to build two inclined cable railways, each rising 2,000 feet in 6,000 feet of length. These inclines, with concrete mixers, crushers and other machinery, required over 3,000 horse power of electric motors [Pacific Light and Power Corporation 1914:1].

The best description of the new System as it appeared when completed in late 1913 was contained in two articles in Stone and Webster Construction Company's own journal. The first article covered the hydraulic and mechanical features, and the second reviewed the electrical aspects of the System. Taken together, the highlights of these two articles provide an excellent summary of the shape of the completed initial development as of late 1913:

Dam No. 1, which closes the outlet through which Big Creek leaves the basin, is 132 feet high to the spillway and 139.5 feet to the top of the piers from which the sluice gates are operated. The end sections of the dam are straight and are joined by a curve of 954.3 feet radius, making the present dam 812 feet long. It is of the gravity type, arched up stream, constructed of concrete and mass rock and contains 59,000 cubic yards of masonry. The upstream face is vertical, while the downstream face is stepped to permit bonding the concrete, which will be added when the height of the structure is increased 50 feet for the ultimate development. Three 42-inch hand-operated sluice gates are provided, through which the reservoir can be emptied. These gates were used to control the stream flow while the construction work was in progress.

Dams Nos. 2 and 3 are, respectively, about one mile and one and a half miles from dam No. 1, and are of similar design. The former is 81 feet high, 1,015 feet long, arched to 800 feet radius, and contains 27,200 cubic yards of masonry. The latter is 126 feet high, 450 feet long, arched to 625 feet radius, and contains 31,300 cubic yards of masonry. . . .

All three dams were built to an elevation of 6,915 feet, and provision has been made on the top face for the installation of flashboards to raise the water surface to 6,920 feet elevation. The dams are built on solid granite foundations, the depth of the excavation below the original ground surface varying from 20 to 90 feet.

The reservoir formed by these dams is about four and a half miles long and one-half mile wide, and contains sufficient storage to develop 84,000 H.P., at fifty per cent load factor, for 180 days. Records of run-off, taken over a period of several years, show that with this storage a continuous flow, sufficient to produce 90,000 H.P., at fifty per cent load factor, will be at all times available.

Water is drawn from the reservoir into the conduit system through an intake tower located near the northerly end of dam No. 1, this being the artificial outlet through which water will flow when used for generating power. The intake tower is a reinforced concrete structure 20 feet inside diameter and 104 feet high. The entrance contains a steel bar screen to prevent debris from entering the tunnel. The screen extends for the full height of the tower and is divided into three sections 7 feet 6 inches wide. It is equipped with motor driven mechanical rakes designed for operation over the entire screen area. Opposite the screen is the entrance to Tunnel No. 1, a 9-foot diameter gate controlling the admission of water. The gate and frame are of heavy construction, the disc being of cast steel and the frame of cast iron. All wearing surfaces are bronze trimmed. . . .

. . . After passing the gate, the water flows into a tunnel 12 feet in diameter and 3,880 feet long, excavated through the granite mountain adjacent to the westerly shore of [the] reservoir, which in turn connects with a pipe line a short distance below dam No. 2. The tunnel will supply sufficient water to drive six 20,000 H.P. impulse wheels under 1,900 feet head, and is laid on a grade of 2 feet per thousand. . . . Just outside the tunnel portal the pipe connects with a steel plate "Y" having two 84-inch outlets. One is closed for the present, and from the other leads an 84-inch steel pipe 6,480 feet long, and has capacity for supplying four main units. This conduit is laid to a gradient of 7.5 feet per thousand. It is supported on concrete saddles, spaced about 35 feet apart, and all elbows are securely held by large reinforced concrete anchors. The location chosen is such that the earth covering over top will not be less than one foot thick. . . .

. . . The 84-inch pipe terminates at the top of the slope, 1,942 feet above power house No. 1 and 4,500 feet distant from it. It is provided with four 44-inch diameter outlets, each of which will connect with a pressure line leading to one of the main units. Two outlets will be used for the present development, the remainder being blanked for future extensions. Near the top of each 44-inch line is a 42-inch hand or motor operated gate valve to control the water supply from the flow line to the pressure lines. They are arranged with a remote control for operation from the power house. Just below these valves are 24-inch standpipes which extend up the hillside for 425 feet, ending in vertical surge tanks 36 inches in diameter and 35 feet high.

A short distance below the gate house, for the 42-inch valves, the pressure lines begin the descent of the mountain side in two parallel lines, 7 feet apart, and having varying angles, both horizontal and vertical, depending on the ground profile. The pipes are lap welded steel tubes, each about 20 feet long and of varying diameter and thickness. At the upper end, where the pressure is least, they are 42 inches in diameter and 3/8 of an inch thick, while at the power house, the point of maximum pressure, they are 24 inches in diameter and 1 inch thick. For pressure not exceeding 1,460 feet the circular joints are riveted; but for greater pressures they are flanged and bolted, the joint being especially designed to withstand great pressures. Proceeding down the slope the increasing pressure necessitates thicker shells for a given size tube, so that when the limit is reached for a certain diameter and thickness, the diameter is decreased two inches, and his size is used up to the maximum thickness allowable, this method being continued on to the end of the lines.

Since each main unit requires two nozzles, each pressure line is divided into two parts by a 36"x26"x26" cast steel "Y" located up the slope 800 feet from the power house, the 26-inch lines being laid 5 feet apart and spreading out at the power house to suit the spacing of the main units. Just outside the power house the lines are reduced to 24 inches for connection to the hydraulic gate valves, this size continuing to the wheels.

The valves are designed for a working pressure of 1,000 lbs. per square inch, but all have been tested to a hydrostatic pressure one and one-half times that amount. They weigh 20,400 lbs. each and are all protected by a single building integral with the power house.

The pipe lines connect with the castings containing the mechanism for forming the water jet which turns the main unit shaft by impinging on the wheel buckets. Assuming the water elevation in the reservoir for the ultimate development as 6,965 feet, and the center of the nozzle as 4,819 feet, we find that the water must fall 2,146 feet before it is released to do work. This is the gross or static head available, from which must be deducted the average head in the reservoir and the frictional losses in the conduit to ascertain the mean effective head under which the wheel can operate for producing its rated capacity. Subtracting these losses we find that the water will issue from the nozzles in power house No. 1, when the wheels are developing 10,000 H.P. each or 20,000 H.P. per unit, in a jet 5 1/2 inches in diameter, at a velocity of over 300 feet per second. If the reader has never seen a jet under these conditions, it may be difficult to comprehend its meaning with respect to the energy which it contains.

The initial hydraulic equipment for power house No. 1 consists of two main impulse water wheel units, each developing 20,000 H.P. under an effective head of 1,900 feet when running at 375 r.p.m.; also two exciter impulse water wheels having 350 H.P. capacity, under the same head, when running at 750 r.p.m., together with the necessary governors, pressure regulators, central pressure oiling system and other auxiliaries.

The main units are of the two runner type, the wheel discs being pressed onto the projecting overhung ends of the shaft of the 11,000 kilowatt generator. They are the largest impulse units ever constructed, in addition to operating under one of the highest heads in the world. The wheels are 94 inches in diameter on the impulse circle and contain nineteen cast steel buckets each held in place on the nickel steel wheel disc by three pressure fitted bolts. The main shafts are hollow forged nickel steel, 20 inches diameter at the journals, 27 inches diameter at rotor fit, and 28 feet 11 inches long over all. They are each supported by two ring-oiling, water-cooled, self-aligning babbitted bearings 20 inches diameter by 60 inches long, placed either side of the generator, between it and the wheels. Each wheel is enclosed within a cast iron-steel plate housing, split on the shaft center so the upper half can be easily removed for inspection purposes.

The shaft speed of each unit is controlled by two hydraulic oil relay or hand operated governors of the latest type, the enclosed fly ball element of each being belt driven from the main shaft. They are also provided with a remote electric speed control operated from the switchboard room connected with the proper mechanism to the needle for adjusting the jet diameter to suit the load conditions. The governor arrangement permits operating either wheel of the unit without the other at maximum efficiency, especially when the output from the unit is 10,000 H.P. or under. . . .

. . . dam No. 4 has been constructed in Big Creek gorge several hundred feet below power house No. 1, to form a small reservoir for collecting the water from which tunnel No. 2 is supplied. This dam is of the arched type but not of gravity section. It is 73 feet high, 288 feet long and arched to a radius of 150 feet. It is provided with a hand operated sluice gate 72 inches in diameter. On top of the dam are piers for supporting the flashboards and a walk-way leading to the 72-inch gate operating mechanism. With this arrangement the water for power house No. 2 wheels can be controlled and the energy which might otherwise flow over dam No. 4 unused is conserved to good advantage. The spillway elevation is 4,805 and the walk-way 4,814 feet.

Tunnel No. 2 commences near the southerly end of dam No. 4 and across the creek from power house No. 1. Its entrance contains a steel bar screen built into the concrete headworks, and provision is made for a gate similar to the one at tunnel No. 1 entrance. The tunnel is 12 feet diameter by 21,300 feet long, driven in granite on a gradient of 3.2 feet per thousand and terminating in a concrete lined surge tank 30 feet diameter by 120 feet high.

The surge tank outlet is through a 9-foot diameter gate similar to the one in tunnel No. 1, the arrangement of the by-pass air shaft and gate operating mechanism being the same. The 108-inch diameter pipe connects to the casting just below the gate and extends through a concrete lined tunnel for 250 feet, at which point it connects with the pressure lines leading to power house No. 2. The arrangement of the water conduits, with their accessories, leading to this second station, together with their general design, are almost identical with those for the first development. While the head available for power house No. 2 is 120 feet less than power house No. 1, the fact that the size of the units is the same in both plants leads to practically the same hydraulic design in both cases. Both developments have their tunnels, pipe lines, standpipes, control valves, inlet pipes, nozzle pipes, impulse wheels with auxiliaries and power houses, the principal difference in the two schemes being in the length of the component parts of the conduit system and in the effective head. The wheels for power house No. 2 differ from power house No. 1 only in the number of buckets on the wheel disc, the former requiring two less than the latter. On account of the less head, the wheels in No. 2 will require more water per horse power than those in No. 1, the effiency being the same, so that in the ultimate development No. 2 will contain one unit less than No. 1 [Hageman 1913:236-247].

The two Power Houses are practically duplicates structurally. Each is 85 feet wide, 171 feet long, and 104 feet high; the total height over the steel structures on the roof being 138 feet. The ultimate development will require a length of 213 feet, the other dimensions remaining the same. The design provides a simple and uniform layout having a minimum of space, but permitting extensions without disturbing the existing equipment.

The General Electric Company has furnished the electrical equipment for Power House No. 1, and the Westinghouse Electric & Manufacturing Company for Power House No. 2. The Power Houses are so designed, with respect to dimensions, floor loads, and layout of equipment, that future apparatus for either may be either of Westinghouse or General Electric manufacture.

The present installation includes in each Power House, 2 main generators, 2 main transformer banks, 2 exciters, 1 bank station service transformer, 2 150,000–volt outgoing lines, 1 local 6600–volt outgoing line, 1 storage battery, and auxiliary equipment. . . .

Each generating unit consists of a 50–cycle, 6600–volt generator on the same shaft with two impulse type water wheels, one wheel being mounted on each end of the shaft.

. . . The exciter generators are rated at 150 KW. at 250 volts with a speed of 750 R.P.M. They are of the interpole compound type and each is capable of exciting both the main generators. . . .

The two banks of main step–up transformers are each made up of three oil insulated and water cooled single phase transformers rated at 5833 Kva. A spare transformer is provided. . . .

All 6600 and 150,000–volt switch gear is of the remote controlled, electrically operated, non–automatic type. The 6600–volt switches are of the H–3 type. The 150,000–volt switches are of the K–21 type and consist of three single pole elements mounted in separate boiler iron tanks, the weight of a complete switch with oil being 28,000 lbs. and the space occupied 6 feet by 20 feet by 10 feet high.

The low and high tension buses are both double with selective disconnecting and oil switches on each bus as indicated on the diagram. All 6600–volt buses are installed in separate concrete chambers with individual cells for generators, tranformers, etc. . . .

The switchboards in the two Power Houses are identical except for the type of instruments and control switches. The main board for the control of the generators, transformers, exciter motors, lines, etc., is of the bench type and an upright board is provided for the control of the light and power, storage battery and charging sets. . . .

All lighting throughout the Power House is by means of Holophane high efficiency reflectors and Mazda lamps. The intensity of illumination varies from three candle feet in the generator room and switchboard gallery to 1.5 candle feet in the basement.

A complete telephone system is installed putting the switchboard room in communication with all parts of the Power House and the system generally, including Los Angeles and Power House No. 2. . . .

The general direction of the two transmission lines leaving Power House No. 1 is westerly to Power House No. 2, thence almost directly south to Los Angeles. The line is 241 miles long, the country for about half this distance being rough and mountainous and for the other half

> rolling or hilly. The route crosses two mountain ranges, the Sierra Nevadas from an elevation of 5,000 feet and the Tehachapis south of Bakersfield, at 4,500 feet. . . . There are two tower lines spaced 80 feet apart on centers on a right of way 150 feet wide.
>
> Standard towers are designed to withstand the breaking of two conductors on the same side of the tower.
>
> Anchor towers are designed to withstand all three conductors and ground wire broken on same side of tower and a pull at right angles to the line sufficient to permit of their use as angle towers for turning an angle of 60 degrees.
>
> The total number of towers is 3401, of which 2214 are standard and the remainder anchor, angle, and extra length, including six anchor towers 65 feet high. The total weight of a standard tower is 5600 lbs. and of the anchor tower 8050 lbs. [Anderthon 1913:326–331].

By the time of completion of the Big Creek System in late 1913, Henry E. Huntington had complete personal control of Pacific Light and Power Corporation, holding almost the entire stock of this company which in turn controlled the Big Creek project. By this time Huntington had purchased the holdings of Balch and Kerckhoff in Pacific Light and Power, selling to them in return his interest in the Southern California and Midway gas companies. However, this spring 1913 sale of properties had no effect on the San Joaquin Light and Power Corporation, which remained under the control of Kerckhoff and Balch (Fresno Morning Republican, April 25, 1913:16).

World War I, 1914–1918

Things were relatively quiet at Big Creek during the few years immediately following the end of construction. The thousands of workers who had made the mountains echo with seemingly endless activity were now gone, and the Big Creek region settled into a more normal routine. Most activity in the area now consisted of operation and maintenance of the new Hydroelectric System to assure the high output of which it was capable. A second concentration of energy during this period was on continued small-scale construction carried out according to long-range plans for ultimate development of the Big Creek System.

In the 1914–1918 period, this work consisted of tunnel construction downstream from Powerhouse No. 2, as well as further construction on the Huntington Lake dams. During 1916 and 1917 the three dams at Huntington were raised 35 feet and a fourth dam was added, doubling capacity of the lake and laying the basis for later addition of more turbines and generators in each powerhouse (SCE 1923c:2; 1928a:2). Work on Tunnel No. 3, just below Powerhouse No. 2, began in July 1914. Since only a small crew was employed, progress was very slow (Bergh 1956a:211). Due to World War I, the capital needed for rapid expansion was not available, nor was demand in Los Angeles high enough to justify such expansion. There was no real reason to rush the work, and it was not until 1919 that the pace of construction picked up (Bergh 1956a:211; Redinger 1949:82).

During this quiet period of relatively little construction activity, the focus of life in the Big Creek region changed dramatically. In the early days of massive construction, the population of Big Creek consisted primarily of men—most of them young, single, and recently away from their family homes. By 1914, the population of Big Creek had changed. Not only were there far fewer men employed by the company, but many of the workers, now married, brought their families along to settle in the Big Creek area. At first the region was ill-equipped to deal with the needs of women and children, but in time new institutions were established, catering to needs of families.

One of the first notable additions brought about by this change in demographics was establishment of a schoolhouse at Cascada. The first teacher, Mrs. Posterfield, taught anywhere from 30 to 50 students in grades one through eight. As payment for her ability to cope with such circumstances, Mrs. Posterfield received the considerable sum of 80 dollars per month (Schiebelhut 1977:n.p.). A later teacher, Miss Orva Eicher, described what it was like to teach at the Cascada School in 1916:

> We are 35 in number, working in a small but comfortable building with plenty of windows on all sides to give light and fresh air. . . . All eight grades are under the management of one instructress . . . [and] sometimes our happy family is compared with the little old woman who lived in the shoe, with all her children she didn't know what to do [Eicher 1916:8–9].

While the schoolhouse was a definite plus for families in the area, such bonuses were few and far between. Life for women and children at Big Creek was not what they were generally accustomed to, and so a great many adjustments were required. At least one woman, Edith Redinger, wife of David Redinger, found her surroundings somewhat humorous. As she commented on her arrival at Big Creek as a 1917 bride, "We were met at the funny little mountain railway station by the townspeople. School had been let out so all the children could join in the festivities." If the surroundings were amusing, the rustic living quarters must have been less so. As Mrs. Redinger explained, the accommodations provided upon her arrival were "the best available—a tent with a wood stove and a corrugated iron roof to ward off the snow (E. Redinger 1977:4). From the tent, the Redingers moved to a single wall, board and bat house built especially for them out of green lumber. Despite these inconveniences, Mrs. Redinger, like other women who settled there, learned quickly to adjust to life in the remote region of Big Creek.

A final aspect of life in these years was an increase in recreational use of the Big Creek region. Even during the construction rush, the San Joaquin and Eastern Railroad carried passengers, and it wasn't long before a number of amusing nicknames had been coined for the San Joaquin and Eastern. During the days of heavy construction, the "down" train was known as the "Millionaire's Limited" because it carried happy construction workers and their pay checks to Fresno. The "up" train was called the "Hobo Special" because it transported broke workers back to camp. The cost of a rough ride on the San Joaquin and Eastern was ten cents a mile, and locals referred to it as the "Slow, Jerky, and Expensive" for obvious reasons (Johnston 1965:91; Sievers 1956:11). The powerful Shay and (later) the Climax engines which pulled the train from Auberry to Cascada at a speed no greater than 15 miles an hour were known as the "galloping geese" (SCE 1923b:9). After construction was over, the San Joaquin and Eastern continued to operate, carrying large numbers of passengers looking for escape into the high country.

Another sign of expanding recreational use of the Big Creek country was construction of a hotel at Huntington Lake. Built by a subsidiary of the San Joaquin and Eastern Railroad Company, the hotel, it was thought, would increase the number of passengers on the Big Creek rail route. Huntington Lake Lodge opened on July 4, 1915, boasting, among other things, hot and cold running water, electric heat and lights, a ballroom, billiard room, tennis courts, and barber shop (Pacific Light and Power Bulletin 1916:12). Construction of such luxurious accommodations in an area of relative isolation was yet another sign of the region's changing focus. Big Creek was no longer a place where a largely male population lived in rustic seclusion; industrialization had changed not only the physical surroundings but the social and cultural climate as well.

Huntington, Miller, and the Great Merger, 1916–1917

For almost a decade and a half, Henry E. Huntington had wanted to merge all of southern California's electrical properties into one giant combine, an actual monopoly to correspond to the natural monopoly which this field represented. In this attempt he had mainly been frustrated by John B. Miller, President of the Southern California Edison Company, and his associates. But Huntington was now near the end of his career. As president and main stockholder of Pacific Light and Power Corporation in 1916, he had more work than he wanted at the age of 66. Furthermore, he had achieved fame and fortune as few men had; in fact, some in his organization saw him as a "superman." The Pacific Light and Power *Bulletin* carried the following statements on him in its June 1916 issue:

> Hugh Chamlers has said that all men are pretty much alike, so far as their physical equipment is concerned. Each of us has two hands and feet and a place to wear a hat. When set to work each of us will handle so many loads of dirt or sacks of grain in a given time. To this point we resemble so many truck horses and there is no particular distinction between the subject of this sketch and the humble scribe who is writing it.
>
> But when we come to mental equipment, what a difference! Now we distinguish between man and superman. Very rarely we see the man who has those qualities of vision, initiative, persistence, patience that mark the superman. Such is our President, Henry E. Huntington. When you see an industrial triumph, an unknown power turned into a commercial necessity, a desert converted into a Paradise, look for the superman. Emerson says, "Every great institution is the lengthened shadow of a single man."
>
> Not many years ago Southern California was occupied by a few vast ranches operated by an unprogressive people. Now it is divided into small farms supporting a hustling and prosperous tenantry who enjoy all the advantages of efficient public service. This development is due almost entirely to the aggressiveness of Mr. Huntington who untangled a jumble of poorly managed public service companies and united and extended them into the network which has made Southern California what it is. Any community is at the mercy of its transportation facilities. Transportation, power and water have made Southern California and there are few developments of this sort in which Mr. Huntington's hand is not seen. . . .

> The Big Creek development is an instance of his daring. More power was needed—250 miles away power was available. Engineers said, "It cannot be done." Mr. Huntington has a way of finding men who can do things. The result was a plant of tremendous dimensions, using a 2000 foot head of water, operating at 150,000 volts, over a distance of 242 miles. But that is not all; to get materials to Big Creek it was necessary to construct a standard gauge railroad 56 miles long, and to control the water it was necessary to create an artificial lake which is truly a monument to the name it bears—Huntington Lake.
>
> We know Mr. Huntington as the President of our own Corporation, as the owner of the Los Angeles Railway and the Huntington Land Company. He is also owner of the largest private shipyards in America, the Newport News Shipbuilding and Drydock Co., and is director or official in fifty other corporations. . . .
>
> One is inclined to say that Mr. Huntington has been fortunate in the selection of his lieutenants. To be accurate we must say that one of his talents is his splendid judgment of men. It is not chance that places such men as the officials of this Corporation in the positions they hold. They have had to meet the specifications of this superman who started in the hardware store and rose to a position among half a dozen of the richest men in this country.
>
> Patience is another prominent characteristic. First vision, an opportunity in the distance—then good judgement—then patience. Mr. Huntington said, after he had poured millions into his properties in Los Angeles, "I believe in this proposition and am willing to wait." He is not the man to say, "I might have done so-and-so if———" or "If I had only known this ten years ago———." He has the rare faculty of seeing ten years ahead. Those of us who have not this faculty are fortunate in being associated in an enterprise guided by a man who has it. . . . [Smith 1916:3-4].

In short, Huntington had accomplished about everything he could want to in the world of business—except a merger with Southern California Edison. Since he wanted to retire from day-to-day management in order to focus on his San Marino library and art gallery, Huntington, in 1916, exchanged his stock in Pacific Light and Power Corporation for Southern California Edison second preferred stock. This exchange made Huntington a director and a main stockholder of Edison—in short, a partner in that enterprise. The move was also a good deal for Edison, for more than one reason. First, due to the exchange of stock, no money was borrowed or property mortgaged in order to effect the purchase. The stock Edison gave Huntington was worth just over 12 million dollars—a good price for Edison since it received in exchange absolute control over an enterprise worth much more than that amount. The second reason, which focused on efficiency, was stated by the State Railroad Commission in its decision approving a merger of the two companies:

> The Pacific Light & Power Corporation has a large hydro-electric development which is not and will not in the near future be put into full use unless this consolidation occurs. On the other hand Southern California Edison Company is using to capacity its hydro-electric installations and unless this consolidation occurs will be confronted with the almost immediate necessity of increasing its production of electric power. Therefore, by this consolidation there are brought together two

systems which complement each other in this respect. The considerable surplus of power now possible of generation in the plant of Pacific Light & Power Corporation will be brought into use for the consumers of Southern California Edison Company and this will provide for a very considerable expansion of business by the consolidated company without the necessity for large expenditures in increasing production capacity.

Furthermore, it is proposed to completely consolidate these plants and to operate thereafter as a unified whole, thus greatly decreasing operating expenses.

It is estimated by the applicants that there will be a saving in operating expenses for the first few years of approximately $400,000 a year and the electrical engineers of this Commission believe that this statement of probable savings is very conservative and may be stated as a minimum. It is their belief that the savings will be very much greater as the plants are consolidated and operating expenses are cut down and business increases.

The benefits of this consolidation to the public will be the elimination of the necessity for duplicate facilities and the greater efficiency made possible by the serving of a great community by one plant and organization" [as cited in Southern California Edison 1917a:6].

Following the merger, which was finalized in May 1917, the Edison Board of Directors was increased from nine to 12 to allow representation of the Huntington interests, and several top Pacific Light and Power Corporation officers became high officials of the Edison Company. The new directors were Henry E. Huntington, Howard E. Huntington (Henry's son), and W. E. Dunn (Henry's lawyer). The new vice presidents were R. H. Ballard, former secretary of Pacific Light and Power, and G. C. Ward, former vice-president of the same corporation. A. N. Kemp, who had been treasurer and comptroller of Pacific Light and Power, was also to serve as comptroller for Edison (SCE 1917a:6–7).

War's End and Renewed Plans for Expansion

The new Southern California Edison Company operated in a broad area of southern California. In 1918, with the great war in Europe almost over and demand again beginning to outrun the supply of electric power in Los Angeles, Edison began to consider expansion of the Big Creek System. In its *Annual Report* for 1917, Edison's leaders stated that installation of a third unit in Big Creek Powerhouse No. 2 and completion of Kern River Powerhouse No. 3 should meet immediate needs (SCE 1918:11). Plans for this work were underway during 1918, but development was not rushed until 1919, when, in the wake of the war, demand for electricity jumped tremendously. As Edison's *Annual Report* for 1919 expressed it:

> All classes of business, particularly industrial, oil development and agricultural, were given a tremendous impetus upon the signing of the armistice. This placed before us unusual demands for electric power, which are increasing. These will be met by development of additional power. We are fortunate in having 900,000 hydro-electric horsepower capable of development on a commercial basis in the watersheds in which the company's principal power plants are located [SCE 1920:9].

The ups and downs of economic demand due to war in Europe affected the level of agricultural and industrial activity in the Los Angeles region, which in turn determined how much electricity Edison needed to supply—the key factor influencing the pace of development at Big Creek. Formerly a remote region of the world, Big Creek had, during the 1911–1913 years, been integrated into a network of socio-economic and cultural connections which spanned the globe. At the end of 1918, due to the end of a great war, the Big Creek region again stood on the verge of a frenzied period of construction. The initial phase of Big Creek development had been completed. The great expansion of 1919–1929—a period when the Big Creek Hydroelectric System saw the construction of many new facilities—was still to follow.

PART II

THE GREAT EXPANSION, 1919–1929

Superlatives characterized the decade of the 1920s in the history of Big Creek. During this decade, the bulk of construction was completed on one of the world's greatest engineering projects of the first third of the twentieth century. This enterprise included building three new powerhouses and expanding two others; construction of two major dams and several smaller ones; drilling of several major tunnels; and installation of penstocks and hydraulic and electrical generating and transmitting equipment needed to create a System capable of generating over one–half million horsepower and almost 400,000 kilowatts. Several world records (in tunnel size and length, dam length, transmission voltage, and size of hydraulic equipment) were set during the course of this expansion project. Almost as much money was expended in this work as was spent in creating the Panama Canal—the other great engineering project during the first third of this century. During the 1920s, as many as 5000 men at a time were employed in building the Big Creek System. Some of them braved the high Sierran winter year after year in order to complete Florence Lake tunnel, which was the centerpiece of the entire project. The chapters in this section detail the "great expansion"—a period of intensive construction activity which, by 1929, resulted in completion of the basic features of the Big Creek Hydroelectric System.

CHAPTER 4

THE GREAT EXPANSION, PHASE ONE: 1919–1923

The Great War in Europe, which ended in November 1918, had created an enormous, pent-up demand for a variety of goods and services; also, redistribution of wealth (especially from England to the United States) caused by the war made it possible to satisfy this demand through investment. At the same time, climate and other attractions of the Los Angeles area resulted in continued migration of people to this metropolis of the southland. These developments created a post-war economic boom in industry, agriculture, construction, and commerce in the Los Angeles area, and this boom in turn generated the need for more electric power. The cheapest and most efficient place to get that power was Big Creek. Therefore, in 1919, Southern California Edison Company decided to embark on a vast expansion program which was designed to rapidly increase electrical generation capacity. From 1920 to 1923, Powerhouse No. 1 and Powerhouse No. 2 were expanded by adding third units, and two new powerhouses were built. At the same time, a vast construction effort was begun in order to expand the all-important water supply (cf. Chapter 5).

Edison Purchases Fresno Flume and Lumber Company

The first step in increasing the water supply base for an expanded Big Creek System involved purchase of nearby Shaver Lake and its surrounding lands. This was accomplished in July 1919 with Edison's purchase of the old Fresno Flume and Lumber Company, whose holdings consisted of Shaver Lake, timber rights, a sawmill, and a logging railroad.

The Shaver Mill, in business since 1891, had been one of the largest lumber operations in Fresno County. One of this company's most notable accomplishments was construction, in 1891–1894, of a V-shaped flume for transporting lumber to Clovis. One consultant remembered a rather dangerous childhood pastime of riding the "V's," when he and his friends would ride down the fast-moving waters of the flume (TCR Field Data 1986). Shaver officials would also ride down the flume—but on special home-made flume boats, consisting of "two flat boards put together in a V-shape with a third board across the top for the passenger" (Johnston 1965:69).

In July 1919, Southern California Edison paid 1.4 million dollars for the Shaver Lake property and a month later purchased some adjoining properties for an additional $600,000, bringing its holdings in the Shaver Lake area to 32,000 acres. Part of the land was conveyed by Edison to the Shaver Lake Lumber Company, a corporation formed specifically for that purpose, while the remaining properties were held by the Edison Company (Johnston 1965:75).

Acquiring the Shaver properties and surrounding acreage provided Southern California Edison Company with two items necessary for its expansion plan: another site for additional water storage (Shaver Lake), and many acres of timber needed for the new construction which would soon begin at Big Creek (Johnston 1965:67).

Commenting on acquisition of this property, the *Los Angeles Daily Times* reported that the proposed lake (Shaver) would soon supply "water power for the generation of hundreds of thousands of hydroelectric horse power" (July 14, 1919:3).

The Permit Process and the Great Expansion

During that same month of July, 1919, Edison began to take steps that would eventually provide the legal basis for its expansion of the Big Creek System. Applications for permits were filed with the appropriate state and federal authorities, allowing Edison to divert water and build the desired dams, tunnels, powerhouses, and related facilities. The first application was dated July 3, 1919, and was addressed to the State Water Commission; the second was dated July 15, 1919, and requested that the United States Forest Service grant a preliminary permit for expanded development of the Big Creek System. These applications were frequently amended in various ways over the next 10 years, but they provided two of the key legal bases for the work carried out over the decade of the 1920s (SCE 1967a:8, 1967b:9; Wheeler 1946:1–2). Another major legal foundation for the work at Big Creek was the supplemental agreement signed with Miller and Lux on April 27, 1920, allowing storage of additional water (SCE 1967a:9). Two final, important legal bases for additional development at Big Creek were applications for licenses granted by the Federal Power Commission (which had been established in June 1920) and the Railroad Commission of the State of California. These permits, like those issued by the State Water Commission and the United States Forest Service, underwent a number of modifications over the next few years through amendments requested by Edison as its plans changed (Wheeler 1947:1–5).

David H. Redinger and the Great Expansion of the 1920s

Before any review of the details of the great expansion of the 1920s is attempted, the key role played by David H. Redinger, resident engineer at Big Creek during this period, should first be recounted (Plate 25). Redinger's entire career, and indeed his life, was devoted to Big Creek—the project and its people. Arriving at Big Creek in 1912 to "look things over," Redinger had no idea that he would become resident engineer and remain with the project for nearly 40 years (E. Redinger 1977:1). After just 10 years of service, the company publication, *Edison Partners*, commented that Redinger was "the man on the job, who eats, sleeps, and thinks the world's greatest construction project" (SCE 1923b:18). In fact, the names of Big Creek and Redinger became so synonomous that Redinger was often referred to as "Mr. Big Creek" (Schiebelhut 1977:n.p.).

Born in 1884, Redinger grew up in Kansas, graduating from the University of Kansas in 1911 with a degree in civil engineering. After a brief sojourn for the United States Government in Alaska's Bering Sea area coal fields, Redinger headed for Seattle. There he made the acquaintance of H. P. Banks, who told him of a great hydroelectric project being started in the high Sierra. In the summer of 1912, Redinger and Banks headed for Big Creek.

Plate 25 David H. Redinger, 1923 (SCE var. [a]:Unnumbered Album, No. 9151).

Initially hired by Stone and Webster Construction Company as a transit man, Redinger was promoted by 1913 to the position of tunnel engineer. However, owing to the outbreak of World War I, all survey-associated fieldwork was terminated, and in September of 1914 Redinger was laid off. During this layoff, he was employed with the United States Reclamation Service's Salt River Valley Project in Phoenix, Arizona. This brief stint ended in 1916 when Redinger returned to Big Creek—this time working for Pacific Light and Power as Big Creek's resident engineer (Redinger 1949:43; Schiebelhut 1977:n.p.).

Redinger's return marked the beginning of what was to be a long and distinguished career at Big Creek. When Southern California Edison took over from Pacific Light and Power in 1917, Redinger continued as resident engineer, supervising most of the construction projects of the 1920s. Along with his work as engineer, Redinger published a series of articles in the *Compressed Air Magazine* on construction of the Big Creek System, and later wrote a book on the history of the project entitled *The Story of Big Creek* (Redinger 1924, 1949). In 1955, a lake was named after him in recognition of his many contributions to the Big Creek project (Schiebelhut 1977:n.p.).

It seems that Redinger's job included many innovative duties, as is indicated by an article which appeared under the headline, "Fixing it for the Fishes." Redinger was presented with a problem concerning the stocking of fish in the Big Creek area's lakes. In order to insure the success of the program, snakes and other reptiles had to be eliminated before the fish could be planted. Redinger came up with a plan he thought would do the trick—a thousand pounds of gelatine dynamite detonated in the water:

> Bang! Whuff! went the dynamite. The water lillies bobbed their startled heads, and a flivver-truck full of dead serpents floated to the surface, and David earned a new title of Saint Patrick of the High Sierras [SCE 1923b:18].

David Redinger's contribution to the Big Creek project in the 1920s and in later years is not easily measured. As an employee of Stone and Webster, Pacific Light and Power, and Southern California Edison companies, Redinger always made sure that the job got done—whether it was drilling a tunnel or building a dam. At the same time, he brought a sense of permanence and purpose to the project, and he shared this sense with his fellow employees. The construction of the Big Creek project called not only for technical innovation but for talented, hard-working employees like David Redinger who made the project their life's work and inspiration.

Shaver Tunnel and Enlargement of Powerhouses No. 1 and No. 2

The easiest and quickest way to expand electrical production at Big Creek was to install additional units in the two existing powerhouses by using the additional water supply available at Huntington Lake (a result of the 1917 dam enlargement) and at Shaver Lake. Since it was geographically closest to Shaver, Powerhouse No. 2 was chosen for initial expansion. In February 1920, work was begun on Shaver

Tunnel, an 8-x-11-foot tunnel 14,300 feet long, which linked Shaver Lake (lying about 2400 feet above and four and one-half miles south of Powerhouse No. 2) with the power plant. Shaver Lake in 1920 was formed by a rock-filled dam about 40 feet high and had a storage capacity of only 5200 acre-feet—a much smaller body of water than the present lake. (Redinger 1924:[4,6]).

Work on Shaver Tunnel was conducted at four headings, one at each end and two in the middle (the latter two being reached by a 400-foot-long adit). An average crew of 90 men worked continuously at the four headings (about 350 men in all) until the tunnel's completion in early May, 1921. All the tunnel equipment was modern, much of it powered by two 700-foot compressors at each heading. Pneumatic drill-sharpening machines were also used (Redinger 1924:[6]).

David Redinger later reported on the Shaver Tunnel work:

> The rock encountered was hard granite, with very little seamy material, so that less than 1,000 feet of the entire length of the tunnel required timbering. Drilling was done with No. 248 "Leyner" pneumatic drills, driving from 28 to 34 six-foot holes per round; and three complete rounds were drilled, blasted, and excavated every 24 hours—a shift working at each heading all the time. The blasted material was mucked with air-operated "shuve-loders" working under the same pressure as the drills, that is, at about 100 pounds per square inch, and these placed the broken rock into 1-yard Koppel dump cars. The latter were hauled to the portal by storage-battery locomotives. A total of 55,000 pounds of 40 per cent. and 60 per cent. blasting gelatine was used in driving the tunnel [Redinger 1924:(6)].

Plate 26 shows one of the storage-battery locomotives used in this work.

Despite modern equipment, drilling Shaver Tunnel was still a demanding task for the men involved. To urge the men on, Edison offered a bonus of 35 cents per man per foot for drilling in excess of four feet per shift. During the life of this offer, the company paid out a total of $15,000 to their hard-working employees. While the men no doubt appreciated the money, it was reported that money wasn't their only motivation:

> It wasn't the money that spurred the boys on—it wasn't the money that made them jump to their work like contestants for a marathon; it was the spirit of the thing—the spirit that animates every worker in the Edison organization, and our boys felt that they had a great definite purpose in view [Los Angeles Times, May 22, 1922:6].

Once the tunnel work was well underway, installation of a third unit in Powerhouse No. 2 was begun. Work on the powerhouse and penstock began in late spring and early summer, 1920, and was completed late that year. Camp No. 7, near Powerhouse No. 2, was used as the base for this work. To complete this expansion, a new, small extension was added to the western side of Powerhouse No. 2 to house the new unit (Plate 27). At the same time, a trench was dug and a penstock

Plate 26 Storage battery locomotive, date unknown (SCE var. [a]:Album 3, No. 6029).

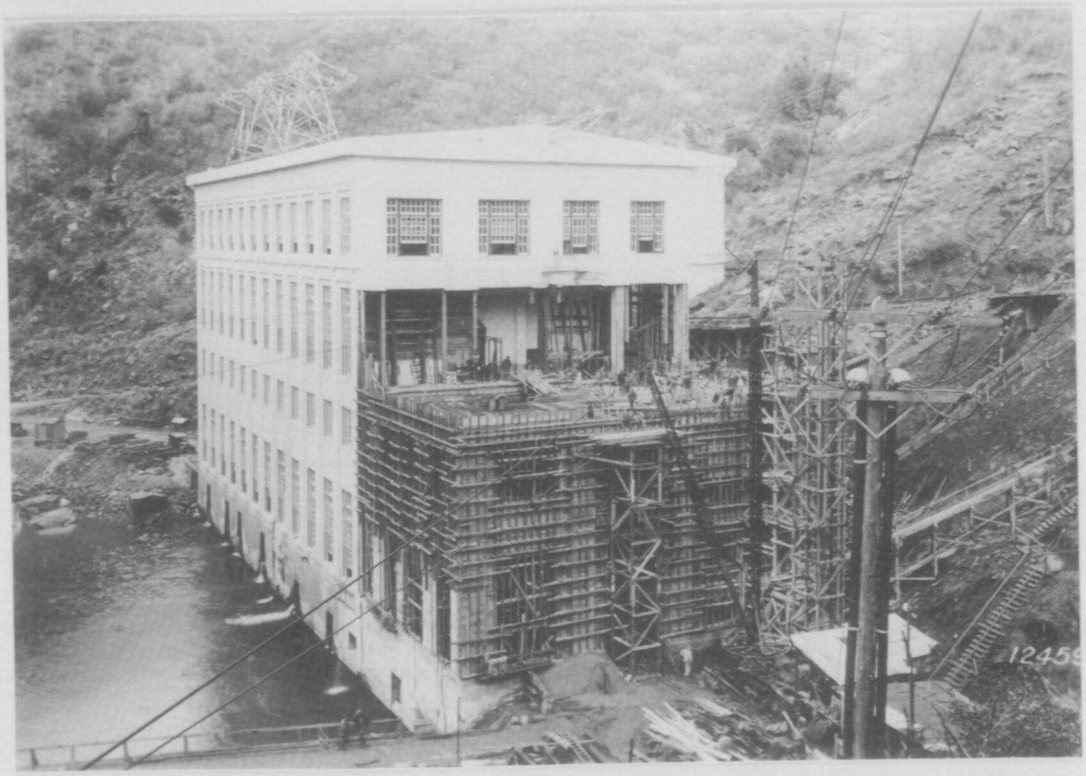


Plate 27 Powerhouse No. 2 Extension, 1920 (SCE var. [a]:Album 5, No. 12459).

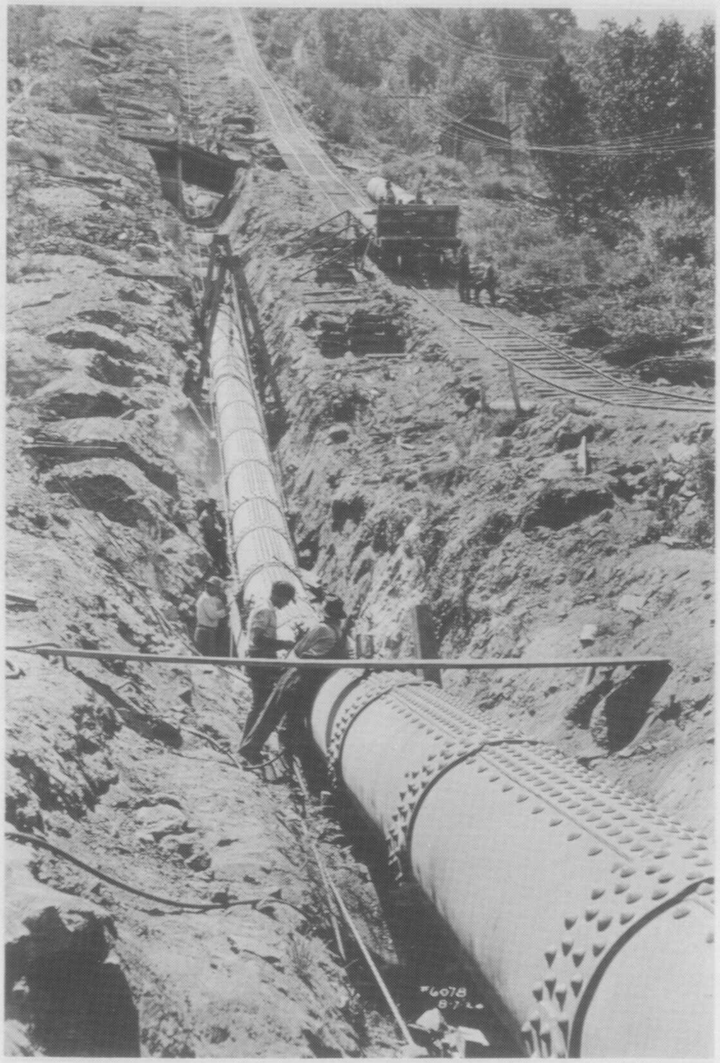


Plate 28 Penstock and Incline Railroad above Powerhouse No. 2, August 1920 (SCE var. [a]:Album 3, No. 6078).

installed using an incline railroad to deliver the pipe (Plate 28). When finished and on line in mid-1921, Powerhouse No. 2 had an increased horsepower capacity to 66,000.

In July 1923, a third unit was also added in Powerhouse No. 1. This improvement gave this powerhouse an additional 22,500 for a total of 62,500 horsepower (SCE 1928a:3, 1928b:B9-7).

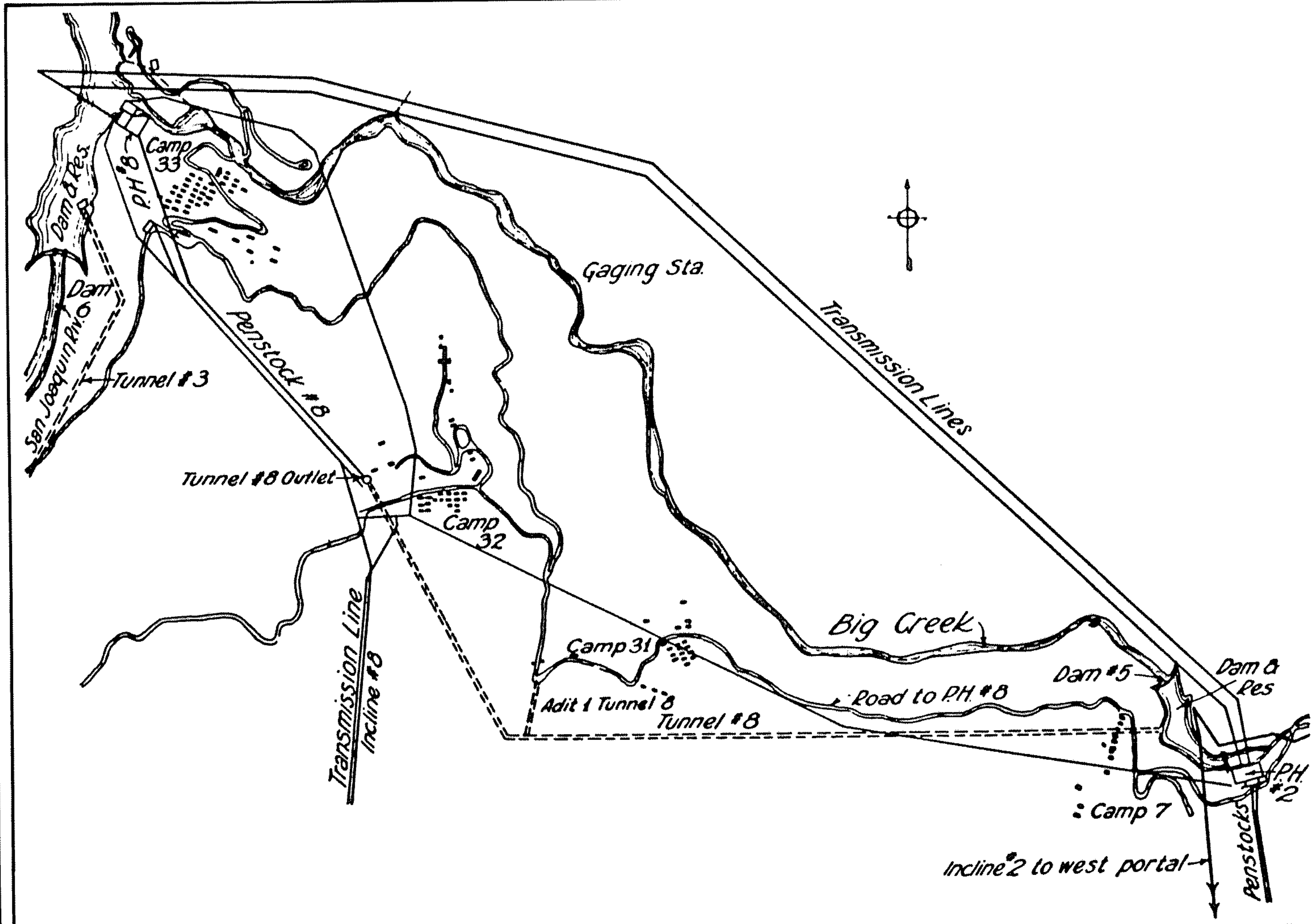
The 90-Day Wonder: Powerhouse No. 8 System, 1920-1921

While Powerhouse No. 8 was called the 90-Day Wonder because the powerhouse itself was completed in only 90 days, a much longer span of time was needed to build all the features necessary to finally bring it into operation. This powerhouse was the result of a fortunate juncture of two events in mid-1920: rapid expansion of electrical demand in Los Angeles, and a technological breakthrough in water turbine design. To understand the link between these events and the building of Powerhouse No. 8, it is necessary to backtrack a little in time.

Intermittent work on Tunnel No. 3 (originally designed to bring water from below Powerhouse No. 2 to Powerhouse No. 3) was carried on from 1914 until 1919. In late 1919, the decision was made to rush this tunnel work, and a base camp was established at Camp No. 7 near Powerhouse No. 2. All work during the first half of 1920 focused on plans to install a 1400-foot-head plant, called Powerhouse No. 3, to be located on the San Joaquin River near the mouth of Mill Creek. In mid-1920, however, it was recognized that the very rapid increase in electrical demand in Los Angeles was likely to create a serious shortage before Powerhouse No. 3 could be brought on line about 1923. Around this same time, the vertical, reaction-type water turbine was perfected, allowing much greater efficiency from low head, high volume power plants. Due to these facts, Edison engineers and corporate leaders decided to build two 700-foot-head powerhouses instead of one having a 1400-foot head. The plan called for Powerhouse No. 8 to be built at the mouth of Big Creek between existing Powerhouse No. 2 and still-to-be-constructed Powerhouse No. 3. (The seemingly out-of-sequence number for this powerhouse reflects the persistence of Eastwood's original design and numbering system.) Due to its much shorter tunnel distance and less lengthy road, Powerhouse No. 8 could be completed about two years sooner than Powerhouse No. 3.

Tunnel No. 8 and Dam No. 5

During 1920 and 1921, work was rushed on the basic hydraulic features needed to bring water to the ridge above the confluence of Big Creek and the San Joaquin River. Tunnel No. 8 (called Tunnel No. 3 until mid-1920) was the biggest job: it required drilling, blasting, and cleaning out a 20-x-20-foot diameter bore 5933 feet long. This tunnel work was almost continuous from early 1920 until June of 1921, and was carried out from base camps at Camp No. 31 (just east of Adit 1) and Camp No. 32 (just east of the tunnel outlet), as well as Camp No. 7 near Powerhouse No. 2 (Map 6). Work on the tunnel mainly used the pioneer drift method. A No. 40 Marion steam shovel and Western six-yard side-dump cars, operated by five-ton, storage battery locomotives, were used for loading and hauling the muck (rocks and dirt) which had to be cleared after blasting (Redinger 1924:[9]).



MAP 6 -P. H. 8 ENGINEERING FEATURES- (Redinger 1924)

Once the tunnel work was well underway, Dam No. 5 was begun. This dam was needed to regulate the waterflow below Powerhouse No. 2 and to guide it into Tunnel No. 8. The first step in this operation was to divert the flow of Big Creek into a flume, which enabled excavation work at the dam site to begin in mid-November, 1920. David H. Redinger described this work as follows:

> Air for operating "Jackhamers" [*sic*] was supplied by a compressor located in Power House No. 2; all blasting was done with 40 per cent. gelatine dynamite; and mucking, due to the limited amount and to the close quarters, was carried on by hand. The muck was loaded into 1-yard, steel side-dump cars, running on 18-inch gage track, and was unloaded alongside the creek channel a maximum distance of 400 feet downstream from the dam site. Leakage from the diversion flume was taken care of by air-operated pumps set in sumps in the excavation [Redinger 1924:(10)].

Materials and equipment to build this dam were carried from the San Joaquin and Eastern Railroad on Incline No. 2, which ran about 6000 feet (1900 feet vertical distance) from the railroad to Powerhouse No. 2. Another short incline railroad was built to connect Incline No. 2 with the dam site. A concrete-mixing plant consisting of a cement platform, gravel bin, concrete mixer, and tower was placed at the upstream face of the dam, and chutes were used to deliver concrete to various parts of the dam. Form lumber, cement, sand, and rock were stored at or near a warehouse at the dam site. The first concrete was poured in mid-March 1921, and the dam was completed by late April 1921. An intake structure was also built upstream from the dam to allow water to enter Tunnel No. 8. No sluice gates were originally installed for the intake; steel rack bars were all that were considered necessary (Redinger 1924:[11]). When completed, Dam No. 5 consisted of a small, simple arch-type concrete dam, 80 feet high and 260 feet long, containing approximately 3800 cubic yards of concrete. Six-foot-high wooden flash boards, controlled by a hand-operated crane, allowed the dam height to be raised or lowered. Two electrically activated 72-inch sluice gates were located at the base of the dam (Redinger 1924:[10]).

Transportation to Powerhouse No. 8 and Establishment of Camp Nos. 33 and 42

At the same time that work on Tunnel No. 8 and Dam No. 5 was being pushed forward, access was gained to the future site of Powerhouse No. 8 by building a road and an incline railroad to the junction of Big Creek and the San Joaquin River. There was already a road from Camp No. 7, near Powerhouse No. 2, to camp nos. 31 and 32 on the Tunnel No. 8 line. In early October, 1920, construction began on the road's extension to Camp No. 33, near the site of Powerhouse No. 8. A Marion No. 21 steam shovel, operated by compressed air, was used to remove rock and earth loosened by extensive blasting. In late November 1920, even before the road was completed, construction began on the 300-man camp to be known as Camp No. 33. This camp was fully occupied in late December, 1920, after the road was completed (Redinger 1924:[11]).

Even though there was now a road, delivery of such an immense amount of materials and supplies (especially the heavier, permanent hydraulic equipment) required an incline railroad. So Incline No. 8 was built, running from the powerhouse site to the San Joaquin and Eastern Railroad—a distance of 10,800 feet and a variance of 2470 feet in elevation. A new station, Feeney, was established on the railroad, with necessary warehouses, stockpiling yards, and other facilities. Camp No. 42 was also established at this site (Redinger 1924:[11]). In 1923–1924, David H. Redinger provided the following details about Incline No. 8's operation:

> . . . it was necessary to put several curves in the incline to conform to the topography of the mountains. The grades vary from a minimum of 6 per cent to a maximum of 50 per cent. The incline is provided with a hoist driven by a 250–H.P., variable–speed motor; and the main brake is one of the hand–operated post type, and is at one end of the drum. The hoist is also fitted with an auxiliary, automatically operated solenoid brake. The incline cable is 1 1/2 inches in diameter and consists of 6 strands of No. 19 plow–steel wire. Using a single line, the outfit has a rated capacity of 35 tons—in other words, a 15–ton "strong back" or incline car can carry a 20–ton load. For the heavier loads, requiring a double line, an 84–inch sheave is provided that travels on a small car between the cable and the main car. By this means a maximum load of 70 tons was handled, or 55 tons on a 15–ton car. . . .
>
> Owing to the time involved in making the trip between Camp 42 and the power house, an auxiliary 200–H.P. hoist was located at the intermediate storage yard at Camp 32. This hoist handled the penstock pipe and the concrete materials for the penstock anchorages and the power house. The aggregates for the concrete were produced by a crushing plant adjacent to the incline [Redinger 1924:(11)].

Construction of Powerhouse No. 8

Once the access road and incline railroad were built, work on the powerhouse itself could begin. Since Powerhouse No. 8 was to be located on the bank and directly in the bed of the creek, it was necessary to divert the flow of Big Creek before excavating for the powerhouse foundation. An 8–x–8–foot diversion tunnel was driven through a short ridge on the north side of the creek, about 500 feet above the powerhouse site, diverting Big Creek's flow directly into the San Joaquin River. This 511–foot–long tunnel was begun on December 20, 1920, completed on January 27, 1921, and the diversion of Big Creek water began on February 5, 1921.

It took a great amount of labor to build a foundation for Powerhouse No. 8 at this location. Work began in early January, 1921, with a crew laboring on the bank with picks and shovels. Hydraulic sluicing was begun in early February. This operation—by making use of a monitor with a three–inch nozzle and water from a storage tank erected on the ridge above the powerhouse—blasted large amounts of surface dirt and loose rocks off the site. In mid–February, a Marion No. 2 oil–burning, revolving steam shovel was brought in to strip away the rocks loosened by blasting and jackhammers. Muck was removed by Western 6–yard side–dump cars operating on a standard gauge railroad track, which in turn was run by a compressed air–operated hoist and cableway. As lower levels were reached, the rock became harder and the size of rocks to be moved larger, so a Marion No. 40 oil–burning steam shovel was brought in to expedite the work. Finally, by late April, the excavation was completed (Redinger 1924:[12–13]).

Construction of the powerhouse began immediately upon completion of excavation, and the first concrete was poured on May 12, 1921. From this point on, work continued day and night—a rush to completion. David H. Redinger described the building of Powerhouse No. 8 as follows:

> The aggregate for the concrete was produced from the hard, gray-granite tunnel muck procured from Camp 32. The output of the crushing and screening plant was delivered into storage bins, located on Incline No. 8, from which the material could be loaded directly into the incline cars. These, in turn, carried the material right into the storage bins at the powerhouse. An electric hoist was used to elevate the concrete in a tower which, together with a mixing plant, was situated on the steep hillside immediately back of the power house. A large portion of the concrete was placed from this tower by chutes, and the balance was delivered by buggies to all parts of the building [Redinger 1924:(13)].

Plate 29 shows Powerhouse No. 8 under construction.

When completed, Powerhouse No. 8 consisted of two structures: the lower (or generator) building, housing the turbine-generator set, switchboard, and other equipment; and the upper (or transformer) building, which housed the transformers and switching apparatus. Again, Redinger described the building and its equipment:

> The floor of the generator building is at Elevation 2,250. From that point on down, the building is of reinforced concrete, while the superstructure is a combination of structural steel and reinforced concrete. The transformer building is of structural steel and reinforced concrete throughout. The generator building is made up of 3,015 cubic yards of concrete and the transformer building of 1,460 cubic yards—making a total for the power house of 4,475 cubic yards, all of which was placed from May 12 to September 1, 1921. On June 20, 1921, as soon as the foundation had progressed far enough, the installation of the turbine was commenced. This unit is a 30,000-H.P., single-runner, vertical turbine of the improved Francis-Pelton type, made by the I.P. Morris Company, and is designed to operate at 428 revolutions per minute under a 680-foot effective head. . . . The generator—a 22,500 kilowatt machine manufactured by the General Electric Company—is direct connected to the shaft of the turbine. It is 17 1/2 feet in diameter and 12 1/4 feet in height from the floor to the base of the upper or thrust bearing. The exciter is located above the generator on top of the main shaft [Redinger 1924:(13-14)].

Plate 30 shows this generator in early 1922. Due to load limitations of Incline No. 8 and the size of the generator, it had to be shipped in pieces and assembled at the powerhouse (Redinger 1949:84-85).

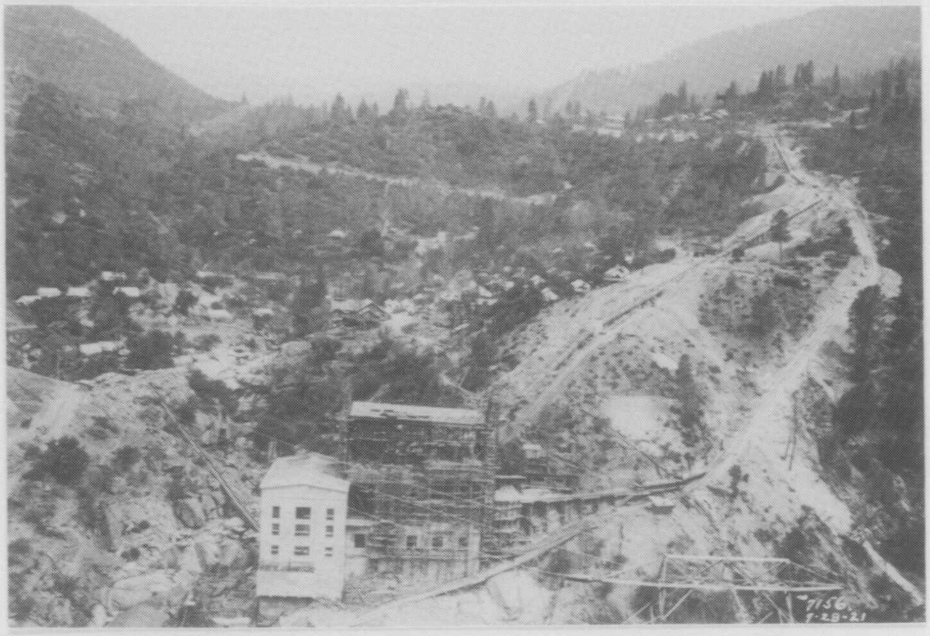


Plate 29 Powerhouse No. 8 under construction in 1921 (SCE var. [b]:Album 2, No. 25–7156).

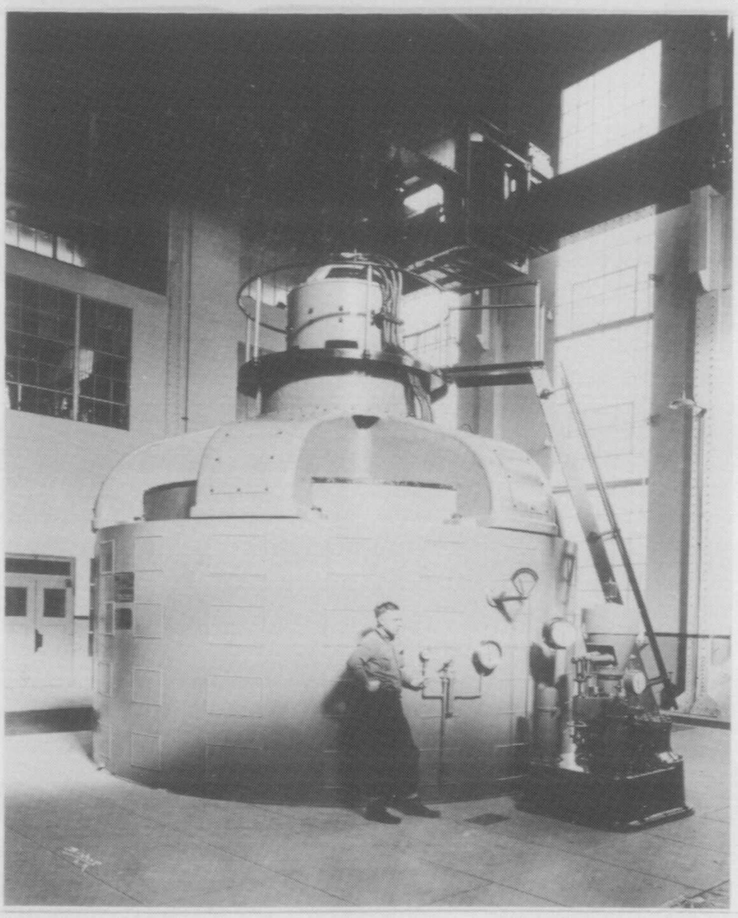


Plate 30 Unit 1 Generator, Powerhouse No. 8, January 1922 (SCE var. [b]:Album 2, 45–7439).

Penstock, Surge Chamber, and Transmission Line

During foundation excavation and construction of the powerhouse, work was also going forward on remaining elements of the Powerhouse No. 8 system: the penstock, surge chamber, and transmission line. The first of these was the penstock excavation in mid-March, 1921. Varied techniques (including blasting, drilling with jackhammers, hand labor, Bagley and Fresno scrapers, and a steam shovel) were required to cut the trench needed to hold Powerhouse No. 8's penstock. Concrete was poured for penstock footings in late May, and by early June sections of pipe were being rolled into place from the incline railroad. By late June all pipe was in the trench and riveting could begin. Redinger provides the following additional details about this penstock:

> Measured on the slope from the surge chamber to the Johnson valve at the power house, Penstock No. 8 has a length of 2,713 feet. The static head on the penstock varies from 47 feet at the upper end to 715 feet at the power house. To take care of this difference in head, the pipe at the surge tank is made of 3/8-inch plate and is 8 feet in diameter, while at the power-house end it has decreased to 6 feet in diameter and is 1 1/8 inches in thickness. The upper 506 feet of piping is riveted, and the remaining 2,207 feet is lap welded. There are five vertical and horizontal angle joints in the length of the penstock, and each of these angles is held in place by large reinforced-concrete anchors. Between these anchors the pipe is supported on concrete saddles spaced approximately 20 feet between centers. A layer of 2-ply roofing paper has been placed between the piping and the concrete so that the former is free to move on the saddles. Expansion joints are located about half way between each set of anchors to provide for any movement in the pipe due to temperature changes. Penstock No. 8 is not back filled. A 72-inch Johnson valve at the lower end of the penstock controls the flow to the turbine [Redinger 1924:(12)].

Due to the need to protect the penstock pipe against possible rupture resulting from sudden surges of water under high pressure, a steel surge tank 35 feet in diameter and 90 feet high was installed at the outlet of Tunnel No. 8. Redinger provides further details about this surge chamber:

> The surge tank has trash racks and 3 penstock outlets: one, 8 feet in diameter, is utilized for the present unit, while the two others, each 10 feet in diameter, are provided for future units. The officials of the Southern California Edison Company are of the opinion that the progress made in designing turbines and generators may warrant them in installing at some future day units of greater capacity than the initial one.
>
> There is an 8-foot gate valve between the surge tank and the present penstock that is electrically operated from the power house through remote-control apparatus; and a 36-inch diameter standpipe on the penstock below this gate provides an air vent. The surge tank is set on a concrete foundation, and has a 24-inch drain valve in the bottom. Owing to delay in the delivery of structural steel, this tank was not completed until several months after Plant No. 8 was put in service. In

the interval, the power house was operated as a flow line instead of under pressure, with an accompanying loss of head of practically 50 feet [Redinger 1924:(11)].

Finally, a transmission line was constructed to tie Powerhouse No. 8 into the main transmission line at Powerhouse No. 2. The 27 transmission towers and lines needed to make this connection were erected in June and July of 1921 (Redinger 1924:[14]).

The 90–Day Wonder Goes On Line

On August 10, 1921—just 90 days after pouring the first concrete at Powerhouse No. 8—water was allowed to flow from Dam No. 5 into Tunnel No. 8, through the penstock and the turbine, turning over the giant generator unit for the first time. A record for this kind of construction, this accomplishment was a monument to the thousands of men who worked on the job—from managers at the top of the Edison hierarchy down to engineers, equipment operators, and workmen.

Electrical World described the completed hydraulic and electrical system of Powerhouse No. 8 as follows:

> At the lower end the penstock is 6 ft. (4.8 m.) in diameter and connects to a Johnson valve having an intake diameter of 6 ft. and a discharge diameter of 4 ft. 6 in. (1.4 m.). This valve is connected to the turbine casing through a cast–steel pipe containing a Y–connection for a relief valve. The relief–valve disk is mechanically connected through a piston rod, heavy link, lever and reach rod to the operating ring of the turbine gates. The turbine, which was built by the I. P. Morris Department of the William Cramp & Sons Ship & Engine Building Company, is designed to develop 30,000 hp. under a 680–ft. (207–m.) head at a speed of 428 r.p.m. It is of the vertical–shaft, single–runner type. The runner is of bronze and is made entirely in one part, including the labyrinth seals. Special guide vanes of the Overn disk type are provided in order to reduce leakage. The draft tube is of the Moody spreading type. The intermediate section of the tube immediately below the runners is made removable in order that the runner may be replaced from below.
>
> The governor is of the I. P. Morris double floating–lever type furnished with an automatic device known as the Taylor control system. By the use of this system a movement of one hand lever permits a change–over from governor to hand control and thus avoids all danger of a runaway or difficulties due to loss of control of the unit during the change.
>
> The generator was manufactured by the General Electric Company and generates 11,000 volts. A direct–connected exciter is provided on the upper end of the generator shaft. Between the generator and transformer is connected an oil switch which is to be used primarily for synchronizing, particularly when the later units are installed. A bypass connection is provided around the switch so that it may be worked upon without taking the generator out of service. There is no low–tension bus.

> Auxiliary electric power for the station lights and for the motors on the auxiliaries is provided from a separate 187-kw., 220-volt generator driven by an impulse-type turbine. This generator has a direct-connected exciter. In addition to this generator a source of auxiliary power is provided in a 6,600-volt circuit from the Big Creek No. 2 station, which is but 2 miles (3.2 km.) distant. A second unit similar to the above noted 187-kw. unit is to be installed in the near future.
>
> The connections from the generator to the low-tension switch and from this to the transformers are made of rectangular copper bars rigidly braced every few feet to hold them in position against the stresses produced by severe short-circuit currents.
>
> The transformers, which are of General Electric manufacture, are rated at 8,233 kva., 220,000 volts, and involve several new features of construction. The fact that they are to be connected without resistance to a permanently grounded system made possible the attachment of the line terminal to the middle of the coil stack and the attachment of the neutral to the top and bottom of the coil stack [Electrical World, December 3, 1921:1117].

The location of much of this equipment is illustrated by a cutaway diagram of the powerhouse (Figure 1).

Penstock Problems

Perhaps due to delay in completion of the surge tank for Powerhouse No. 8, the penstock for this plant suddenly ruptured early on the morning of August 20, 1921—only ten days after going on line. The break was near the powerhouse building and the water caused extensive damage. David H. Redinger later recounted the accident:

> The tear in the huge pipe occurred in such a way as to direct the water, rushing out under full pressure, against the east side of the generator room, where a temporary covering of corrugated iron had been placed, with an eye to future extension of the building. Such a cover served as no barrier for the water, which tore through it as though the wall were tissue paper, and into the generator room and transformer bay, carrying with it timbers, concrete and debris. The 150,000 volt leads were grounded, and about five hundred feet of penstock at the upper end collapsed. With all hands working around the clock we were able to have service restored on September 13 [Redinger 1949:86].

This was not the last problem Edison had with the penstock for Powerhouse No. 8. A second failure occurred on New Year's Day, 1924, when water rushing down the steep hillside crashed into a cottage, killing an employee's wife and her sister. Repairs to the penstock were completed and service was restored on January 15. In 1924 and 1925 the penstock pipe was reinforced with steel bands and lap-welded to prevent future breaks (Redinger 1949:88).

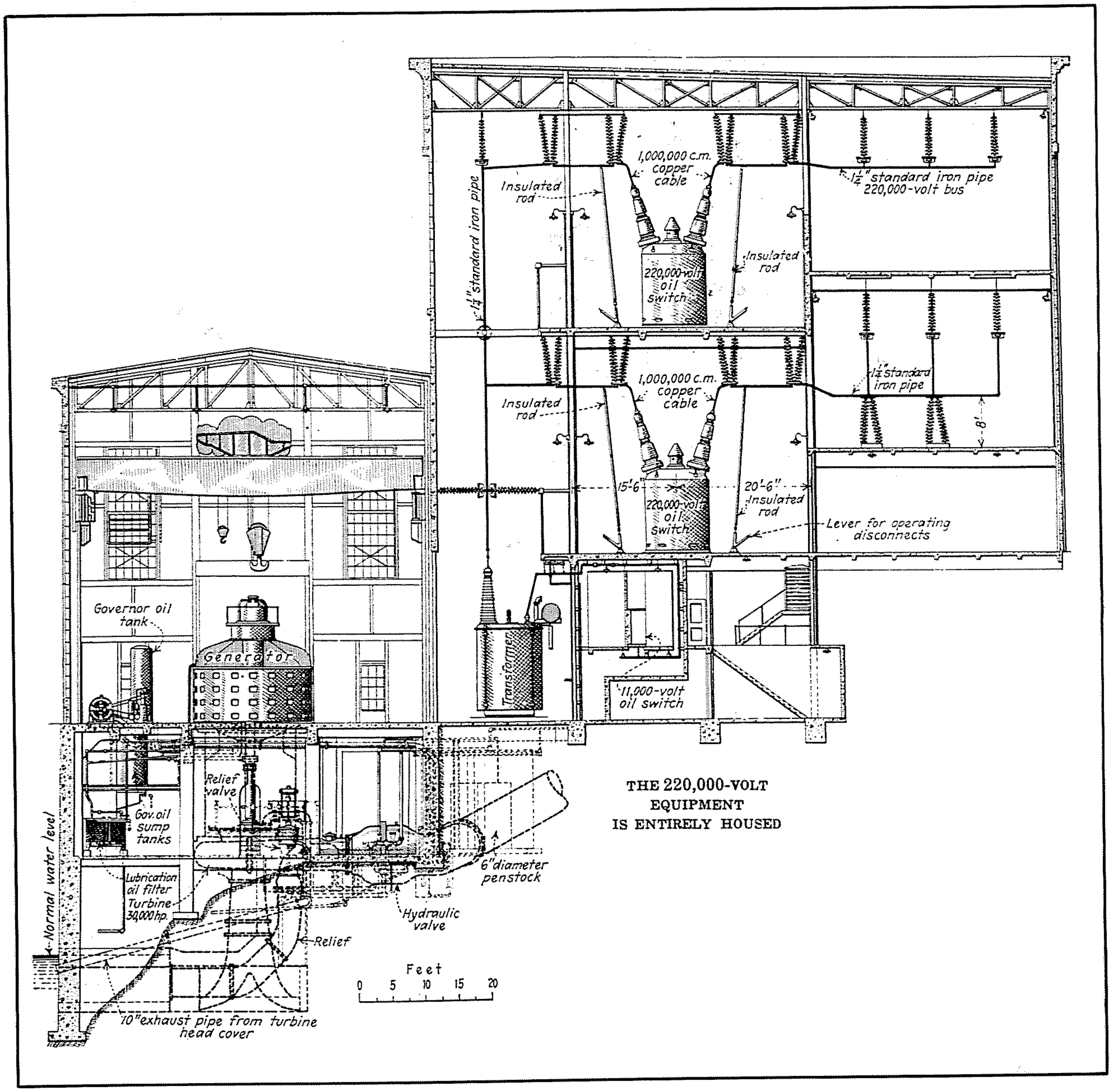


Figure 1 Cross-section of Powerhouse No. 8, illustrating placement of penstocks, turbine, and generator (left center) (Electrical World 1921:1117).

Electric Giant of the West: Powerhouse No. 3

Immediately following completion of Powerhouse No. 8 in August 1921, work was begun on an even larger hydroelectric plant to be located about seven miles downstream from No. 8. Named Powerhouse No. 3, this plant was so large that it was also known as "the electric giant of the west." When put in operation in September–October 1923, this facility had a capacity of 105,000 horsepower and was the most powerful hydroelectric plant in the western United States.

The Million Dollar Mile and Incline No. 3

Another massive construction project was to build a road and incline railroad to the powerhouse site. The road especially was a difficult project because the only place to build it was down a canyon which had an average slope of 45 degrees, and a nearly sheer drop–off in many places (Plate 31). Jackhammers, dynamite, and a Marion No. 40 steam shovel operated by compressed air were also used on this difficult project. After December 1, 1921, work was conducted from both ends of the road, and Camp No. 39 was set up at Hairpin on the San Joaquin and Eastern Railroad to facilitate work at the downstream end. As the road reached the sites selected for tunnel adits, camps were also established at these locations. Camp No. 34 at Adit No. 1 was set up in late October 1921, and Camp No. 35 at Adit No. 2 in mid–March 1922. Camp No. 36 at Adit No. 3 and Camp No. 37 (consisting of two locations, one exclusively for families) at the tunnel outlet were established in March and April of 1922 (Redinger 1924:[18]). A branch road about one and one–half miles long connected Camp No. 38 (at the site of Powerhouse No. 3) with the main road. Camp No. 39A was located near the junction of these roads (Map 7).

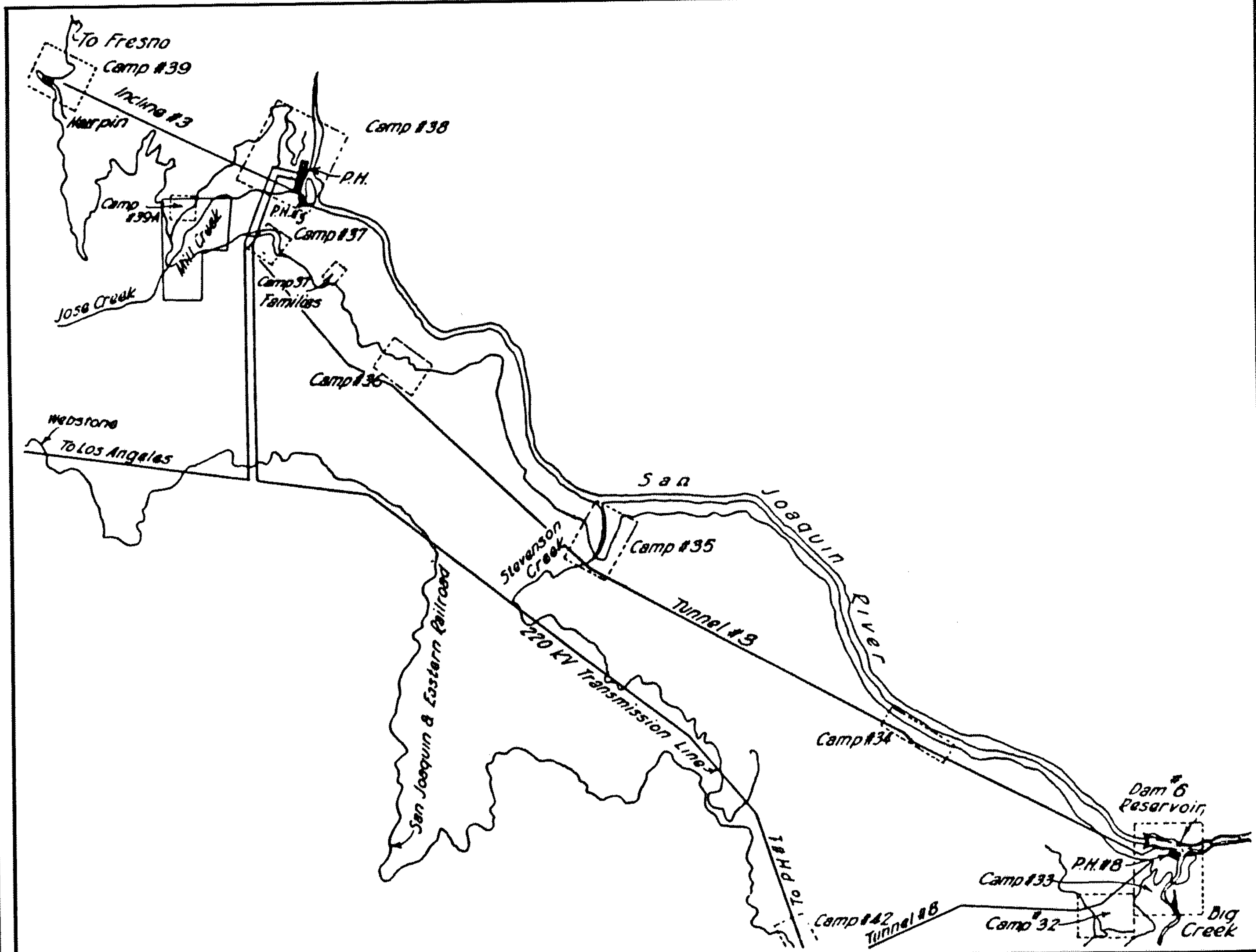
While the road to Powerhouse No. 3 is called "The Million Dollar Mile," the maximum cost of the most difficult portions of the road was actually $200,000 a mile—still an expensive piece of construction (Edison Facts, 1923b:[2]). The *Fresno Morning Republican* described the road as "one of the most expensive . . . ever built in the high Sierras" (June 18, 1922:10). Since the road was eleven miles long, plus an additional one and one–half miles to the powerhouse, its total cost was quite a substantial sum.

While work on the road was underway, a 7200–foot–long incline railroad was constructed from Camp No. 39 at Hairpin to the powerhouse site. This railroad conveyed the materials and supplies needed to build the powerhouse and Camp No. 38; later, it also facilitated installation of the penstocks (Bergh 1956b:144). When installed, this incline reportedly had the longest continuous cable in the world—three miles without a single splice (Edison Facts, 1923b:[2]).

Tunnel No. 3

As was usually the case for the Big Creek project as a whole, the tunnel drilling needed to bring water to Powerhouse No. 3 took longer than development of any other feature. Even so, this time was shortened considerably by driving three short adits—a procedure allowing Tunnel No. 3 to be drilled and blasted from eight headings (that is, from each end and both ways from each of the three adits). The bench–and–heading method of driving was employed at all headings. A new

Plate 31 Crew working on the Million Dollar Mile, January 1922 (SCE var. [a]:Album 5, No. 7433).



MAP 7 -P.H. 3 ENGINEERING FEATURES- (Redinger 1924)

Ingersoll–Rand drill, the Model X–70, was used extensively to drill holes for blasting. Gelatine dynamite was employed to blast the hard gray granite rock. Very little of this rock had to be timbered. The muck from blasting was loaded by Marion steam shovels, operated by compressed air and using 16–foot booms and 11–foot dipper sticks to maneuver effectively within the 21–x–21–foot tunnel. Each tunnel camp had a large compressor plant to provide air for this machinery. Two types of ventilating apparatus were used in Tunnel No. 3, Root blowers and American fans (Redinger 1924:[19]). When completed in early August 1923, the 23,313–foot tunnel could carry 3000 cubic feet of water per second.

Dam No. 6

To divert water into Tunnel No. 3, a dam was needed below Powerhouse No. 8. The search for a suitable dam site began as early as January 1921, when diamond drillers were already taking core samples to find the right rock formation. This work involved erecting a platform over the river and running a diamond drill rig directly over the stream bed.

When a site was selected, a large–capacity timber bypass flume was constructed to carry the San Joaquin River water around the site. This flume was 530 feet long, 28 feet wide, and 15 feet deep at the intake end. Once the river bed was empty, three Marion shovels operated by compressed air were used to excavate the site. Thirteen pumps of two types were used to handle water seepage. Excavation was completed in mid–November 1922, when the erection of concrete forms began. Rock–crushing and concrete–mixing plants were set up to provide the materials needed for this dam. David H. Redinger later described the process of concrete mixing and placement:

> The concrete mixing plant was composed of one 2–cubic–yard mixer and one 1–cubic–yard mixer put up between the storage bins and the dam. A belt conveyer carried the sand and rock from the bottom of the storage bins to this plant, and the mixers discharged the concrete into skips which lifted and delivered it into 1–cubic–yard, bottom–dump cars on top of a trestle paralleling the dam. Electric locomotives pulled trains of these cars to distributing points from which the concrete was placed wherever desired by means of chutes. Owing to the fact that the low–water period of the river extends from around August 1 to February 1, it was necessary to hasten the construction of the dam in that interval to a point where it would be well above any likely damage by floor water. The entire concrete plant was, therefore, planned with this in mind; and it had a capacity of 400 cubic yards per 8–hour shift.
>
> The placing of concrete was commenced on November 20; and by December 6 the portion of the dam west of the by–pass flume was poured up to Elevation 2,162, that is, 4 feet above the top of the by–pass flume. The rectangular sluice gates in this section were concreted; and in addition to the four 7x7–foot gates three 8x12–foot temporary openings were left to divert the flow of the river while the foundation for the dam under the by–pass flume was being excavated and concrete poured up to a safe elevation above the river channel. Concreting was stopped on December 6, and the flow of the river was then carried through the sluice gates and the temporary openings. The by–pass flume was next removed so that that part of the dam site could be excavated. This work was finished on December 27, when the pouring of concrete was resumed.

> The placing of concrete on this job was completed on February 28, 1923, except for the closing of the temporary openings in the dam [Redinger 1924:(16)].

The completed arch dam was 495 feet long and 150 feet high (SCE 1967a:9).

The construction of the concrete and steel intake structure to control the flow of water into Tunnel No. 3 was begun in early January, 1923, and completed in mid-March. It consisted of a circular concrete tower-like building which housed a 50-ton gate operated by an electric motor and fitted with a gasoline engine for emergency operation (Redinger 1924:[17]). Plate 32 portrays Dam No. 6 while under construction, shortly after work on the intake structure had begun. Powerhouse No. 8, Camp No. 33, and Incline No. 8 also appear in this photograph.

Construction of Powerhouse No. 3

Excavation for Powerhouse No. 3 began in early June, 1922, and continued for over six months. Fully 70,000 cubic yards of rocks and earth had to be moved to create the space needed for the foundation of this mammoth building. Camp No. 37 can be seen at the top of the ridge. The building on the left was a camera house, used to take photographs as the construction work progressed. By early July, a steam shovel had been brought to the site, and soon thereafter a small line of railroad track was set up to help clear the area. A hydraulic monitor was also used to sluice away some loose material. Concrete pouring for the foundation began in January 1923. Plate 33 illustrates the powerhouse building in progress in mid-April 1923, by which time much of the penstock had been excavated (at least some of it blasted), and some steel superstructure of the powerhouse building was in place. Plate 34 indicates progress a few months later (note that the transformers are already installed); Camp No. 38 is seen on the right hand side of this photograph. The powerhouse was completed by August, and equipment installation was begun. Plate 35 views the interior of the completed plant with its three generators, which were connected to three reaction-type water turbines. Plate 36 shows the operating room and instruments.

Work on the various features needed to bring water from Tunnel No. 3 to the powerhouse was conducted simultaneously with final-stage work on all other aspects of the Powerhouse No. 3 system. There were four prominent features between the end of Tunnel No. 3 and the powerhouse vicinity: a surge chamber, a manifold structure, three penstock pipes, and a switchyard (Plate 37). The surge chamber was located near the outlet of Tunnel No. 3, and its function was to act as a cushion for the water column in the penstock, preventing rupture by giving the column somewhere to go in case of a sudden shutdown of the machines in the powerhouse. This surge chamber was unusual in that it was hollowed out of solid rock in the shape of a giant hourglass over 200 feet high and from 26 to 78 feet in diameter.

Just downstream, in the tunnel from the surge chamber, a 309-foot section of 18-foot-diameter riveted pipe was installed to provide a transition between the tunnel section and a manifold structure which, in turn, was connected to the penstocks. As Redinger described it:

Plate 32 Powerhouse No. 8 and construction of Dam No. 6, January 1923 (SCE var. [b]:Album 3, No. 10–8299).

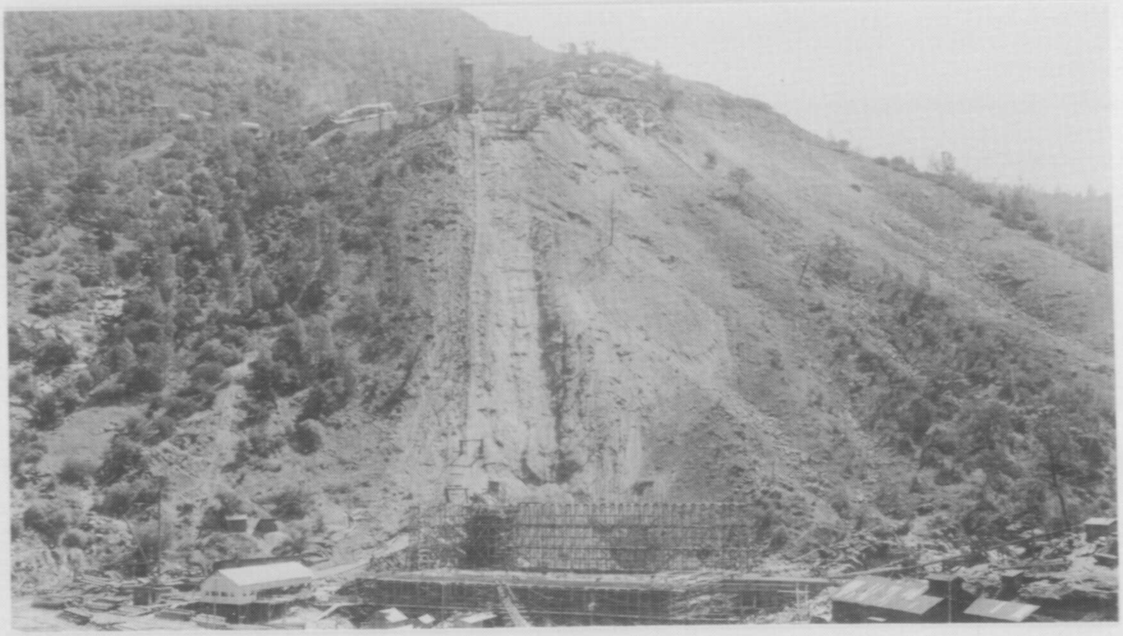


Plate 33 Powerhouse No. 3 under construction, April 1923 (SCE var. [a]:Album 3, No. 8590).

Plate 34 Powerhouse No. 3 under construction, 1923 (SCE var. [a]:Album 2, No. 8974).

Plate 35 Generators and Turbines in Powerhouse No. 3, ca. 1923 (SCE var. [a]:Album 4, No. 12098).

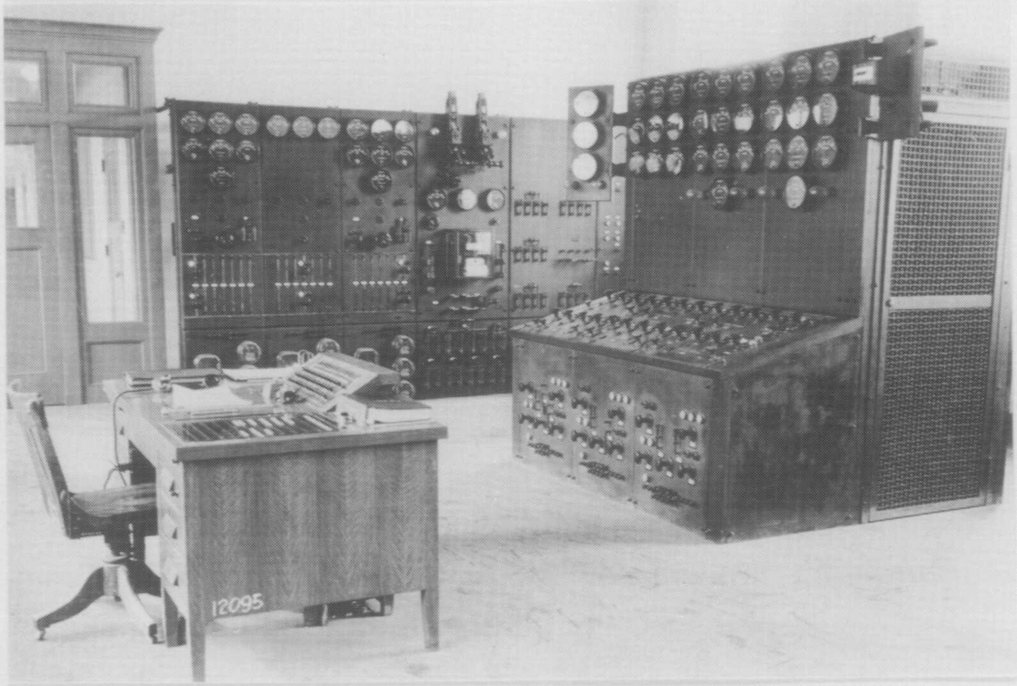


Plate 36 Operating room, Powerhouse No. 3, 1924 (SCE var. [b]:Album 3, No. 73–12095).

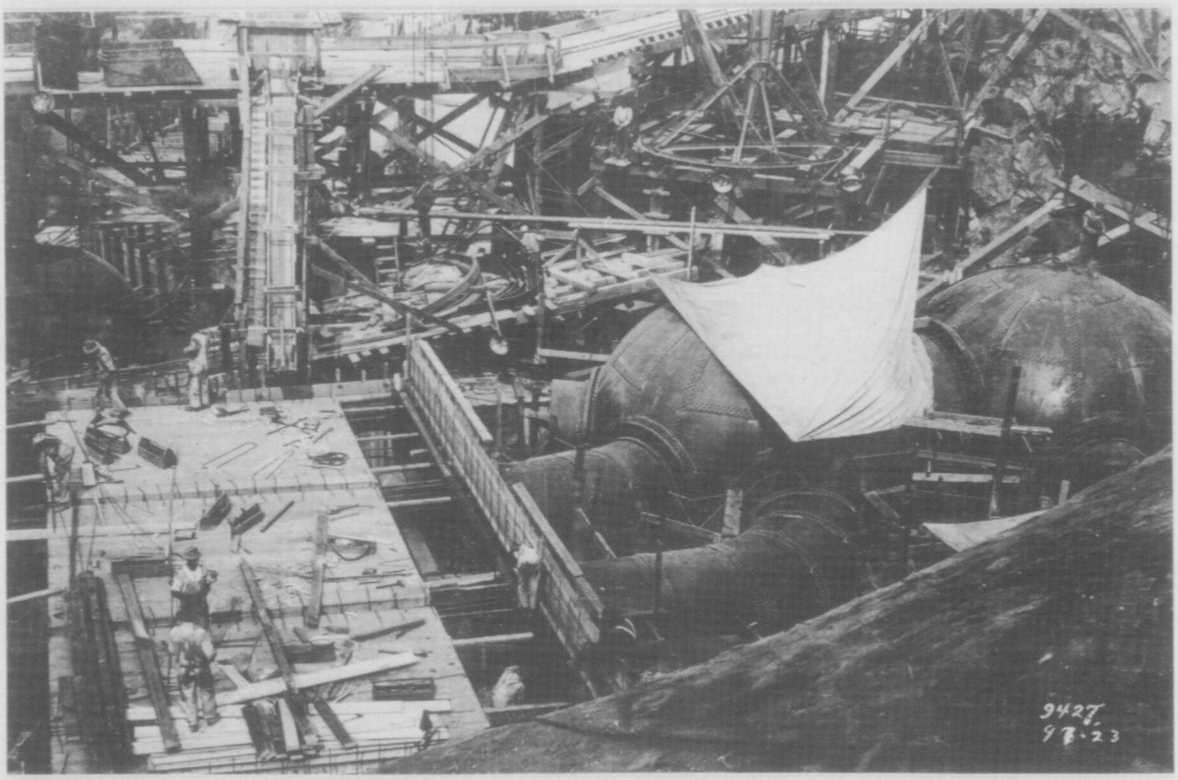


Plate 37 Installing the manifold at Powerhouse No. 3, 1923 (SCE var. [a]:Unnumbered Album, No. 9427).

> This manifold was required to form a "transition" from the 18-foot pipe to the six 7-foot 6-inch penstocks. On account of the large diameter and the high head at this point it was not found practicable to pattern a manifold on lines similar to those of the ordinary branch fitting. Such a fitting, under the existing head of 160 feet and the diameter of 18 feet, would have involved unbalanced stresses around the outlets to the penstocks that would have been virtually impossible to take care of satisfactorily. In consequence, a radical departure was necessary; and, as a result, a manifold was adopted consisting of two 24-foot-diameter, plate-steel spheres. These two spheres are connected by a short section of 15-foot piping: one sphere having outlets for four penstocks, the other for two penstocks. The advantage of the spherical design is that the only force to be provided against is a simple hoop tension around the outlets. This force is overcome in a very simple manner by reinforcing rings placed on the outside of the pipes. The entire structure is made of riveted steel plating; and as it was wholly assembled in the shop before shipment it was erected in the shortest practicable time and with a minimum of trouble. In the bottom of the sphere that connects with the 18-foot pipe there is provided a 24-inch drain for the purpose of cleaning out any sand or sediment that might accumulate there, while a 4-inch air vent in the top of each of the two spheres terminates in a pipe that leads up to the top of the main air vents, which are attached to each penstock a short distance below the manifold [Redinger 1924:(22)].

A final step in the long road to a functioning powerhouse was installation of the three penstock lines and a switchyard. Each penstock began at the top with a 90-inch diameter; this was gradually reduced to 54 inches at the entrance to the powerhouse. The thickness of the steel plating varied from only one-half inch at the top to one and one-fourth inches at the powerhouse. These penstock lines were installed in the summer of 1923 by use of an incline railroad and cables. Finally, a switchyard, which was connected to the main transmission line running from Powerhouse No. 1 to Los Angeles, was constructed just west of the powerhouse.

When it went into operation in October 1923, the Big Creek Powerhouse No. 3 system consisted of a large concrete powerhouse, 80 feet by 205 feet, and a 220-kilovolt outdoor switchyard. Within the powerhouse stood three vertical-type Francis reaction water turbines built by the Wellman-Seaver-Morgan Company, with three Westinghouse 28,000 kva. generators connected above each turbine. Each turbine was equipped with Woodward governors and operated at a speed of 428 revolutions per minute under an effective head of 740 feet. The generators had exciters directly connected to the top of these machines. Power was generated at 11,000 volts and stepped up to 220,000 volts through seven 18,500-volt Westinghouse transformers located on a large platform just outside the building (Edison Facts 1923b:[2-3]; Redinger 1924:[23]).

When completed, Powerhouse No. 3 transmitted power at 220,000 volts--the first powerhouse in the world to begin power transmission at that voltage. The entire Big Creek transmission line had actually begun transmitting at that voltage in May of 1923 (Edison Facts 1923a:[1]).

A sad and unfortunate accident which took place at Powerhouse No. 3 a few months after it began operating illustrates the almost incredible power of water under high pressure, as well as the dangers which sometimes faced the workers at Big Creek. David H. Redinger later described this accident:

> Two men were working on the plunger valve inside the No. 3 penstock, a short distance above the turbine. For some cause unknown to this day, the butterfly valve at the top of the penstock opened, letting in a full head of water. One man was literally blown out the man–hole, unhurt, onto the turbine floor, but the other was forced through the eight inch relief valve opening. The geyser from the penstock man–hole tore through the powerhouse roof about one hundred feet overhead, and attracted the attention of the crew of a passing train on the San Joaquin & Eastern, several miles above [Redinger 1949:97–98].

This chapter has offered a detailed description of large–scale construction work from 1919 to 1923 in the lower elevations of the Big Creek–San Joaquin River region. While these efforts were going forward in the lowlands, at the higher elevations another grand–scale construction saga was taking place during the same period: a gigantic water–diversion project designed to deflect part of the flow of the San Joaquin River into the Big Creek System. This—the epic story of the Florence Tunnel/Florence Dam project—constitutes the next focus of this study.

CHAPTER 5

THE GREAT EXPANSION, PHASE TWO: 1920–1927

At the same time as Powerhouse No. 8 and Powerhouse No. 3 were being built, another massive construction project was put in motion in the higher mountains northeast of Huntington Lake. This project had the ultimate aim of supplying the large quantities of water needed for continued expansion of the Big Creek System. Called the Florence Lake Dam and Tunnel project, it involved diverting water into Huntington Lake and thence into the series of powerhouses developed below. This diversion of the South Fork of the San Joaquin was one of the greatest engineering and construction epics of the first third of the twentieth century. Operating year after year in the high country, up to two thousand men drilled, blasted, and cleaned out the longest water tunnel the world had ever seen--a little over 13 miles in length. They built a massive multi-arch dam to create the reservoir needed both for diversion purposes and to store water for dry months, and diverted two nearby creeks into the long tunnel as well. In many ways, Florence Lake Dam and Tunnel constituted the centerpiece of the entire Big Creek complex, for it supplied a high percentage of the water which was the life blood of this Hydroelectric System.

Problems and Plans

The key problem facing Edison during the 1920s was how to get additional water into the Big Creek System. Although located in the high Sierra, the Big Creek area lay in the southern part of that mountain chain where rainfall--and therefore available water--was less abundant than farther north. An additional limitation was the Huntington Lake watershed, which drained only about 80 square miles of this part of the Sierra (SCE 1925b:12). At the same time, full expansion of existing powerhouses required more water than was available in Huntington Lake basin.

Edison planners had long been concerned with this problem and were searching for answers. Their ultimate solution was found in early plans of John Eastwood who, even in 1902, had his eye on waters of the southern fork of the San Joaquin River, over Kaiser Ridge from Big Creek Basin. Eastwood's 1902 survey included running a line over Kaiser Pass to determine the length of tunnel needed to bring in water from the South Fork (Redinger 1949:7).

In 1917 Edison followed up on Eastwood's work, sending one of its employees into the high country east of Huntington Lake to measure water flows and locate dam sites (Sohier 1918:1). On one of these trips, a dam site was located near a small natural lake, called Florence Lake, at an elevation of about 7200 feet. Since Huntington Lake was just under 7000 feet in elevation, it was readily apparent that a tunnel could be built from Florence to Huntington, diverting water from the South Fork San Joaquin River into the Big Creek System and more than doubling the drainage area available to that System (SCE 1925b:12).

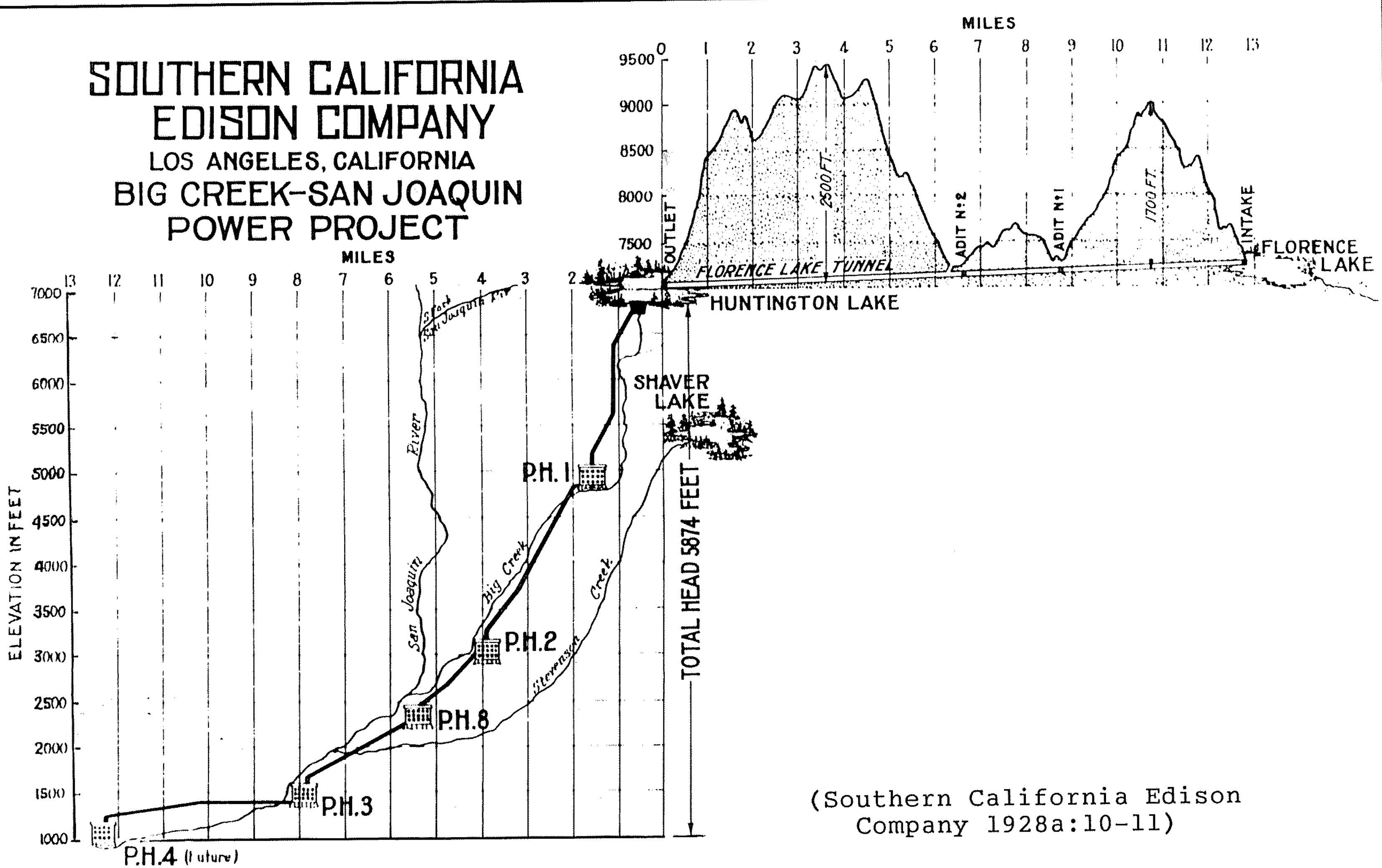
Once the determination was made to go forward with this plan, several key problems still faced Edison planners. Of paramount concern was the fact that

Kaiser Ridge—a mountain of granite rock over 9000 feet in height—stood between Huntington and Florence lakes. The direct route through this ridge was 10 and 3/4 miles long. Due to the height of Kaiser Ridge (about 2500 feet higher than the tunnel line), following a direct route would allow tunnel work to proceed only from the intake and outlet ends, providing only two work faces. It would be impractical to drill the 2500-foot shaft necessary to provide another two faces, but to drill a 10-and-3/4-mile tunnel from only two faces or headings would take several years longer than if other points of entry to the tunnel line could be established. Additional surveys were conducted, and it was found that by angling the tunnel line in a northwesterly direction before turning south, two additional points of entry could be engineered. Since this would save about two years in tunneling time, it was decided to bore the longer route—just over 13 miles in length (Map 8). This construction effort would create the longest water tunnel in the world and one of the longest tunnels of any type ever constructed.

Despite resolution of this difficulty, further problems immediately presented themselves. The main concern involved how to gain access to the high country's rough terrain and keep routes of supply and communication open during winter, when ten or more feet of snow lay on the ground. The area was normally snow free for only about five months of the year, and tremendous volumes of equipment and supplies would be required to drill the long tunnel. Due to these conditions and the area's extremely rough terrain, the idea of constructing a road was a daunting one. For a time, the use of airplanes to haul men and supplies was considered, but this idea was finally rejected in favor of a road (Bergh 1956a:215; Redinger 1924:[25]).

Initial Infrastructure Development, 1920–1921

The basic planning stage was complete by the summer of 1920, and work could begin. Camp No. 60, established at the outlet portal at the eastern end of Huntington Lake, became base camp for the road-building effort of that summer. The connecting road between Camp No. 60 and Camp No. 61 was blasted and graded using a donkey engine, mules, and Fresno scrapers, with the road crew staying at five temporary camps (numbers 61A–61E) along the road (Redinger 1924:[25], 1949:99–100). After several months' work, the road was completed and supplies for the winter of 1920–1921 could be trucked into a newly established Camp No. 61. At an elevation of about 7000 feet, Camp No. 61 was the main camp in the high country beyond Kaiser Pass and also a center for tunneling operations. Both Camp No. 60 and Camp No. 61 were permanent living quarters for 500 men, with "double decker" buildings capable of housing 16 men. These buildings were storm proof and heated with wood stoves (SCE 1923b:4). In order to provide power for the camp and for construction efforts, a 30,000-volt transmission line was run from Powerhouse No. 1 to Camp No. 61. The transformers and other electrical equipment needed to provide electrical service to Camp No. 61 had to be transported up the railroad incline above Powerhouse No. 1, conveyed by boat across Huntington Lake, and finally hauled by truck over Kaiser Pass (Plate 38). Since a telephone line was considered too uncertain and too expensive to maintain due to the severe winters, radio communication was used to keep the camps in touch with the outside world (Plate 39) (Redinger 1924:[29]). Infrastructure development also included upgrading one of the temporary road construction camps (Camp No. 61C on the northern side of Kaiser Pass) into an emergency shelter. Here, a log cabin was built which was large



(Southern California Edison Company 1928a:10-11)

MAP 8 -BIG CREEK CROSS SECTION 1928-

Plate 38 Transformers on Huntington Lake en route to Camp 61, 1920 (SCE var. [a]:Album 2, unnumbered).

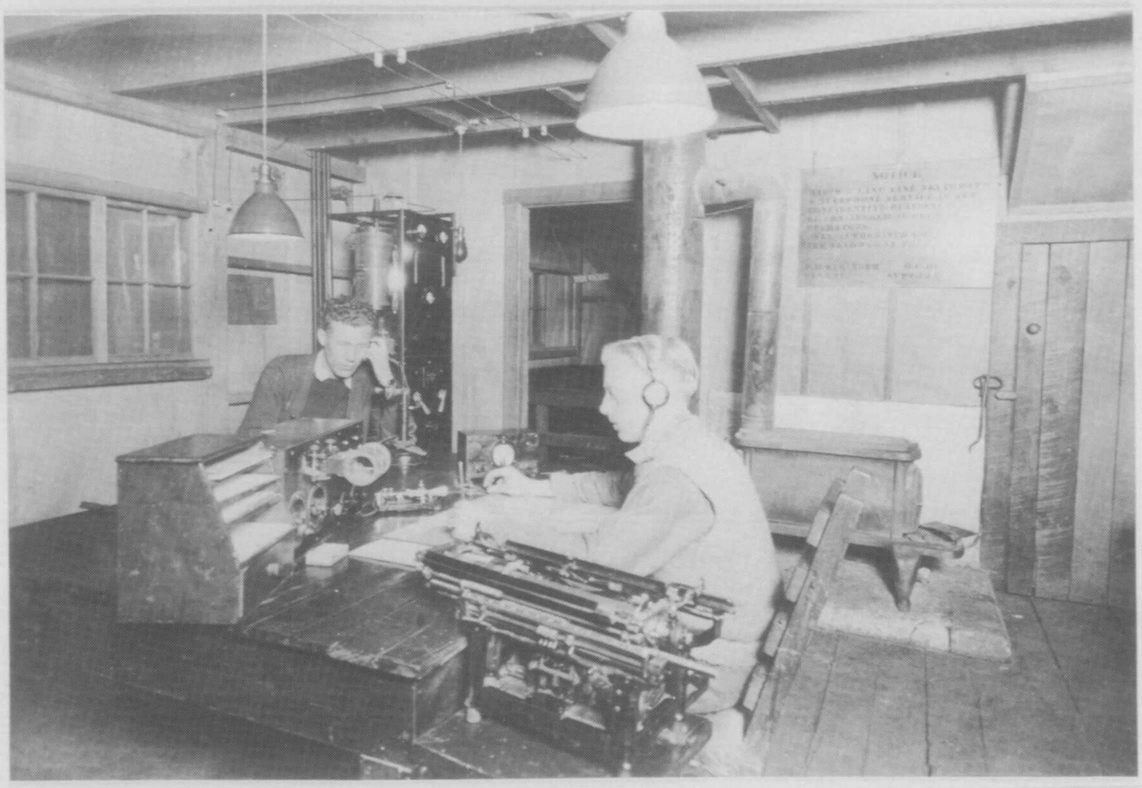


Plate 39 Radio Communication Office, ca. 1922 (SCE var. [a]:Album 5, No. 12441).

enough to provide temporary shelter for several men if they had to stay overnight while traveling between camp nos. 60 and 61. A cook was stationed at Camp No. 61C to prepare meals for these travelers (Redinger 1949:101).

Once road access was secure and communication arranged, there remained the task of supplying camp nos. 61 and 61C for the winter to come. Trucks were used to haul vast quantities of supplies into Camp No. 61—enough to support hundreds of men for the approximate six months when snow would block Kaiser Pass road (Redinger 1949:101–102). Just before Christmas, a snowstorm closed the road. Edison officials were then faced with the problem of delivering mail and small amounts of supplies (medicine especially) to the isolated camp. This problem was solved by employing a driver and dog team from Alaska.

For the next few years, Jerry Dwyer and his seven dogs became a legend in the high country east of Huntington Lake. Normally, the team would make the trip from Camp No. 60 to Camp No. 61 in one day and return the next. Dwyer, a "closely knit figure . . . as silent as the Great White North from whence he came," cared for his dogs as if they were his children, and mourned each of the three who died during the next several years (SCE 1923b:22). The dogs' graves on Kaiser Pass were marked with redwood slabs erected by the Forest Service (Redinger 1949:105–107). In 1927, Dwyer took his dogs and left the area. Except for a brief postcard to Mrs. Redinger in 1931, he was never heard from again (Redinger 1949:110).

Initial Tunneling Operations, 1920–1922

By mid-October 1920, preparations at Camp No. 60 were advanced enough that tunneling operations could begin at the outlet end. The distance between the outlet portal and Camp No. 61 was six and one-half miles, the longest single stretch of any of the Florence Lake Tunnel sections. Almost immediately, the tunnel work at Camp No. 60 ran into serious difficulties in the form of water, boulders, sand, and mud caving into the tunnel. Much timbering was necessary and, since this required hand labor, progress was slow (Redinger 1949:124–125).

In November, 1920, tunneling was begun at Camp No. 61 beyond Kaiser Pass. The first step was to drive an adit, over 1000 feet long, through the mountain to the tunnel line. This itself was a difficult task due to adit length, unstable ground, and the great influx of sand. Painstaking manual labor, with use of breast boards and timbering, was required to make even slow progress. Mucking was done with Armstrong shuveloaders and one-cubic-yard capacity cars hauled by storage battery locomotives. The adit was made full-tunnel size (15-x-15 feet) in order to allow a double railroad track to be run through. Due to problems encountered, progress on the adit at Camp No. 61 was very slow. To speed the work two shafts were sunk: the first was drilled to tunnel grade 1655 feet west of the intersection point of the tunnel line and the adit, so work could be conducted on the tunnel itself. The second shaft was sunk to the adit, about 170 feet from its point of intersection with the tunnel line, thus allowing work to proceed from two more headings—toward both Camp No. 61 and the tunnel line. In early 1922, after well over one year of hard work, this adit was finally completed and the tunnel line reached (Redinger 1924:[26], 1949:116). Work then became easier, due to harder ground as well as better equipment and organization.

Camp No. 62, Camp No. 63, and the Push to Completion, 1922–1925

Once the longest tunnel section was well underway, attention turned to establishment of camp nos. 62 and 63, located between Camp No. 61 and Florence Lake. During the summer of 1922 the road was extended to Florence Lake, and by late fall the two new camps were in place and well stocked with supplies and equipment to last through approximately eight months of winter isolation (Redinger 1924:[26]). Camp No. 62 was located on the tunnel line about two miles east of Camp No. 61, and Camp No. 63 was located at the intake. Tunneling operations from these points added three faces to the three already being worked. For the following two years and several months, work on Florence Lake Tunnel was both constant and intensive. All important aspects of this work were well described by David Redinger in one of a series of articles he wrote in 1923–1924 for *Compressed Air Magazine*. This description, with photographs, recreates the equipment and techniques used to dig, drill, and blast this important tunnel (Plates 40, 41, 42).

> . . . The heading-and-bench method was practiced at . . . headings with drills on horizontal as well as vertical bars. When the bench was being drilled the horizontal bar was utilized, while the vertical columns were used for drilling the top heading. The depths of the holes in the top headings varied from 10 to 14 feet, and the total number in a round ran anywhere from 40 to 50.
>
> It was found that with three 8–hour shifts the work could be done to best advantage. Furthermore, the law has limited work underground to eight hours. It is difficult to arrange an altogether satisfactory schedule because one crew cannot always get a round of holes drilled during an 8–hour shift, which makes it necessary to have a second crew complete the round. This is not desirable, so each shift on the job finishes the round it starts.
>
> On account of the time required to complete Florence Lake Tunnel, it was thought worth while to fit the equipment to suit the tunnel section. Taking the cross section as a basis, and setting aside that part of it required for the operation of an air–driven shovel, dump cars were built of a size that could be operated in the remaining available space. It was necessary to keep their height down to a point which would permit loading by the shovel dipper. These special cars have 14–inch wheels and are 4 1/2 feet high.
>
> It might be well at this point to mention some of the improvements which served to make for progress after the work was better organized. By replacing the small-capacity Shuveloaders with a special type of No. 25 Marion steam shovel, operated by compressed air, the time required for mucking was greatly reduced. The principal modifications in these shovels consist of minor changes in standard design that enable them to work effectively in a 15x15–foot tunnel. . . .
>
> The removal of muck was speeded up by replacing the 1–cubic–yard dump cars with others having a capacity of from 4 to 6 cubic yards and by transferring the empties, for loading, from the track behind the shovel to the main track alongside—the work of transferring being done by means of a suitable derrick, attached to the rear end of the shovel, operated by a "Little Tugger" air hoist.

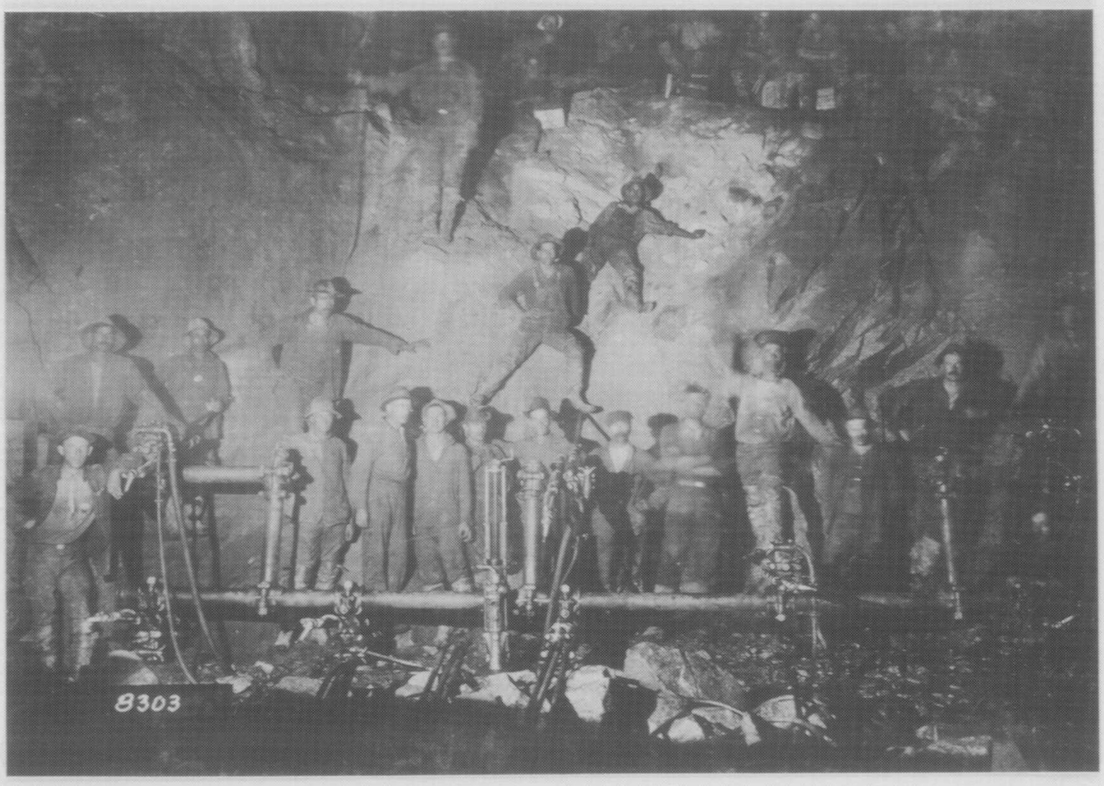


Plate 40 Drilling set–up, ca. 1923 (SCE var. [a]:Album 6, No. 8303).

Plate 41 Timbering operations in the Florence Lake Tunnel, 1923 (SCE var. [b]:Album 1, No. 13–8958).

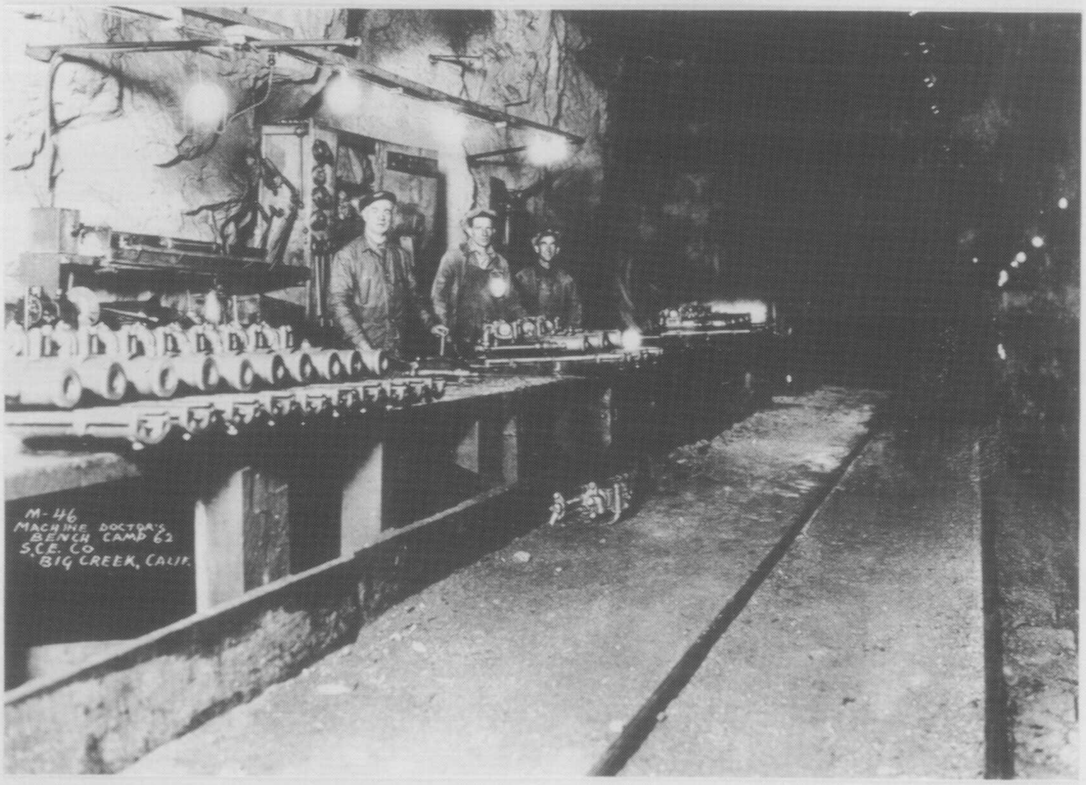


Plate 42 Machine doctor's bench, ca. 1923 (SCE var. [a]:Album 3, No. M–46).

The substitution of locomotives with a combination storage battery and trolley for those of the straight storage-battery type makes it possible to haul heavier trains up to a point within 800 or 1,000 feet of the heading and enables locomotives to go wherever the track is clear without dependence upon flexible leads or trolley wires, which are subject to destruction by flying rock fragments. The locomotives are of the Baldwin-Westinghouse 8-ton type; and, in addition to the regular trolley, are equipped with Hobbs 17-plate storage batteries rated at 220 ampere-hours and 275 volts, the same as the trolley voltage.

By standardizing the drilling equipment, and by using X-70 Ingersoll-Rand rock drills instead of the smaller No. 248's of the same make formerly employed, the tunnel headings are being pushed forward at a faster rate.

By means of larger blowers and 24-inch wood-stave piping the working faces are cleared of gases after blasting in much less time than when the smaller blowers with their 12-inch, iron pipe were in service. Wood-stave piping was first preferred for two reasons, namely, there is not so much danger of collapse after concussion, and if a heavy rock fragment falls on it the result is only a hole which can readily be patched. Iron pipe, on the other hand, if crushed or shattered requires the renewal of a section or sections.

The No. 7, positive type Root blower, which has displaced a No. 3 of the same kind, handles the ventilation very well for distances up to 11,000 or 12,000 feet. For longer stretches it is necessary to add another blower to the line, which acts as a booster. . . .

The blower pipe is run up to within 300 feet of the tunnel heading and is suspended from the roof by suitable hangers so as to give more floor space along the tunnel wall for storing ties, piping, rails, etc. Another advantage is that the gases generated by blasting, which ordinarily rise, are somewhat easier to exhaust than when the blower pipe rests on the floor. For about an hour after a round is blasted, the blowers are operated so as to exhaust; and to assist the blowers to withdraw the powder smoke the use of an air curtain has been found to be very effective. To create this air curtain, a 1-inch pipe is laid on the floor at right angles to the center line of the tunnel and about 75 feet from the intake end of the blower pipe towards the portal. This pipe is perforated with holes 3/32 inch in diameter, spaced about 4 inches apart, and is turned just enough to point the holes toward the end of the suspended blower pipe. Before a round is blasted, and when the last man leaves the heading, air is fed through this line. In this way a curtain is formed that tends to hold the gases between it and the tunnel heading, thus enabling the blower to clear the working face quicker than ordinarily. By this method it is feasible for tunnel crews to return to headings from 10 to 15 minutes sooner; but in no case is a man allowed to go back until after half an hour has elapsed. This is a safety-first measure against delayed holes. After a blast, a crew generally resumes operations at a heading in from 30 to 45 minutes.

The various companies that supply blasting powder have been endeavoring to provide one that would generate the smallest amount of poisonous gases; and a means to this end is the use of a special kind of paper wrapper. The explosive utilized exclusively at the present time—a 40 to 60 per cent. gelatine powder—is a great improvement in this respect. All blasting in the heading and the bench is done with delay-action exploders connected in multiple and ignited electrically from a 440-volt circuit.

> In order to load the holes more efficiently, a standard has been adopted in the matter of cartridges—namely, 1 1/4x12-inch cartridges are loaded in the bottoms of the bench holes, while those for the heading holes are 1 3/4x12 inches in size [Redinger 1924:(26, 28)].

The flavor of what it must have been like to work on the project was best captured by journalist Lurline Lyons, who visited Camp No. 60 in early 1925 when the tunnel was nearly complete. Lyons pointed out that when under construction, Florence Lake Tunnel was considered one of the most daring engineering feats of the twentieth century. No doubt encouraged by management, workers on the tunnel also treated the project (in some respects, at least) like a sports competition—to see which group could work fastest and most efficiently. As Lyons expressed it:

> "It's like the last hand of a game with seventeen million dollars in the jack pot," said Scotty Gilzene, foreman at the outlet portal of the great Florence Lake Tunnel, as he stood looking at the strangest score board that has ever fixed the gaze of eager eyes. Behind him the members of the "bull gang" came crowding up as they emerged from the black mouth of the tunnel and its long throat yawning back miles under the Kaiser Range of the High Sierras in Fresno County, California, and stamping their way across the strip of snow covered ground that lies between the tunnel's mouth and the division office of the south portal camp, above which hung the score board.
>
> The "bull gang" or the morning shift at one of the six underground points at which the work of completing the longest tunnel of its size in the world is now being rushed to its completion, had just come off duty. In jack boots and slickers wet and damp from the moisture of the tunnel's depths they gathered about Scotty and studied the figures of the score board. The keen zero atmosphere of an altitude of over seven thousand feet was freezing the water that clung to their oil skin coverings into little globules of ice, and their breath congealed into frostings on bearded faces. They were a grim, stalwart, dark-faced group of miners and drillers and shovelers, who for the most part had been spending a good portion of their lives undergound [*sic*] since the great tunnel was commenced in the fall of 1920. It is their task with drill and dynamite, hand shovel and steam shovel; pick and bar, to gouge a hole fifteen feet in diameter for a length of thirteen and a half miles under one of the loftiest mountain peaks in California to the upper waters of the San Joaquin River, so that this stream may be diverted forty-five miles from its natural course and pour its waters down six thousand feet through a chain of eight [only four powerhouses had been built by 1925] Southern California Edison Company power houses that stretch for thirty miles down ravine and canyon that lead to the peaceful valley seven thousand feet beneath, and generate a million horse power of electricity. They were typical—absolutely typical of the workmen that Executive Vice-President Russell Ballard, the Big Chief, terms the pioneers of progress.
>
> "We sure put one over on the north portal this shift," said Scotty as his index finger indicated the last chalk mark on the board and the members of the "bull gang" crowded closer, while some of them did some fast figuring in mental arithmetic and others leaned over Scotty's shoulder and watched him working out an odd problem on a scratch pad.

> The dark, grimy faces lit up with the joy of conquest as the problem worked out, and up there in the solitude and the snows of the lonesome mountains in the back country of California, near the Nevada frontier, I saw in the faces of the "bull gang" crew the light that shines when victors score home runs at national ball games; when polo riders charge through the wickets and make scores; and multitudes yell and cheer a collegiate football team; when a brave touchdown punctuates a climax of seasons [Lyons 1925b].

Underground work was assisted by an extensive support structure aboveground. Beside the camps mentioned above, there was the old Shaver Lake sawmill which was moved over the pass and installed near Camp No. 61 during the summer of 1921. However, its approximate production of a million board-feet did not stretch far with so many demands for lumber both above and below ground (Redinger 1949:102). Camp No. 61 could boast the operation of both a laundry and a base hospital, while other camps had first aid stations. A concrete plant, including crushing and screening facilities, was built at Camp No. 62 to provide concrete needed to line some of the tunnels. Concrete plants probably existed at other camps as well. David Redinger described other activities in and around the camps:

> Each camp had to be self-sustaining in practically all respects. Each had its own compressor plant to furnish the large amounts of compressed air required for the respective tunnel headings. A machine shop, sufficient for mechanical maintenance, was busy continuously. Machine "doctors" for keeping their X-70 "patients" in drilling condition had their work benches inside the tunnel and out. Day and night the heavy thump of the pneumatic drill sharpeners could be heard, as if they were playing bass to the pound of the huge compressors before the pressure was relieved by the unloader valves. "Nippers" shuttled in and out of the tunnel, bringing drill steel to be sharpened, and hurrying back with a load ready to go into the machines at the heading. The miles of track required the continuous attention of maintenance crews, or "gandy dancers," as they are called today. . . .
>
> Electricians were "on the go" like everyone else, the electric locomotives requiring not only their attention but also that of mechanics. Storage batteries were on the racks continuously, especially for re-charging. Our electric railway system was rather unique, although its use was not peculiar to the Florence Lake Tunnel. Ours had, for safety in operation, quite an elaborate, but not complicated block signal system. Extra precautions were necessary where long stretches of single track were involved. Tunnels are usually more or less smoky or hazy. Switches were operated automatically, with red lights indicating on-coming trains, and white, a clear track [Redinger 1949:125-126].

Florence Lake Tunnel and the other Big Creek tunnel projects used enormous amounts of explosives—12 million pounds between 1921 and 1925. The use of explosives was not without danger. On February 5, 1925, an accident occurred on Florence Lake Tunnel when members of a blasting crew cut their fuses too short and were unable to reach safety before the explosion occurred. As a result, four men were killed and another was seriously injured (Los Angeles Daily Times 1925:1).

Undaunted by this tragic event, workers on Florence Lake Tunnel continued to push forward toward completion of the job. After so much drilling and blasting, the exciting "peck-peck" of drills could finally be heard by workers on opposite headings. The "moment of truth" had at last arrived: this was the time when the engineers in charge of the heading surveys became most tense. The calculations upon which millions of dollars and millions of man-days had been spent were now to be proven right or wrong. A legend among tunnel workers states that, when the last blast takes place, these engineers always have their bags packed and are ready with a one-way ticket out of the area. Fortunately, no Edison engineer ever had to use his ticket (SCE 1923b:4).

The final breakthrough on the last section between Camp No. 62 and the intake took place during the night of February 18, 1925. Excavation had been completed nearly two years ahead of schedule. This was the longest water tunnel of its size in the world, and it helped make the Big Creek project world famous (Redinger 1949:130). David H. Redinger summed up the great work of the Florence Lake Tunnel when he wrote:

> Several hundred thousand cubic yards of broken granite will long remain as silent markers of the former camps where men labored, not only for their livelihood, but to help provide more electric power for the comfort and progress of humanity [Redinger 1949:132].

The name of Florence Lake Tunnel was changed to Ward Tunnel after the death of George C. Ward, vice president in charge of construction for Pacific Light and Power Corporation (1912–1917) and later for Southern California Edison (1917–1932). He was president of Edison when he died in 1933 (Marquis Who's Who 1976:637; Redinger 1949:132).

Construction of Florence Lake Multiple-Arch Dam, 1925–1926

While the site for a dam impounding water for Florence Lake Tunnel had been chosen early, the exact type of dam to be built at Florence Lake was not decided until after the tunnel was well underway. Many varieties of dams were considered, but finally a multiple-arch dam was chosen—a dam originated and first designed by John S. Eastwood. This kind of dam was appropriate both for site topography (which required a long dam) and for the great distances which materials had to be transported. A multiple-arch dam required less concrete than some other types, so there would be less tonnage to transport from the railhead at Big Creek (Cascada). Although such a dam would require more lumber for forms, the old Shaver sawmill was available, as were the trees of the adjacent forest. One problem recognized early (and still being dealt with today) was harmful effects that extreme cold and freezing temperatures would have on the concrete of the dam (Redinger 1949:134–135; SCE 1927:11).

Plans for the new dam began to be implemented immediately upon completion of Florence Lake Tunnel. The rail line in the still empty tunnel was initially used to haul material from Huntington Lake to the inlet. This practice soon ended, however, as water from the South Fork of the San Joaquin was needed for electrical power generation, and water diversions through the tunnel began in mid-April 1925. These diversions were made possible by construction of a low, timber-crib, rock-filled dam built in what would later become the bed of Florence Lake. This dam also controlled water flows while the main dam was under construction (Redinger 1949:130-131).

Work on the main Florence Lake Dam began early in 1925. Since the dam site was located in granitic high country, extensive excavations for its foundation were not necessary. All foundations were anchored in solid, live granite, using the plug-and-feather method of blasting--a method avoiding heavy explosions that could shatter the foundation granite. After the foundation was grouted, concrete-pouring began on March 4, 1925. A large, rock-crushing and screening plant was built at the dam site, downstream from arch number 42, with the central mixing plant next to it. Two other mixing plants stood across from arch numbers 15 and 50. All cement was delivered in sacks--first through the tunnel railroad, then by truck over Kaiser Pass. Until it was used, the cement was stored in a large warehouse for protection. This warehouse, heated with wood stoves, was located below arch number 25. To distribute the concrete, an Insley chuting system was constructed; chutes were suspended from two Insley steel towers several hundred feet in height (Redinger 1949:135-136; SCE 1925a; 1927:14).

Due to the problem created by extreme cold, it was very important that high-quality concrete be used to build Florence Lake Dam; therefore, a well equipped field laboratory was constructed to cure and test samples of concrete. This laboratory consisted of a double-walled, temperature-controlled, moist-air curing room to assure that tests were conducted in uniform conditions unaffected by outside weather. Specimens of concrete were taken each day, cured, and then tested after varying lengths of time. These tests helped assure a safe and permanent dam (SCE 1927:16).

Another phase of infrastructure development needed to carry on dam construction was removal of the old Shaver Lake sawmill from Camp No. 61 to new Camp No. 65 at the reservoir site in upper Jackass Meadow. The sawmill operated at this location during 1925 and 1926, providing lumber for the vast job of building forms for 56 arches, as well as for construction and other purposes. Best 60-type tractors were used for logging--an improvement over the horses and high wheels method formerly used for Edison construction projects (Redinger 1949:138). There was plenty of timber in the region around the dam site, and, in any case, the reservoir site had to be cleared.

Headquarters for Florence Lake Dam construction was Camp No. 63, located in the area which would later be flooded by waters of the enlarged Florence Lake. This camp was established in the fall of 1922 during Florence Lake Tunnel construction. When construction of the dam was completed, the main buildings were moved to nearby Camp No. 64 (Redinger 1949:138).

After a winter shut-down from November 1925 to April 29, 1926, dam construction was pushed to completion during the summer of 1926. When finished, Florence Lake Dam was the longest multiple-arch dam ever built--about 3200 feet. Its length, high Sierran setting, and unusual design reportedly attracted considerable attention among both engineers and the general public (Redinger 1949:136). Plates 43 and 44 document some key aspects of the building of Florence Lake Dam. Plate 43 shows Camp No. 63 and dam construction in August 1925, and Plate 44 illustrates progress made by October 1925. In the foreground stands the rock-crushing plant

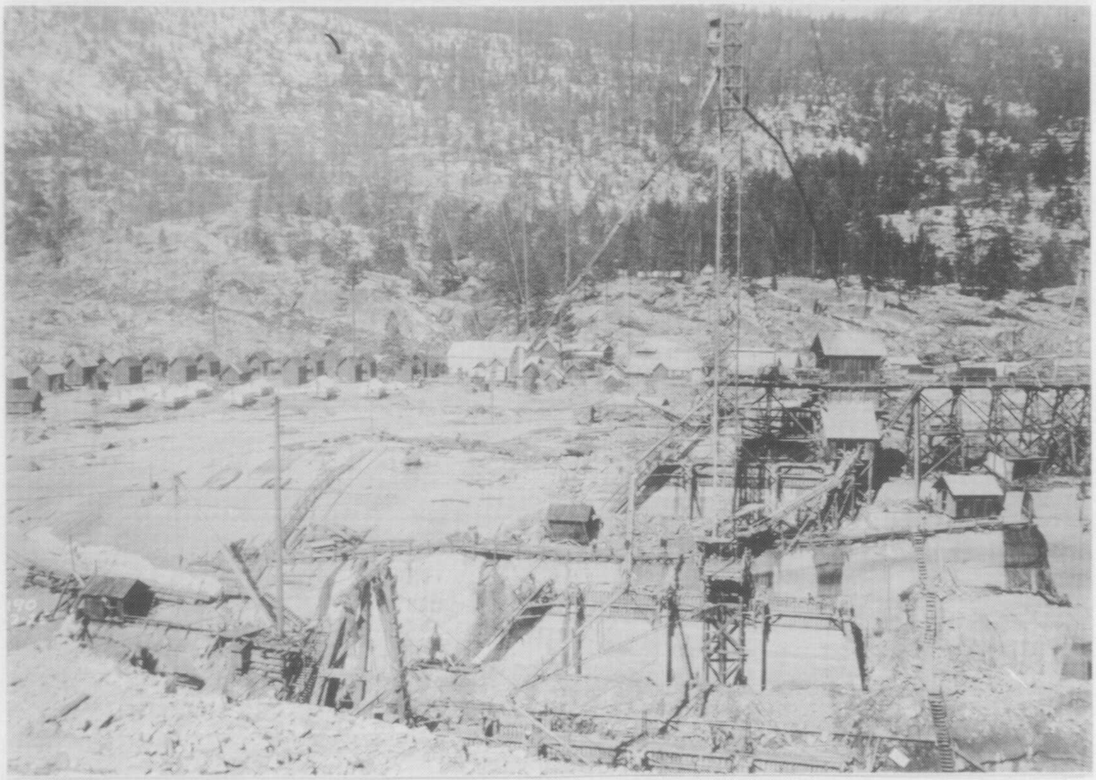


Plate 43 Florence Lake Dam construction and Camp No. 63, 1925 (SCE var. [a]:Unnumbered Album, No. A190).

Plate 44 Construction of Florence Lake Dam, October 1925 (SCE var. [a]:Unnumbered Album, No. A263).

and central concrete-mixing plant. North along the main rail track, the small building on the right is the concrete-testing laboratory. Farther along the track, the first of two larger buildings is the tool-sharpening house, and farther still is the cement warehouse. An electric shop is located west of the cement warehouse. Plate 45 illustrates progress by July 1926, and Plate 46 views the completed dam in mid-September 1926.

When completed, Florence Lake Dam was by far the most expensive dam in the Big Creek System, costing almost three million dollars to build. A 1963 Edison report on the Big Creek System provides technical data on this dam, and points out that constant efforts are required to preserve the dam in the face of yearly attacks of the high Sierran winter.

> Florence Lake Reservoir, with a drainage area of 171 square miles and a storage capacity of 64,406 acre-feet, was created by the construction of a multiple arch dam 3,156 feet in length with a maximum height of 154 feet above the foundation contact line. Fifty-six thousand cubic yards of concrete were used in the construction of the dam. The spillway elevation of this dam is 7327.5 feet.
>
> Florence Lake Dam is one of the longest multiple-arch dams in the world. The dam was constructed in a five tangent alignment in order to benefit from an irregular rock ridge forming part of the basin, its granite foundations are exposed for the entire length of the structure except for a short distance across a secondary channel. Because of the expense of hauling and the relative inaccessibility of the site, fill dams of various types were considered in early studies but neither the quality of local materials nor the techniques of the day permitted fill construction and a mutiple-arch was decided upon.
>
> The 58 arches were designed on five centers; it was found that temperature, shrinkage and rib-shortening stresses could be best taken care of by a modification of the shape of the arch from the conventional normal circular section. Buttresses, which are on 50-foot centers, are stiffened by counterforts at the upstream head, the downstream edge and intermediately. The extrados surface is a compound cylinder and the intrados an inverted compound cone.
>
> The spillway is controlled by two 50 x 14 foot drum gates with controls arranged so that the crest can be maintained at any elevation desired within their range. This type of gate was selected because of the ease in handling trash and logs and because no electric power is available at this location for power-operated gates.
>
> Operating conditions permit keeping the reservoir empty through the winter and hence ice pressures are avoided but the arch surfaces are exposed to the sun and snow. The freezing and thawing cycles at this location are exceptionally severe with some 200 such cycles occurring in certain years. Adequate protection of the exposed surfaces against frost damage has been the subject of extensive research, and in the course of investigation over sixty commercial waterproofing preparations were tested in the laboratory and the more promising of these tried on the dam. This research indicated that a membrane made of asbestos roofing fabric impregnated with a waterproofing compound would provide adequate surface protection. Such a coating was applied to the upstream surfaces. This coating has relatively low resistance to abrasion but by carrying out annual repair of any damage areas it has proved successful

Plate 45 Florence Lake Dam, July 1926 (SCE var. [b]:Album 1, No. 47–14013).

Plate 46 Florence Lake Dam, September 1926 (SCE var. [b]:Album 13, No. 13842).

> in keeping the surface concrete protected from damage due to the freezing and thawing of the snow. Recent tests have shown that the concrete has maintained good strength since the coating was applied. Currently, various types of epoxy materials are being tested on the dam [SCE 1963b:3].

Mono Creek and Bear Creek Diversions, 1926–1927

In order to tap even more of the South Fork San Joaquin watershed, two creeks north of Florence Lake were diverted into Florence (Ward) Tunnel. Begun in July 1926, work needed to complete this project included a six to seven-mile-long road, seven camps for about 1500 men, two small diversion dams, two tunnels, and a siphon (pipe conduit) to take diverted water into Florence (Ward) Tunnel. David H. Redinger described some of the work on this project as follows:

> The "80" series of numbers was assigned for the camps established for the construction. Camp 80 was built near the site for the Mono Dam; 81 at the intake of the Mono Tunnel; 82 at the intersection of both tunnel outlets, where the siphon would connect; 83 and 84 along the siphon; 85 at Bear Creek tunnel adit; and 86 at the Bear Creek damsite.
>
> Between six and seven miles of road had to be built through the worst terrain imaginable. Boulders the size of houses, and huge ledges of the hardest granite, were encountered. Steep grades and sharp turns resulted from dodging such obstacles. The routes appeared to be almost impossible, since many large trucks would have to be used for the delivery of material. It is amazing what men with determination, portable air compressors, jack hammers and powder, can accomplish when once started. The "C. and N."—Cheap and Nasty—road was completed, camps made ready, and work on the conduit got under way in July, 1926. Winter caused stoppage of activity on November 24, and it was resumed again in the early spring of 1927.
>
> A 1 1/4-cubic yard Link-Belt gas-operated shovel was purchased for use largely as a crane for placing the siphon pipe sections. To reach the job early, we used it in May, 1927, to dig its way over Kaiser Pass through snow six feet deep, and of course, in doing so, it opened the road for all traffic [Redinger 1949:146–147].

The Mono Creek and Bear Creek dams were both small concrete-arch structures used for stream diversion only. The Mono Tunnel and conduit were both about three-quarters of a mile long, and the Bear Tunnel, one and one-half miles long. They connected to a siphon-type conduit, three miles long, which crossed the South Fork of the San Joaquin on a bridge and emptied into Florence Lake (Ward) Tunnel at the adit near Camp No. 62. Pipe for this conduit was hauled by truck from the top of Big Creek Incline No. 1, at Huntington Lake, to the high country. The conduit was covered with dirt in order to minimize the formation of ice on the inside of the pipe (Redinger 1949:146, 148–150). The job was completed on November 15, 1927, and water diversion began.

The completion of the Mono–Bear diversion system successfully ended the major effort, begun over seven years before, to tap the great water–resource base of the high Sierra country northeast of Huntington Lake. As always was the case for the Big Creek System, an added water supply meant that new units and a new powerhouse could be constructed. The last chapter in the great expansion story of the 1920s covers this new construction from 1926 to 1929, and also reviews the social history of this era at Big Creek.

CHAPTER 6

THE GREAT EXPANSION, PHASE THREE: 1925–1929

The third and final phase of the great expansion of the 1920s was begun late in 1925 and completed in June of 1929. This final phase involved drilling another long tunnel, construction of a new dam and powerhouse, and expansion of Powerhouse No. 8. First, a tunnel was drilled from Huntington Lake to the North Fork of Stevenson Creek (a stream flowing into Shaver Lake), allowing water from the Florence Lake/Huntington Lake watershed to be diverted into Shaver. Second, a large dam was built at Shaver Lake which vastly increased its holding capacity. Third, Powerhouse No. 2A was constructed next to Powerhouse No. 2 and a second generating unit was added to Powerhouse No. 8.

The expansion period of the 1920s also saw changes in the social life of the region, which in many ways were significant aspects of the success of the Big Creek project. This era of social change is also reviewed in this chapter.

Original Plans and New Solutions

John Eastwood's original plan for development of Big Creek called for construction of a multiple-arch dam on Pitman Creek just below its confluence with Tamarack Creek. Water from the projected Pitman Creek Reservoir was then to be conducted by flume to Huntington Lake, to be used in Powerhouse No. 1 and all of the power plants lying below. When the application for this project was filed with the Department of Agriculture in early 1918, Southern California Edison still adhered to Eastwood's original concept. However, once Edison had purchased Shaver Lake and surrounding properties in 1919, the company reconsidered the original plan and decided instead to divert Pitman Creek water directly into a tunnel which would in turn divert water from Huntington Lake to Shaver Lake (Bergh 1956a:216). The water diverted into Shaver could be transported through the already existing tunnel linking Shaver with Powerhouse No. 2, and a new powerhouse, No. 2A, could be built and brought on line. The addition of Powerhouse No. 2A and the interconnection of these reservoirs gave the entire water and power System a new flexibility. The storage capacity of the System was much larger, decisions could be made about which powerhouse could most efficiently use the often limited supply of water, and water could be easily transfered from Huntington Lake to Shaver Lake.

Huntington–Shaver Conduit

With planning and decision-making phases completed, in early 1925 the preliminary work of building roads and setting up camps needed to build the Huntington–Shaver conduit could begin. Three camps, numbered 71–73, were established as follows:

Camp 71 - at outlet portal of the short tunnel below Dam 2 near Huntington Lake

Camp 72 - at the only adit, located on the steep slope of Big Creek canyon near Snowslide Creek about one and one-half miles southeast of Powerhouse No. 1

Camp 73 - at the outlet portal of the tunnel on the North Fork of Stevenson Creek above Shaver Lake [Redinger 1949:159]

Actual tunnel work began in November 1925 at camp nos. 72 and 73. At Camp No. 72, a short adit had to be driven to reach the tunnel level (Plate 47). The tunnel size was 14 feet by 13 feet, 4.8 miles long. Along with construction of the tunnel itself and cutting a hole in Huntington Lake's Dam No. 2 for water control gates, the key part of this work was building a siphon across Big Creek canyon. This siphon consisted of an 8 to 10-foot-diameter pipe, about 3200 feet long (Redinger 1949:160; Ward 1928:201).

Work on this tunnel continued for well over two years (Plate 48). The tunnel was not completed without tragedy, however; in fact, the worst single accident in the history of the Big Creek project occurred during construction on this tunnel. In February of 1927, as a result of heavy snows, Camp No. 72 was destroyed by the "worst snowslide ever recorded in California" (Rose 1985b:n.p.). As a result of the rushing mass of snow and rock that came crashing down the hillside, one woman and 12 men were killed and 22 others were injured (Los Angeles Daily Times, February 17, 1927).

While this accident was certainly a great tragedy for the residents of Big Creek town, it was also the stuff from which legends were made—specifically, the legend of Jetvo "Jumbo" Vasilovich. According to newspaper accounts and interviews with residents, the six-foot-seven-inch, 260-pound "Jumbo" was the first to rouse the sleeping town when the accident occurred. Yelling to the stunned townspeople, "What are we waiting for?" and "Let's go down there and get them out!" Jumbo was one of the first on the scene and was "all over the mountain," rescuers said, digging for survivors in the debris. Dozens of rescuers, drawn by Jumbo's example, soon arrived at the site to help save the buried victims (Rose 1985b:n.p.).

Vasilovitch was said to have come straight from Yugoslavia to Big Creek to work during the construction period; he was the subject of other stories as well. Jumbo could speak no English upon his arrival, but along the way someone had told him that if he wanted to eat he should ask for "ham and eggs." So for the first six months he ate ham and eggs three times a day, because that was the only English he knew (Rose 1985b:n.p.).

Jumbo became something of a legendary character in the history of the Big Creek project, and his extra-large physique certainly added color to a great many stories. One tale that appears often (but not always in the same way) tells how, as part of Jumbo's job as a railroadman, he was frequently required to carry 90-pound sacks of cement. While regular hod carriers could carry only one sack at a time, Jumbo would carry two or three (depending on the version of the story) under each

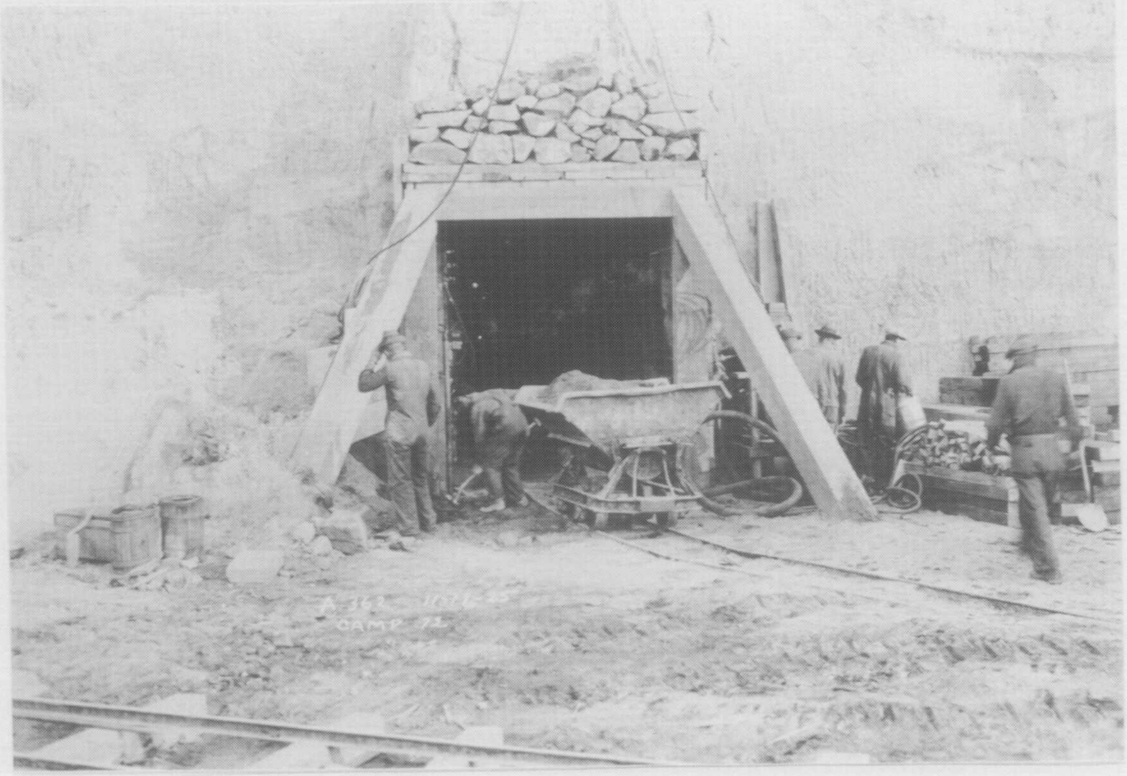


Plate 47 Work at the Camp No. 72 adit, November 1925 (SCE var. [a]:Unnumbered Album, No. A362).

Plate 48 Camp No. 71, at the outlet portal near Huntington Lake, 1926 (SCE var. [a]:Unnumbered Album, No. A531).

arm (Glenn 1975:14; Henry 1960:7B). Another anecdote describes how he carried 300-pound blocks of ice. Along the way to the icebox he would stop, order a beer, and drink it—all without relinquishing his load—then calmly continue on to his destination (Henry 1960:7B).

A different kind of story shows the good-natured side of Jumbo and the affection shown to him by the inhabitants of Big Creek:

> He ordered his extra size shoes from a company back east. On one particular order his constant inquiries of the expressman were getting monotonous. Finally, after a week of asking, the clerk led him down to Cascada Station and there were his shoes, the sole burden of a flat car of the train [Henry 1960:7B].

Apparently, the entire town was in on this practical joke, which was enjoyed by all—even a somewhat red-faced Jumbo.

While many of the narratives involving Jumbo's abilities were dissimilar, all agreed that he was an affable character. Even those who mentioned Jumbo's trouble with "keeping his elbow straight" remarked that his practice of "ordering a round too many" never prevented him from arriving on time for work. Still other storytellers remembered Jumbo for his kindness to children. A single man without children of his own, he delighted in treating the kids to a round of cornucopias at the local ice cream shop.

Jumbo died in 1947 at age 57 (Rose 1985b:n.p.). At his funeral in Fresno, so many company employees showed up that "it seemed like the giant of a man had restored the Cascada history to life again" (Henry 1960:7B).

Shaver Lake Dam, 1926–1927

The second major piece of construction work in this last phase of Big Creek expansion during the 1920s was the erection of Shaver Lake Dam, which formed the largest (135,568 acre-feet capacity) of the three major reservoirs on the Big Creek project. Exploratory work had been conducted during the first half of the 1920s, and several possible dam locations were drilled before the actual dam site was selected. A gravity-type dam (i.e., one that resists water pressure solely by its weight) was selected as most appropriate to the dam site and its intended function.

Clearing the foundation area for the dam began in late April, 1926. Excavation, conducted by steam shovel, amounted to 150,000 cubic yards, about one-half of it in solid rock (Plate 49) (SCE 1927:19). Camp No. 21 was set up on the hill above the dam site, and a 4.6-mile standard gauge railroad was built from Dawn on the main line of the San Joaquin and Eastern Railroad to the construction zone. This railroad allowed the huge amount of materials, especially cement, to be brought to the dam site (Redinger 1949:152). Since there were no natural deposits of sand and gravel available in the immediate area, a quarry had to be opened about a mile from the dam. A narrow gauge railroad was then built to haul granite rock from the quarry to the dam site, where it was crushed into sand and rock suitable for concrete mix (SCE 1928a:9).

Two steel towers were erected to support the chutes used in pouring the concrete, and a concrete-mixing plant was built. At about this time (late summer 1926), Florence Lake Dam was completed and the entire Florence Lake concrete crew moved to the Shaver Dam site. The first concrete was poured in early September 1926 (Plate 50). Due to weather conditions, concrete work was suspended in early December, 1926, and resumed in early April, 1927. David H. Redinger later described the process of completing Shaver Lake Dam:

> The dam was built in fifty-foot blocks, with a construction joint between each. Besides the usual key-way at each joint, a thin copper sheet about thirty inches in width extends from top to bottom, spanning the joint to make it water-tight. The sheets were placed in ten to twelve foot lengths, lapped and brazed at the ends. Concrete expands and contracts with temperature changes, and to allow the copper sheets to withstand the slight movement of the huge blocks without breaking, they were corrugated, or "V" shaped in the center.
>
> Another feature provided in the dam is the large gallery running through most of its length, a short distance above the foundation. Its twelve-foot height was to permit the later operation of a diamond drill for holes which would relieve pressure from possible seepage water. Water will find its way through crevices in the foundation rock in spite of precautions to seal them by grouting. It will also work its way, more or less, through a day's work joint and even around a construction joint. Such a gallery provides the means for periodic inspections also. The one in the Shaver Dam is the only one among the dams on the Big Creek project. Several years later, another and shorter gallery was excavated along the contact of the concrete and bedrock for purposes of observation.
>
> The largest mess hall on the project, seating several hundred men, took care of the "inner man," and sleeping quarters upstairs accommodated those who were not allocated to bunk houses.
>
> Another big job, clearing the reservoir site, was handled by Bretz Brothers, local men, who programmed their work to have the site ready for storage as the dam approached completion, which occurred on October 23, 1927. Between April and August 1 of that year, an average of 1,431 cubic yards of concrete was placed, the maximum for one day being 1,808 [Redinger 1949:153].

One of the last jobs to be done in clearing the Shaver Lake reservoir area was to burn all remaining structures. These included what was left of the old Shaver Lake sawmill, store, post office, and surrounding buildings. The buildings still contained relics of early lumbering days, including, for example, a box of oxen shoes for the draft animals used to haul logs to the mill (Redinger 1949:154).

When Shaver Lake Dam was completed in October of 1927, it had the longest crest length (2169 feet) and capacity (135,375 acre-feet) of any gravity dam in California (Mermel 1963:2-50; SCE 1967a:9). Standing 183 feet above the stream bed, it contained 281,300 cubic yards of concrete (SCE 1963b:5).

Plate 49 Initial Excavation for the Shaver Lake Dam, April 1926 (SCE var. [a]:Unnumbered Album, No. A402).

Plate 50 Shaver Lake Dam with concrete plant, sand and gravel, and Camp No. 21 in background, 1926 (SCE var. [b]:Album 2, No. 23–14256).

Construction of Powerhouse No. 2A, 1926–1928

Construction of the Huntington Lake–Shaver Lake tunnel (Tunnel No. 7) and Shaver Lake Dam had the dual aim of creating a larger area for water storage and providing the basis for a new powerhouse. Called Powerhouse No. 2A, this structure was erected from 1926 to 1928 on the northeast side of Powerhouse No. 2. Only after the usual preliminary steps (that is, excavation for the powerhouse foundation, building of a coffer dam and bypass flume to divert the flow of Big Creek, and erection of a mixing plant, carpenter shop, and concrete–placing tower) could the pouring of concrete begin for the foundations and superstructure of Powerhouse No. 2A itself. This stage in construction was reached by early May 1927 (Plate 51). The construction effort was facilitated by the fact that it was built adjacent to Powerhouse No. 2, with its readily available electric power, incline railroad, and other facilities. Concrete work was ongoing during 1927, and the new powerhouse building was completed by early 1928 (Plate 52).

While construction of Powerhouse No. 2A was underway, work was begun on the long penstock system needed to bring water from the outlet of Shaver Tunnel (built in 1920–1921 and discussed in Chapter 4). The single penstock for Powerhouse No. 2A was the longest (about 6400 feet) of any on the Big Creek System (SCE 1955b:n.p.). Because of the extremely high head used at this powerhouse (second highest in California and the Western Hemisphere during the 1920s), this penstock had to be built to withstand very high water pressure. Near the powerhouse, the penstock pipe was fully three inches thick (SCE 1955b:n.p.). Work was ongoing during the winter of 1927–1928, and the job was nearing completion by late February 1928 (Plate 53, also showing West Portal station of the San Joaquin and Eastern Railroad). David H. Redinger described the penstock for Powerhouse No. 2A, pointing out that it varied in diameter

> . . . from one hundred and eight inches at the top to sixty–six near the power house. The water must be carried to each water wheel—hence the two 48–inch branches, each of these branching into two 24's. An interesting feature involving the three huge "Y" pieces, reinforced by heavy steel bands, is that they were made by the once great Krupp Works in Germany. Riveted pipe, made locally, constitutes the upper portion of the penstock. The banded forge–welded central portion was made in Poland, and the bottom section, forged and seamless, was made in this country [Redinger 1949:157].

Once the Powerhouse No. 2A building was completed, the complex job of installing the large waterwheels, generators, and other hydraulic, electrical, and transmission equipment could begin. Unit number one was installed first, then unit number two. Plate 54 shows the generator rotor shaft of unit number two being installed in mid–April 1928.

Powerhouse No. 2A, complete with all its equipment, was finished in the summer and fall of 1928. Unit number one went into service in August, unit number two in December. The powerhouse's main features consisted of two double over–hung impulse waterwheels (turbines) which were the largest of their type installed anywhere in the world at the time. Each of the two generators was also

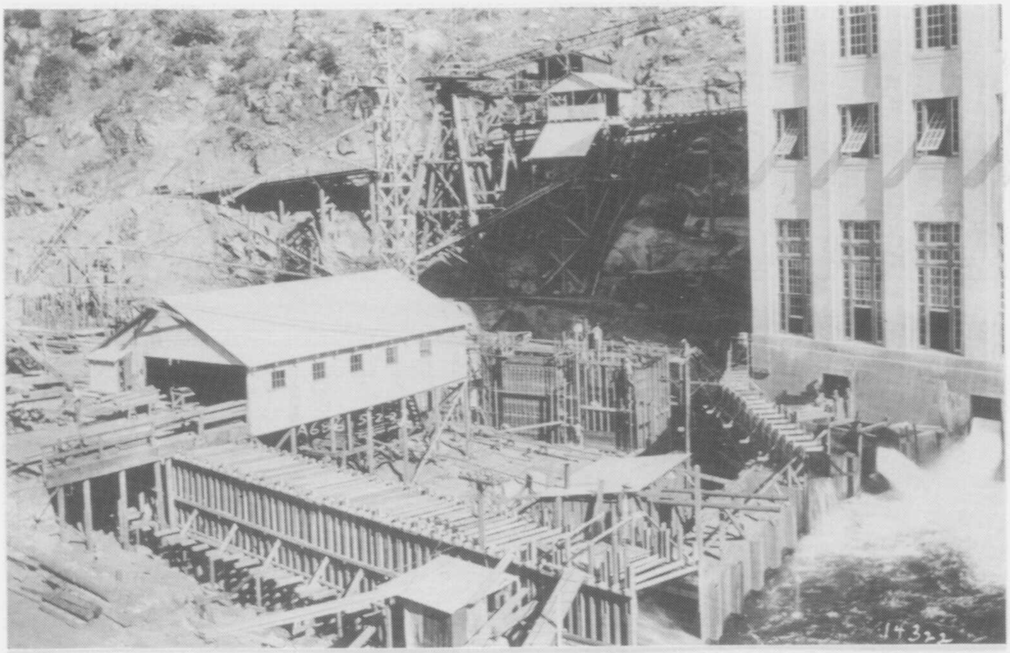


Plate 51 Foundation work at Powerhouse No. 2A, May 1927 (SCE var. [b]:Album 2, No. 25–14322).

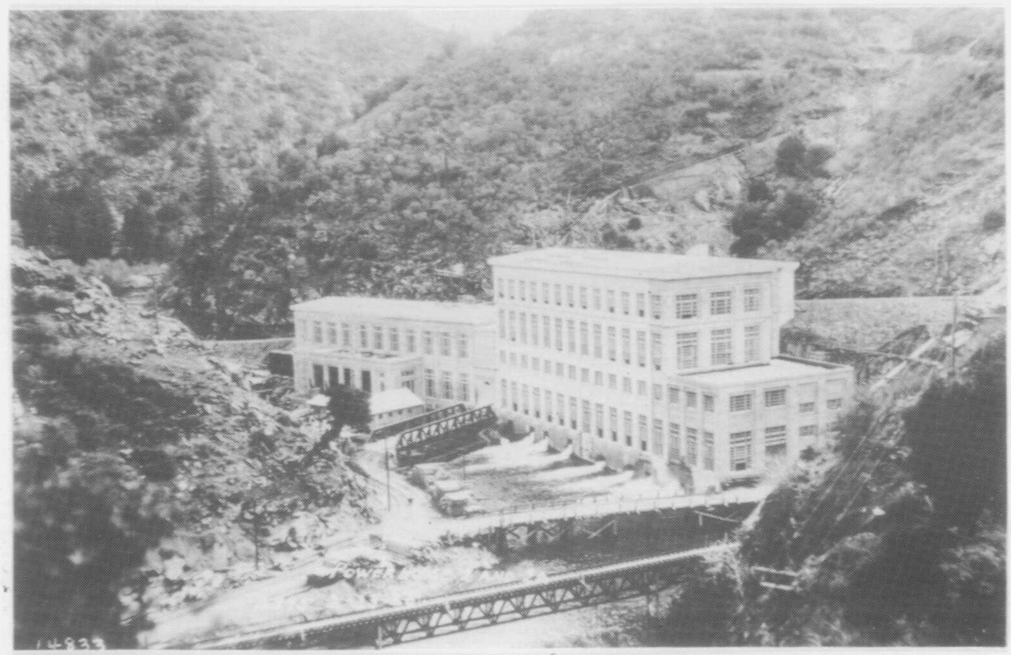


Plate 52 Powerhouse No. 2 (right) and 2A (left), 1928 (SCE var. [b]:Album 2, No. 30–14833).

Plate 53 Construction of Penstock No. 2A, February 1928 (SCE var. [b]:Album 2, No. 9–14825).

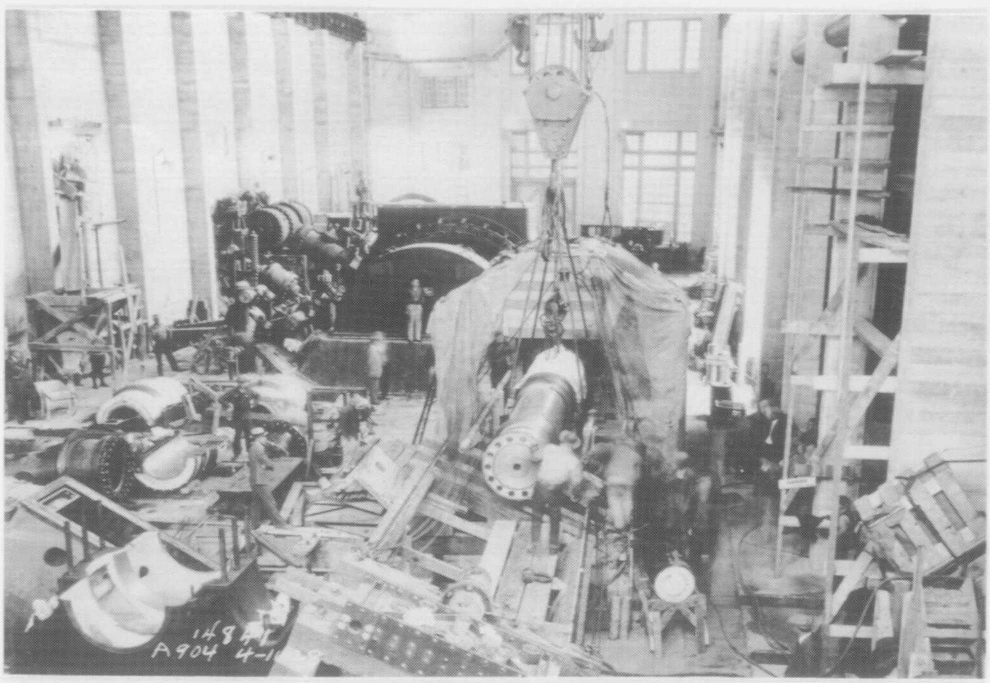


Plate 54 Erection of Unit 2 in Powerhouse No. 2A, April 1928 (SCE var. [b]:Album 2, No. 33–14841).

very large, with an operating capacity of 46,500 kilowatts. The whole system operated under a head of over 2400 feet (Redinger 1949:156). The cost of this plant and related works during 1928 alone was almost four million dollars (SCE 1929b:12).

Completion of Powerhouse No. 2A System

In November of 1928, the industry journal *Electrical West* described the hydraulic and electrical features of Big Creek Powerhouse No. 2A, tracing the flow of water through the various features of the 2A system to the powerhouse itself. The highlights of this article are excerpted here, providing a good summary of this powerhouse's equipment and operation at the time of its completion.

> A 120-in. riveted steel pipe concreted solidly into a tunnel driven through the concrete base of the No. 2 dam at Huntington Lake provides the intake for the Shaver conduit. Inflow is controlled by means of a 120-in. circular slide valve. A bypass around the gate permits the short section of pipe between the slide gate and the regulating valve to be filled so that the slide gate normally operates under equalized pressures.
>
> A duplex gate valve immediately downstream from the dam is used to control the amount of water passed through the conduit. This valve is designed to operate at various openings so that its discharge may be regulated. . . .
>
> About 700 ft. downstream from the dam and the duplex regulating valve the 120-in. pipe line enters a 2,200-ft. tunnel. A 42-in. vent pipe about 100 ft. upstream from the tunnel portal permits the escape of entrapped air. The downstream portal of the tunnel connects with a riveted steel inverted siphon which carries the water across Big Creek Canyon. . . .
>
> Downstream from the Big Creek siphon a 22,500-ft. tunnel completes the flow line to the point where it discharges into the north fork of Stevenson Creek. From this point the water follows the natural stream bed of this creek to Shaver Lake.
>
> One of the unique features of this latter portion of the conduit is the diversion of the Pitman Creek waters into the tunnel at the point where the creek bed crosses over the tunnel. The flow in the creek is confined to the center of the creek bed by wing walls and is guided to a horizontal trash grating through which the water falls into a 185-ft. vertical shaft which conducts the water into an offset chamber at one side of the tunnel. The water then runs into a long chamber the top of which always is above the hydraulic gradient of the main tunnel, and the air that is compressed by the falling water is allowed to separate from the water and escape through an air vent to the ground surface above.
>
> Shaver Lake reservoir is formed by a gravity dam across Stevenson Creek, 183 ft. high, 2,222 ft. along the crest and 123 ft. thick at the base. The completion of this dam in 1927 increased the reservoir's capacity . . . and made it the largest of the three reservoirs on the Big Creek project.
>
> A 250-ft. overflow spillway at the center of the dam with its crest 1 ft. lower than the top of the dam takes care of any water in excess of the capacity of the reservoir. However, it is not intended to spill water in any great amounts from this reservoir because the inflow can readily

be regulated. Excess water can be better disposed of in large quantities from the higher reservoirs, Huntington or Florence Lakes.

A single sluiceway is provided at the base of the dam with two 3.5x5-ft. sluice gates in series. These gates are so arranged that the upper one can be bypassed and operated as a balanced gate. This arrangement was used in order to have one gate in reserve in case of failure of the other. The gates are operated by admitting high-pressure oil to operating cylinders mounted above each gate leaf, the necessary pressure provided by electrically operated screw pumps controlled from a drainage gallery within the dam.

Water enters the Big Creek 2-A intake tunnel through a rectangular trash rack at a maximum velocity of 0.15 ft. per sec. Velocity increases to 6.5 ft. per sec. at the first section of the tunnel. Head-gate control is provided by means of a 6x9-ft. slide gate, the operating hoist for which is in a gate house about 150 ft. vertically above the valve itself. The gate is actuated by a crosshead rigidly fastened to the gate stem and driven through gears by a 35-hp. electric motor. The operating time to move the gate between extreme positions is ten minutes. The 2-A tunnel is about 13,800 ft. long and 11x7.5 ft. in section. . . .

A single penstock extends from the tunnel portal more than a mile down to a point just above the power house where it is split into two lines by a 66x48x48-in. wye-lateral. Each of these two lines is again split by 48x34x34-in. wye-laterals to provide water to the two impulse wheels of each unit. The pipe varies in diameter from 108 in. at the top to 66 in. at the first wye-lateral. The upper portion is of riveted steel, the middle portion is banded pipe and the lower portion forged seamless pipe.

An electrically operated 102-in. butterfly valve at the top of the penstock immediately outside the tunnel portal can be operated by remote control from the power house, by hand control in the valve house or by an automatic closing device. . . .

The four 34-in. lines to the waterwheel nozzles enter the power house at an angle of 30 deg. with the horizontal, the water from the nozzles striking the impulse wheels at this same angle. Four gate valves of the follower-ring type just inside the power house walls permit a smooth and uninterrupted flow of water when open, due to the follower ring which fills the position the disk occupies when the valve is closed. . . .

The two 56,000-hp., horizontal double-overhung, single-jet impulse units are designed to operate at a speed of 250 r.p.m. (50 cycles) under an effective head of 2,290 ft. Provision has been made to change over to 300 r.p.m. for 60-cycle operation whenever it may be desired to feed the electrical output of plant 2-A directly into that portion of the Southern California Edison distribution system which operates at 60 cycles. . . .

One unit was designed by the Allis-Chalmers Company and the other by the Pelton Water Wheel Company, both to meet the same general specifications and both with high efficiency guarantees. Since the two generators are made by the same manufacturer and since all operating conditions affecting the two units are exactly comparable, the waterwheel manufacturers have made great efforts to attain the highest possible operating efficiencies. Research in waterwheel design and operation, stimulated by this situation, has paved the way for refinements in design which constitute a definite step in advancement.

To justify the manufacturers in making the expenditures required for this research work, substantial bonuses will be granted them for efficiencies realized over and above the guaranteed efficiencies. This arrangement is only fair since an increment in overall operating efficiency means a substantial net gain in productive capacity to the Edison company.

The Allis-Chalmers unit takes care of sudden load rejection by a jet-deflecting nozzle actuated by a governor-controlled servo-motor. The full energy of the deflected jet as well as that of the full jet at run-away speed is dissipated by a special baffle or "energy absorber" mounted in each wheel pit. . . .

In the Pelton design sudden load rejection is cared for by means of relief valves which are mechanically interconnected with the main needles and which can be operated either "water-saving" or as synchronous bypasses. These relief valves may be operated either directly by hand or by a motor mechanism controlled from a local station. . . .

The Allis-Chalmers governor was designed to have a full-stroke closing time of 3.5 sec. Opening time from a closed position is adjustable. To insure reliability of operation and to mitigate the "bump" which occurs when the splice in the governor driving belt passes over the governor pulley, two separate driving belts are provided. The Pelton governor has a direct-connected mechanical drive operating through a set of spiral gears and a set of bevel gears interconnected by a countershaft running on ball bearings. . . .

The Building and Electrical Equipment

The plant No. 2-A building is a steel-frame, reinforced concrete building, two stories lower in height than the old plant 2 building because all of the high-tension bus and switching equipment is mounted outdoors. . . .

Two 150-ton cranes, each with a 15-ton auxiliary hoist, serve the entire generator floor. A railroad spur enters the building to enable the direct handling of heavy equipment and a transfer arrangement permits the plant No. 2 transformers to be brought into the 2-A building for handling with the crane. . . .

The main electrical circuits of plant 2-A are very simple indeed. The two generating units operate in parallel on a single low-tension bus through duplicate sets of oil circuit breakers. Connections between the low-tension bus and the low-tension windings of the main transformer bank are rigid and the bank, electrically speaking, is practically a part of the low-tension bus. On the high-tension side of the bank a single oil circuit breaker together with the necessary disconnecting, bypass and grounding switches serve both for normal operation and for protection purposes. . . .

The two Westinghouse generators are rated at 45,000 kva., 11-12.5 kv., with a reactance of 15 per cent. These two machines are designed for operation either at 50 or 60 cycles since the transmission system serves some 60-cycle distribution areas although, of course, the great bulk of the load is at 50 cycles. Thus the units have a double speed rating of either 250 or 300 r.p.m. according to the service required of them. Assuming a 40-deg. ambient temperature, the maximum continuous rating of each of these machines is 52,000 kva. at 50 cycles and 58,000 kva. at 60 cycles. Of the 273-ton total weight of each unit

186 tons are in the generator rotor and shaft and 27 tons in each of the two water wheels on each unit. The shaft itself weighs 43.5 tons and varies in diameter from 40 in. at the center to 24 in. at the waterwheel hubs. . . .

The high-speed generator field excitation and control system adopted for plant 2-A is known as the "exciter-rheostatic" or "pilot-exciter" type. With this system of excitation the main exciter is not self-exciting in itself, but depends for its field excitation upon a smaller pilot exciter. Both of these exciters are mounted in tandem on an extension of the main generator shaft. In this particular case the main exciter for each unit is rated at 375 kw., 250 to 290 volts, while the pilot exciter is rated at 4 kw. . . .

The main leads from each generator are conducted through cable tunnels to small annex buildings on the stream side of the power house, one opposite each of the two generators. These small buildings house the generator switching equipment and the automatic voltage regulators for the related units. Two Westinghouse type 0-44 25-kv., 3,000-amp., automatic solenoid-operated oil circuit breakers are provided for each of the generators. These breakers have an interrupting capacity of 87,000 amp. at 11 kv. and each may be isolated by a double set of gang operated 15-kv., 3,000-amp., E.E.E. remote control disconnecting switches. In each case both sets of disconnecting switches are operated at the same time and are mechanically interlocked with the related oil circuit breakers to prevent a wrong sequence of operation.

A short section of 11-kv. bus in each of the two small annex buildings, together with the outdoor portion of 11-kv. bus which traverses the outdoor transformer bay, comprise the "sum total" of 11-kv. bus. Disconnecting switches immediately inside each of the annex buildings and adjacent to the wall bushings permit the isolation of either end section for maintenance or inspection.

As mentioned before, the outdoor portion of the 11-kv. bus is tied solidly to the low-tension windings of the transformer bank. The transformers are four in number (one serving as a spare) and they are placed on a platform on the tailrace side of the power house between the two previously mentioned annex buildings. These are General Electric transformers and each is designed with a capacity of 30,000 kva., with a voltage rating of 11-12.5/127 kv., a reactance of 12 per cent and for operation at either 50 or 60 cycles. The bank is connected delta on the low side and star on the high side with the neutral solidly grounded.

Transforming cooling water is pumped from the station cistern, duplicate pumps being installed to assure continuity of supply. In case it is impossible to use either pump, emergency cooling water may be taken from the header which supplies the waterwheel of one of the main exciters in power house No. 2. . . . [Electrical West 1928:252-266].

Expansion of Powerhouse No. 8, 1929

Completion of the Powerhouse No. 2A system, including the expansion of Shaver Lake, increased the amount of water available to the two powerhouses (No. 3 and No. 8) lying below this point on Big Creek. One of these facilities, Powerhouse No. 8, was originally planned with the built-in option of doubling its capacity by installing a second unit at a later time. Since additional water was now available, work was undertaken on this installation during the first half of 1929. A second Francis turbine with generator attached was installed in June of 1929, adding another 35,000 kva. to the Big Creek System (Plate 55) (SCE 1929b:12, 1955b:n.p.). The expansion of Powerhouse No. 8 cost about 1.6 million during 1929 (SCE 1929b:12).

Social History of the 1920s

With up to 5000 Edison employees scrambling over an area of hundreds of square miles building a Hydroelectric System without rival in California, the Big Creek area during the 1920s was bound to have had an interesting social history. Despite the hectic nature of construction activity, a growing sense of stability and permanence characterized the community during the 1920s. Most of Edison's workers arrived at Big Creek simply to do a job, but many of them were so taken by the area's beauty and the excitement of such a grand project that they planned to settle down permanently with their families. As George C. Ward, Vice President of Southern California Edison said of the work force in 1925, "many of the men who went to Big Creek in December, 1911, when this vast power project was started, are still living there, and they hope to remain there until the last drop of water has been put to work for the Southland" (Los Angeles Daily Times, February 19, 1925:1). As a result of this influx of workers, the town of Big Creek became quite a growing concern. Edison employees occupied a large portion of the town, providing a ready market for goods and services furnished by the commercial section of town. At the same time, construction activities went on for such an extended period of time that even construction camps and camp life became much more settled. Many more facilities were available to those men stationed at the camps than in early construction years, and in time, as another sign of the growing sense of stability, permanent structures were built near the newly constructed powerhouses.

Development of Big Creek Town

By 1923, the town of Big Creek (called Cascada until the mid-1920s) had developed into two distinct towns: a company town (the lower part) and a private town (the upper part). The company or lower part of town, which consisted of approximately 50 acres, was separated from the upper, private section by a tramway for the incline railway. A partial list of Edison structures at this time included administration buildings, an accounting department, warehouses, a general store, shops, a garage, and recreation halls (Plate 56). For housing its personnel stationed at Cascada/Big Creek, Southern California Edison built bunkhouses and dormitories for single men and permanent homes for engineers, department heads, and operators. This section of the town was built on ground covered by the special use permit issued to the power project by the Forest Service (SCE 1923b:14).

As one young couple who came to live at Big Creek in 1918 described accommodations provided by the company, "Our house consisted of three rooms and a 'path'; we had a fenced yard with lawn and garden space" (Glenn 1975:27). While admittedly it would seem meager by today's standards, this couple was lucky to get a house, because at the time the number of modern cottages was limited, with most of the camp being described as "early American."

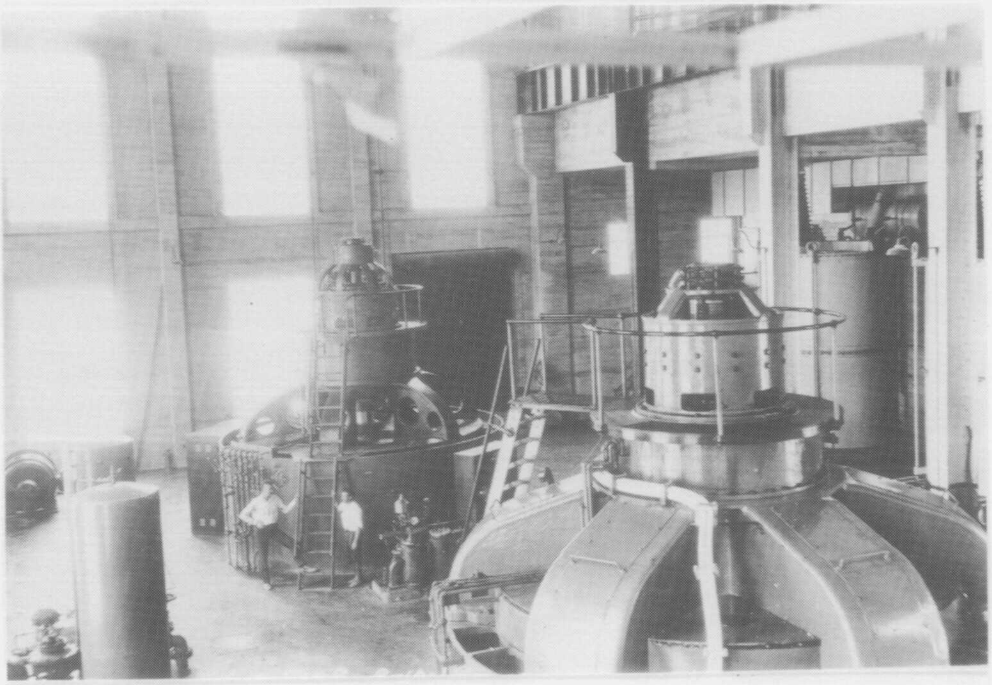


Plate 55 Generator floor of Powerhouse No. 8 after the installation of the second unit (left), 1929 (SCE var. [b]:Album 2, No. 49–15946).

Across from the incline railway lay the incorporated, private town, consisting of 25 acres. This land, like the area where the company town was located, was held by the Forest Service and used under a special use permit. Here, there were department stores, a theatre, pool hall, dance hall, and fraternal lodges (Plate 57) (SCE 1923b:14). This area also had a bakery which was, by all accounts, no ordinary bakery: a typical month's output was 55,000 loaves of bread, 5000 cakes, and 36,000 pies (Schiebelhut 1977:n.p.).

In addition to commercial establishments, the private town also had many "comfortable cottages" which had been built on government land by private owners. These were occupied by Edison employees and others who had chosen the town for their residence because of company activities (SCE 1923b:14).

By 1923, Southern California Edison's publication, *Edison Partners*, was touting Big Creek as "the electric city," proclaiming that it was a thoroughly equipped city of 1400 with "a regular city government, peace officers, and a fire protection system" (1923b:14). The opening of a new school at Big Creek in 1922 sparked this article in the October 10, 1922, *Fresno Bee*:

> The opening of the new schoolhouse marks another progressive stride in the development of Big Creek from a construction camp of the Southern California Edison Company to its present population of 1,200 persons within a few years.
>
> . . .
>
> A suitable home for teachers also is supplied by the Edison Company [as cited in Dow 1967:304].

At this time, the school had 80 students in 10 grades, taught by four teachers (Plate 58). By 1923, the number of pupils had jumped to 150 (SCE 1923b:14).

As Big Creek grew, the town's residents attempted to disenfranchise themselves and their town from the Forest Service's administration. In September 1924, as a result of disputes with the Forest Service over the practicality of year-to-year leases for Big Creek's businesses and residents and the manner in which the Forest Service administered those leases, Big Creek residents asked the Department of Interior to create a townsite for Big Creek. At the time of this action, the town consisted of 115 lots: 70 lots with frame dwellings; eight lots with two cottages on each; one lot with four cottages; and three lots with combined apartment houses and store buildings. The remaining lots were occupied by a hotel, theater, school, steam laundry (Plate 59), lumberyard, butcher shop, hardware store, pool hall, general store, post office, dry goods store, tailor shop, garage and store, United States ranger station, offices of the Forest Service, and Moose and Masonic lodges (Fresno Morning Republican, September 28, 1924a:1A). In January 1925, the application to create a townsite of Big Creek was denied.

Looking back on the history of Big Creek, a newspaper article elaborated on what it was like there during the 1920s "boom times."

> . . . the main street of Big Creek then was crowded with places of business, including a hardware store, butcher shop, bakery, laundry, dry goods store, art shop, three barber shops, real estate office, movie

Plate 56 General offices and dormitories (upper floors) at Big Creek, February 1923 (SCE var. [b]:Album 4, No. M19–8525).

Plate 57 Pool Hall at Big Creek, 1923 (SCE var. [a]:Unnumbered Album, No. 9460).

Plate 58 Schoolhouse at Big Creek, 1923 (SCE var. [b]:Album 10, No. 12006).

Plate 59 Laundry at Big Creek, 1924 (SCE var. [b]:Album 10, No. 12227).

theatre, restaurant, six dentists' offices, two garages, a general merchandise store, beauty shop, and women's apparel store.

Every two weeks, three Fresno banks sent representatives to cash checks and receive deposits [Fresno Bee, February 27, 1955:12A].

In 1926, the town's name was officially changed from Cascada to Big Creek--the name it had been called popularly for years. The man most responsible for this change was Edison Company President John B. Miller, who thought that the name Big Creek sounded more like the rugged outdoors (Shiebelhut 1977). Of course, the fact that there was another Cascada in the state (which received more than its fair share of mail) probably gave some impetus to the decision as well.

During the Roaring Twenties, activities were varied in the Big Creek area. According to David Redinger, a favorite eating place was Carlson's Hotel, located near present-day Camp Sierra, with the favorite meal being Mrs. Carlson's famous chicken dinner (Redinger 1949:27). Al and Louise Schiebelhut reported that Mah Jong was a popular game, movies shown once or twice a week in the local theatre had a good attendance, and boxing bouts were much in demand (Schiebelhut 1977:n.p.). According to one consultant, silent movies shown in the theater were accompanied by a lady playing the piano, and when there were no movies, the hardwood floors of that same edifice made for a handy roller rink when the chairs were pushed back. Another consultant had been told about Model-T races on frozen Huntington Lake during construction days (TCR Field Data 1986). Commenting on local entertainment, a woman who resided in the area for a number of years said that, during those days, "All you needed was a couple of people to make a party" (TCR Field Data 1986).

The atmosphere at Big Creek during construction days was described by one consultant whose family came to Big Creek in 1924. Although she was just a child at the time, she remembered her arrival at Big Creek, when men and dogs were fighting in the streets and her mother wanting to "turn right around and go back." She remembered that period as a time when the men were "hard drinking and hard playing," and even during prohibition, liquor was easily obtained from bootleggers (TCR Field Data 1986).

Judging from newspaper articles, Big Creek was also a popular meeting place for fraternal lodges. According to the *Fresno Morning Republican* (September 28, 1924b:7B), several hundred members of the Order of the Elks had converged on Big Creek for their initiations, and "a program of stunts and entertainment was put on . . . in addition to a big banquet."

Camps and Camp Life

Construction camps on the Edison expansion projects were of two types: permanent camps above the snow line, located primarily along the Florence Tunnel alignment and at the Florence Dam site; and temporary camps, made up of canvas tents, located at lower elevations where the powerhouses were to be built. The camps were numbered one through 73 as they were erected. During the peak of construction, 32 of these camps were in operation, housing over 5000 men employed by Southern California Edison (Schiebelhut 1977:n.p.; SCE 1923b:4).

Starting with the camps established for Shaver Lake Tunnel in early 1920, Southern California Edison began experimenting with portable-frame bunkhouses which could be shipped in sections. These portable houses were so successful that the company began using them at other construction locations, and even to house families living in the town of Big Creek (Redinger 1949:79–80). Because the construction sites of powerhouses No. 8 and No. 3 were at lower elevations, it was possible to use canvas tents in the camps. However, because of the steep terrain, the company was obliged to construct these camps on stilts along the steep canyon of the San Joaquin River. Occupants of these camps were given the nickname "cliffdwellers" (Plates 60 and 61) (SCE 1923b:4). On September 28, 1924, the *Fresno Morning Republican* ran a picture of one of these construction camps with the caption, "No Place for Sleepwalkers" (1924:12). Interestingly, during the initial construction period 12 years earlier, the paper had reported an accident (at the same camp as the picture) under the headline, "Walks in Sleep; Falls Down Cliff" (Fresno Morning Republican, May 23, 1912:20), graphically illustrating the potential hazards of residing in such a dwelling. Photographer Myron Glenn wrote that Camp No. 35, near Stevenson Creek, "looked like a series of beehives, with stairways leading from one level of tent houses to the next. . . . The narrow road was the only level ground in the camp" (Glenn 1975:39).

Supplying food to a crew of over 5000 men was as major an accomplishment as it was an expense, since each month more than 450,000 meals were served to Big Creek workers (Plates 62 and 63) (Collins n.d.:656). For instance, just during the five years that Florence Tunnel was being drilled, the workers consumed 120 tons of butter, 357 tons of sugar, 200,000 pounds of coffee, 4,175,000 eggs, 106,000 gallons of milk, 1.1 million pounds of flour, 885 tons of potatoes, 450,000 pounds of smoked meat, and 1000 tons of fresh meat (Myers 1983:113). The beef and mutton were "driven in on the hoof to the workmen's camps, slaughtered there, and put into cold storage" (Collins n.d.:656). Since potatoes were such an important part of the Big Creek diet, Fred Henry, Edison's purchasing agent, sent a man to Idaho to be on the spot when the potatoes came out of the ground (Redinger 1949:121).

One of the practical problems encountered at these distant camps was what to do with the substantial amount of garbage generated by such monumental food consumption. Soon, however, someone hit on the idea of raising hogs—and from that point on, not only was garbage kept to a minimum but camp residents had a fresh pork supply (Redinger 1949:83–84 and 1949:119–120).

For those working on Florence Lake Tunnel, meals were not always served in the camp mess hall. As the boring proceeded farther and farther into the mountain, it became impractical to bring the men out for their mid-shift meals (work went on around the clock). The solution to the problem was simple—meals were sent in to the men by train. These trains consisted of "five electric-lighted flat cars—three equipped with tables and benches, the other two with racks holding the food in hot containers" (Plate 64) (Redinger 1949:123).

Consultants reported that employee turnover was high during this period, as illustrated by the joke that there was always "one crew working, one crew going, and one crew coming" (TCR Field Data 1986). While rapid turnover was bound to occur because of the rough duty, Edison did its best to "make conditions as agreeable and pleasant as possible" by providing a commissary, recreation halls, and libraries, as well as by sponsoring dances and athletic events (Arthur and Meyer 1924:94). Movies, too, were very popular at the camps, and one author who visited the area described how they were shown:

Plate 60 Camp above Powerhouse No. 3, 1923 (SCE var. [a]:Album 7, No. 8529).

Plate 61 Cliffside campsite, ca. 1920 (SCE var [a]:Misc. Photographs, No Number).

Plate 62 Kitchen at Big Creek, 1923 (SCE var. [a]:Unnumbered Album, No. 9470).

Plate 63 Dining Hall at Camp No. 72, 1925 (SCE var. [a]:Misc. Photographs, No. A360).

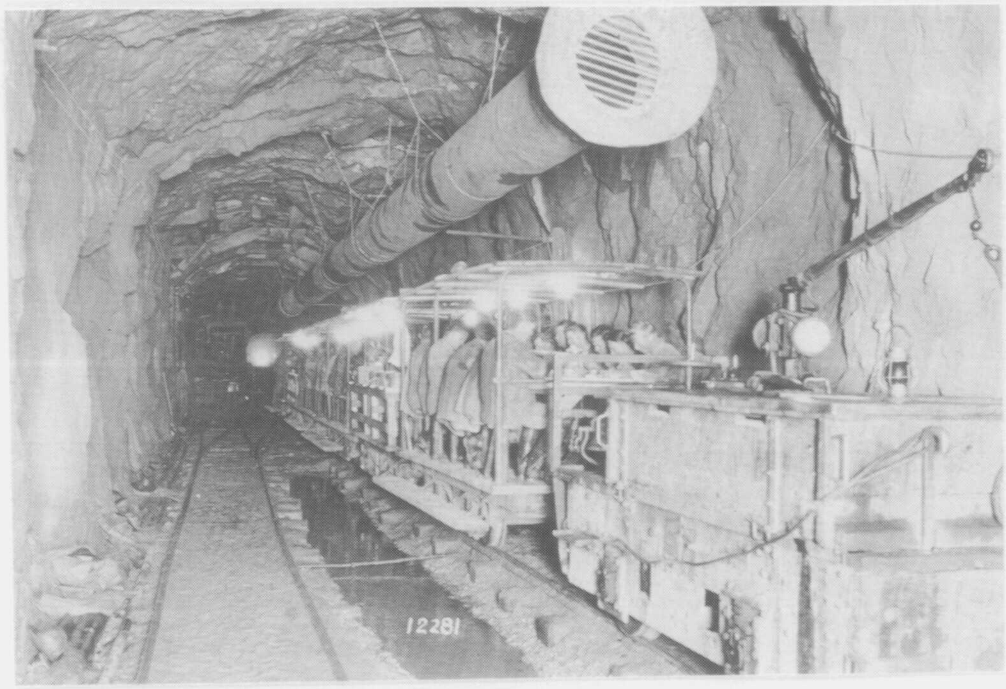


Plate 64 Lunch train at the Florence Tunnel heading, July 1924 (SCE var. [b]:Album 1, No. 32–12281).

> Once, and sometimes twice, a week in each of these camps the company provides a free motion picture performance for the workmen. A portable projector and a light automobile made the tours of these camps on regular schedules and gave the men an exhibition almost identical with those seen in motion picture houses in the cities and towns. It consisted of a news reel, a comedy and a drama. . . . Some of these exhibitions were given in the open air during the warm summer nights.
>
> . . . once . . . the cinematographers' outfit and films were conveyed 30 miles over mountain tops on a big sled drawn by a team of Alaskan dogs over a road drifted 20 feet deep with snow and impassable for horses [Lyons 1925a:10].

While not all camps were equipped with such "luxuries," each had to be self-sufficient, containing at least a mess hall, some form of recreation, and other facilities such as machine shops for equipment repair. As an example, Camp No. 61, the main camp for construction of Florence Lake Tunnel, consisted of several two-story bunkhouses for single men, cottages for families, large mess hall, cook house, bakery, machine shop, maintenance garage, and hospital (Glenn 1975:43).

In addition to the benefits afforded their employees working in the construction camps, Edison began building permanent dwellings, located near the new powerhouses, for operators and other personnel. In 1924, the company initiated plans to construct 24 new structures at a cost of between $75,000 and $100,000. By December 1924, Southern California Edison architects had produced a standard design for the new residences, and the company began negotiations for their construction (Los Angeles Daily Times, December 21, 1924:V5).

The social history of the years of great expansion in the Big Creek area indicates important changes in the way these people lived and worked together. The growth and development of the thriving town of Big Creek and of the numerous construction camps and related facilities reveals a more stable, permanent community than had been evident in the early years. It was not enough, as it had been before, to house workers in crude dwellings with straw for mattresses; by the 1920s, Southern California Edison employees and their families required much more. The company responded to these new requirements with new and better benefits to their employees, and, as a result, a sense of community developed.

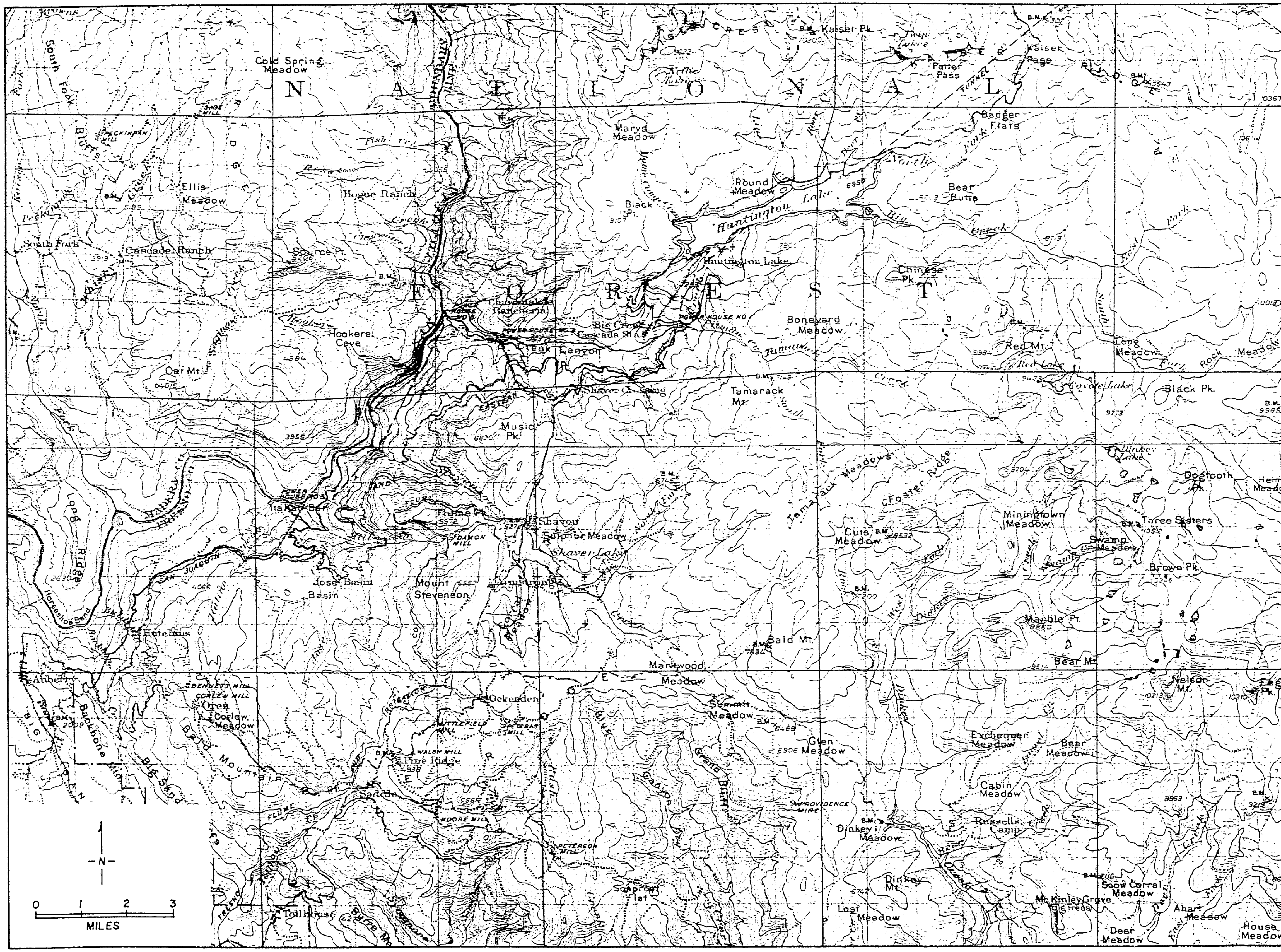
Conclusion: The Completed System, 1929–1930

Achievements of the great expansion of the 1920s were substantial. Coming into this decade, the Big Creek System included only two powerhouses, although both of them were large, expensive to build, and important examples of the hydroelectric art. However, by the end of the 1920s, three additional powerhouses had been added, more than doubling the potential output of the System. In 1920, the Big Creek System had five dams (four of them at Huntington Lake), and during that decade, six more dams (two of them major) were built. Only two tunnels existed in 1920; by 1929 four new, major tunnels had been added. Penstocks, incline railroads, roads, and camps were also increased in similar proportions during this decade. The result was a classic Hydroelectric System, the largest and most important in

California during this period (1911–1929). Map 9 illustrates how the western part of this System appeared in 1923, pinpointing the location of the San Joaquin and Eastern Railroad line, powerhouse sites, tunnel lines, Big Creek town, and other facilities. Investment in this complex System (including transmission lines) between 1911 and 1929 years amounted to about 120 million dollars, which was about 40 percent of the total value of all operating property of Southern California Edison at the time (Electrical West 1928:255).

The Big Creek region underwent a substantial transformation between 1911 and 1929. An area of several hundred square miles, which in 1911 was unmarked except for a few trails and even fewer primitive roads, became the scene of one of the great hydroelectric workshops of the world, with its mosaic of powerhouses, tunnels, dams, penstocks, camps, roads, and railroads. The System ran from Florence Lake at over 7,300 feet to Powerhouse No. 3 at about 1,400 feet. A diagrammatic profile (Figure 2) illustrates the main features of the Big Creek System as of 1928, and Table 1 summarizes the head, horsepower, and generator capacity of each powerhouse as of 1930.

However, with the installation of Powerhouse No. 8's second unit in 1929, the great expansion came to an end. Demand for power in Los Angeles was tapering off as the economy experienced the problems which eventually led to the Great Depression of the 1930s. Plans for further development (Powerhouse No. 4, for example) were put on the shelf, and the Big Creek region headed into a quiet time when production and maintenance of the existing System became top priorities.



MAP 9 -BIG CREEK HYDROELECTRIC SYSTEM 1923- U.S.G.S. Kaiser Quadrangle

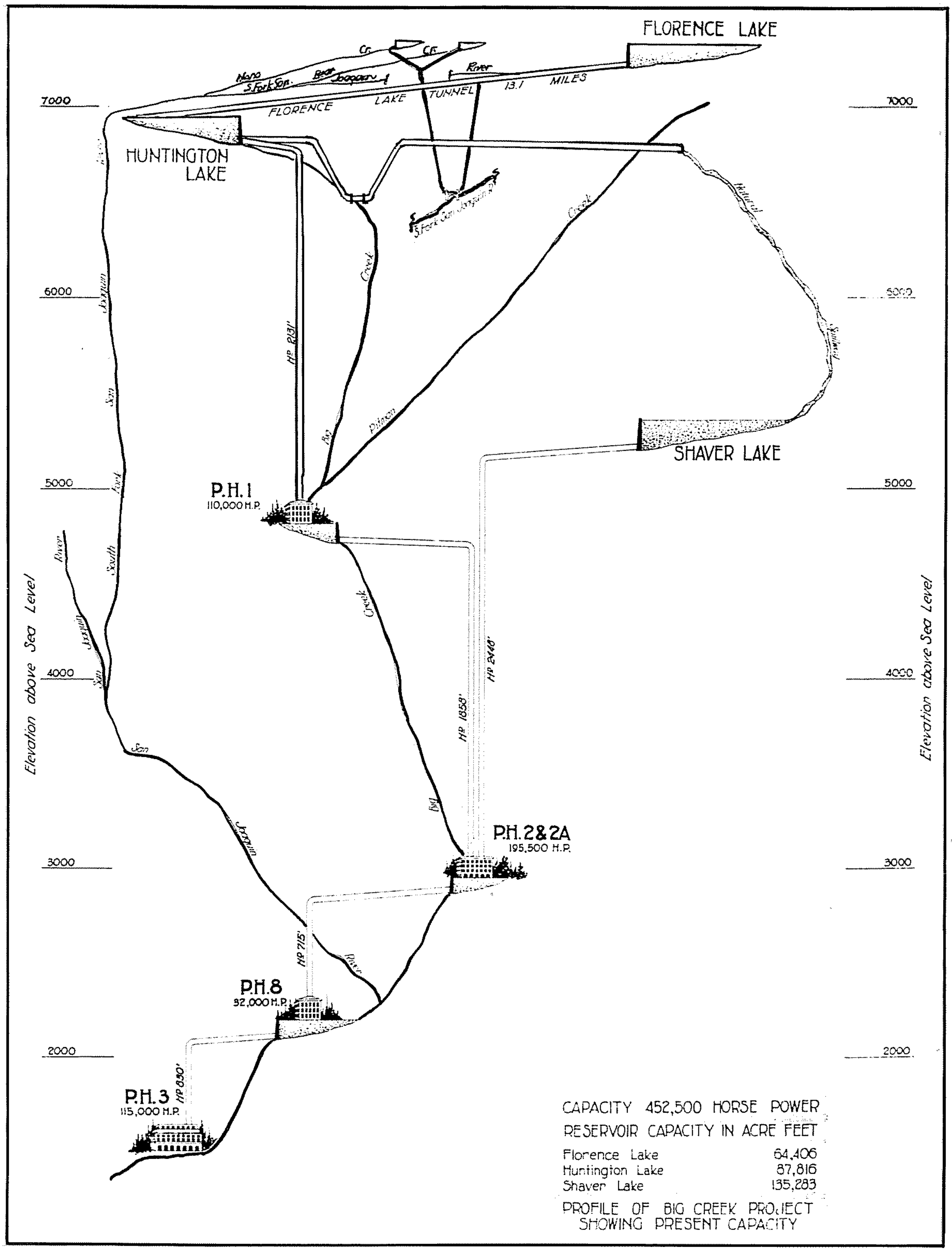


Figure 2 The Big Creek System in 1928 (SCE 1928b:8–1).

TABLE 1

CAPACITIES OF BIG CREEK POWERHOUSES, 1930

(McGraw-Hill 1930:31; SCE 1933:3)

Powerhouse	Generator Capacity (kva)	Hydro-turbine Capacity (horsepower)	Head (feet)
Number 1	80,500	110,000	2131
Number 2	70,000	88,500	1858
Number 2A	90,000	124,600	2415
Number 3	84,000	115,000	830
Number 8	60,000	77,700	715
Total	384,500	515,800	7949

PART III

RECENT TIMES AND A NATIONAL REGISTER OF HISTORIC PLACES EVALUATION

The final section of this report on the Big Creek Hydroelectric System focuses on the period since 1930, and also offers an evaluation of the historical significance of the Big Creek System. The period since 1930 is important mainly due to the need to trace developments and changes at Big Creek and its environs down to the present. Knowledge of the fate of the classic Hydroelectric System constructed during the 1911–1929 years is crucial for the historic evaluation undertaken in the final chapter.

CHAPTER 7

PRODUCTION AND NEW CONSTRUCTION: THE BIG CREEK SYSTEM SINCE 1930

In the decades since 1930, two themes have been dominant in the history of the Big Creek Hydroelectric System. These themes are production—including the infrastructure and social institutions needed to attract and keep a talented work force—and new construction. These two themes have alternated as the central ones during the decades since 1930. During the decade and a half following the completion of Powerhouse No. 2A , the main focus of activity at Big Creek was production—the desire to get maximum output from the five existing powerhouses. This emphasis continued throughout the Depression and World War II, but once the post-war economic boom began to be felt in southern California during the latter part of the 1940s, the need to again expand the Big Creek System became manifest. Therefore, the 1947-1960 years were marked by frequent episodes of new construction, as Powerhouse No. 4, Portal Power Plant, and Mammoth Pool Powerhouse were designed, built, and brought on line. At the same time, three new dams (Dam No. 7, Mammoth Pool Dam, and Vermilion Valley [Lake Thomas A. Edison] Dam) were constructed in order to increase the water resource base needed to operate the expanded System.

Following completion of the Mammoth Pool project in 1960, the stress on production returned until the late 1970s, when plans were again made for new construction at Big Creek. Work on the expansion of Powerhouse No. 3 commenced in 1978, and on the Balsam Meadow project in 1983. Also, a small "fish water" generating unit was installed at Shaver Lake Dam in 1982. Finally, a large-scale expansion of the Big Creek power plants is currently under consideration.

An Emphasis on Production: 1930–1946

As has been seen, the years between 1911 and 1929 saw massive construction at Big Creek. The decade and a half which followed the end of this construction effort were as quiet as the previous era had been frantic. Once the work of the construction army was complete, population sank from several thousand to several hundred. Furthermore, labor turnover was slight during the Depression decade of the 1930s; jobs were scarce. In contrast, the World War II years were marked by high labor turnover due to drafting of employees for service in the armed forces. The threat of sabotage during World War II also resulted in the stationing of United States Army troops, and later the National Guard, in the Big Creek region. Access to the area was sometimes restricted because of this national emergency.

Despite the small population and relative inactivity during the 1930-1946 period, it was nevertheless an important era in Big Creek history. During these years, Edison employees who stayed at Big Creek as the operating force solidified their status as a close community, developing their own activities and organizations. These organizations included the Edison Company hierarchy itself, as well as boarding houses, schools, social clubs, and a commissary. Activities included, first and foremost, the work necessary to maintain the Big Creek

Hydroelectric System at maximum productive efficiency, but also consisted of the economic, social, and recreational needs of this small community. This section, then, will detail development of the Big Creek community in all its aspects, as well as pointing to the production of electricity as its main function and reason for being.

Social Life in the Great Depression

Big Creek in Decline

The end of construction following completion of Powerhouse No. 2A in late 1929 was reinforced by the Wall Street crash in October of that year, which announced, in effect, the beginning of the Great Depression. The Depression of the 1930s resulted in a basically static situation in regard to demand for electricity, temporarily ending any plans for further expansion of the Big Creek System. At the end of 1929, Edison had an operating work force in the Big Creek Division of 190 men (including 42 temporary employees), a commissary which was moved to Big Creek town in that year, and three boardinghouses at powerhouses No. 2, No. 3, and No. 8 (SCE 1930:7). Social clubs already existed at each powerhouse, and "a number of elaborate parties [were] given which were well attended" (SCE 1930:6). The impact of the Depression soon hit Big Creek, however, as Edison had to trim its work force, put retained employees on a short work week, and reduce wages (Glenn 1975:85; SCE 1932:1). By the end of 1930, the number of employees had been cut to 136, and by the end of 1931 to only 126 (SCE 1932:1). The boardinghouse at Powerhouse No. 8 was also closed during 1931, due to the small number of single men working there. Boardinghouses at powerhouses No. 1, No. 2, and No. 3 remained in operation, as did the commissary, which served 80 families and 36 single men in 1931 (SCE 1932:6). These cutbacks were reinforced by other cutbacks, and two serious fires at Big Creek town during late 1930.

The worst of these fires began in October of 1930 when, according to the story, two young men were trying to "make a fast buck" by burning the insulation off copper wire using the furnace in Murphy's Art Shop. Lack of water pressure and the fact that the buildings had been built hastily and close together during the 1920s boom period caused the fire to spread rapidly, and, within a short time, the business district had been virtually leveled. Eighteen months later another fire burned three or four additional buildings, leaving only a small part of the business district intact (Bush n.d.:73–74; Glenn 1975:85, 87).

While some people chose to rebuild, others did not. For C. J. (Aggie) Aggergaard, the fire at Big Creek was particularly devastating—he lost the post office, the store, and his home. As a result, Aggergaard decided to retire and his clerk, Ernest Rassmussen, was given a permit to rebuild the store (Bush n.d.:77; Glenn 1975:87).

At the same time, the Forest Service cancelled 24 of Southern California Edison's Special Use Permits that had been issued during the construction period, thus reflecting the general decrease in company holdings at Big Creek. These cancellations included permits for construction and maintenance of roads, structures, and telephone lines, as well as for Huntington Lake Hotel (Benedict 1929:1–2).

Another indication that things were slowing down at Big Creek came in 1929. After running at a loss for several years, the San Joaquin and Eastern Railroad's daily passenger service to Big Creek was changed to tri-weekly runs. This was soon followed, in May 1930, by the total discontinuation of passenger train service to Big Creek. Anticipating problems with the Railroad Commission over this decision, the San Joaquin and Eastern had, a month earlier, purchased the W. R. Miles Stage Line for $35,000 to insure that an alternate means of transportation to and from Big Creek would be provided (Johnston 1965:103–104; Schiebelhut 1977:n.p.).

This proved to be a good idea, for in 1933 the San Joaquin and Eastern Railroad Company decided to abandon the line completely. By August 1933, the railroad company had received approval from the Railroad Commission and the Interstate Commerce Commission for such a move, and all of its property was immediately sold for $50,000 to an auctioneering firm, representing a Mr. Bill Rosenthal and a group of Bay Area scrap dealers (Johnston 1965:104). Apparently, at the time of the purchase there had been talk that the scrap would eventually be sold to Japan (Fresno Bee, August 31, 1933:B1). Whether this is true or not, consultants interviewed at the time of this study mentioned the irony of possibly having their railroad melted down and sent back to them in the shape of bullets and bombs (TCR Field Data 1986). While there is no further mention of the exact date of the demise of the Big Creek railroad line, by August 1935 most of the cars, rails, and ties had been removed. A consultant who worked on tearing up the line remembered that he rode four hours a day on Model-T traincars back and forth from Auberry, and was paid $3.50 per day (TCR Field Data 1986).

Wherever possible, rights-of-way for the San Joaquin and Eastern Railroad were turned back to their original owners; however, on parts of the old railroad grade, a county road was constructed from Auberry to facilitate transportation to and from Big Creek. With the loss of the railroad and the sale of the stage line to a Fresno firm, the board of the San Joaquin and Eastern Railroad Company voted to dissolve the corporation on September 26, 1936.

The Good Life

While the end of the Great Expansion and the onset of the Depression caused difficulties for some SCE employees, most of those who worked at Big Creek during this period enjoyed a relatively high standard of living. Indeed, some went so far as to say "they hardly knew there was a Depression" (TCR Field Data 1986). This was no doubt due to the somewhat sheltered existence they led—partially due to the "perks" afforded them as Southern California Edison employees. These "perks" included a company-run commissary, housing and electricity at a reduced rate, and access to medical care.

Edison was aware that there were disadvantages to living in such a remote locale, and offered Big Creek employees certain opportunities to somewhat offset this situation. Some of these advantages, like the commissary, were operated at a loss to the company, while the sale of electricity and appliances at a reduced rate increased Edison profits. The situation had benefits for both the employees and the company; while Edison's employees and their families were insulated from outside pressures by company-maintained services, Edison profited from the captive market their employees provided.

The commissary, which supplied food at cost plus 12 to 15 percent (sources vary), was one of the advantages that buffered SCE employees from the Depression (SCE 1930:7). According to consultants, the commissary provided good food at better prices than they could expect outside; and for those who lived at the lower powerhouses, all that was necessary was a telephone call to the commissary and the order would be delivered. One consultant remembered that all her mother had to do was call up and ask for "enough Swiss steak to feed the family and the butcher would know exactly what to send" (TCR Field Data 1986). When the order was received it included a carbon copy of the bill, but the amount was simply deducted from the family's pay check. While this system of deduction might seem like the easiest way, most consultants mentioned that all too frequently the wives would overspend, and there would be nothing left of the husband's paycheck after the commissary bill had been subtracted.

Dairy products were delivered three times a week to "milkhouses" located at Big Creek and the lower powerhouses. These purchases, like those made at the commissary, were deducted from the monthly pay check. According to consultants, the milkhouses were the scene of much social activity, as women would gather there to get their supplies (TCR Field Data 1986).

Another advantage offered to Edison employees at Big Creek was company-owned housing at reduced rate. In the late 1930s, rent for a company house was $25 compared to the $45 that was charged for private houses in the area. However, there were some disadvantages associated with this system—the most significant being availability. Most consultants recalled that Big Creek town as well as the lower powerhouses frequently had fewer houses than people who wanted to occupy them. Seniority and number of children were usually the basis for deciding who would get a house first. Another aspect of living in company housing was that the house belonged to Edison, and the company was very particular about housing maintenance. It was the job of the head of each powerhouse to make sure homes were kept up, and they were inspected annually. One woman remembered, when her family was up for a house, the company inquired into her abilities as a housekeeper. Another consultant recalled being "taken to task" for leaving their garage door open a couple of times too many.

Probably one of the worst things about living in company housing was the necessity of vacating the house at retirement. Many people anticipated this and either leased some land and built a house in Big Creek town, or bought property elsewhere.

The close proximity of medical care was another plus for Southern California Edison employees in the area. The Cascada Hospital was built at Big Creek in 1919, continuing to serve the community until 1952 when the building was remodeled into the Hospital Dormitory (Plates 65 and 66) (Bush n.d.:21). Additionally, in 1920 a house was built especially for the resident doctor. During the 1930s, Dr. W. N. Carter was in residence, serving employees and their families (SCE 1940:7). This was in contrast to the early 1940s when, owing to the general shortage of doctors, Big Creek was only visited once a week by a Fresno physician.

Another one of the advantages offered by Southern California Edison was the direct sale of electrical appliances to employees. The company sold a wide variety of goods, from small to major appliances. Judging from the fact that in 1936 Edison sold 303 appliances totaling $4500, the employees, although no doubt a "captive market," must have appreciated this service. On the other hand, the company benefited not only from the profit from the sales, but also from the additional 127 kilowatts of electricity required to use the merchandise (SCE 1937:10).

Plate 65 Hospital at Big Creek, 1920s (SCE var. [a]:Album 1, No Number).

Plate 66 Christmas dinner in the Big Creek hospital, 1920s (SCE var. [a]:Album 1, No Number).

On the Upswing

Some cutbacks continued during the mid-1930s, such as the reduction in boardinghouses from three to two in late April 1936, when the boardinghouse at Powerhouse No. 1 was shut down. Employees needing meals at Powerhouse No. 1 then ate at the Big Creek Hotel (SCE 1937:8). This apparently represented the end of Depression-era cutbacks, however, for in 1937 and 1938 Edison began hiring again, and a number of consultants interviewed during this study began their employment with Edison at that time. According to many of them, this influx was the start of the "Big Creek Family," when Edison employees envisioned themselves as part of a great extended family. In fact, this "family"—a community actually—had its roots in the construction era of 1911-1929 and was further developed during the 1930s.

Activities during this period reflected the focus on family and friends. Most events took place at the theater, school, Moose Hall, or clubroom of the men's dormitory. The Edison Club, which has been one of the major organizers of events from the early 1920s to the present day, provided most area entertainment. The movie theater doubled as a roller-skating rink, and dances were often held in the Moose Hall (Glenn 1975:34; TCR Field Data 1986).

Reflecting an increase in number of families and children at Big Creek town, a new school was built there in 1936 (Bush n.d.:60). The building consisted of an auditorium and cafeteria, classrooms and school office (Schiebelhut 1977). At the height of its enrollment, the school had 165 students (TCR Field Data 1986).

Another indication of this increase was the new school built in 1932 near Powerhouse No. 3, named Chawanakee Elementary School. Enrollment was low (only eight students) and the school's first graduating class of 1934-1935 consisted of only two students (TCR Field Data 1986).

Because of Edison's policy of not allowing spouses of their employees to teach school, it was very difficult to find people to teach in this relatively isolated area. Often, single female teachers that were hired would meet and marry Edison employees—thus making them ineligible to continue their jobs.

Production: The Economic and Technical Side

The social side of life at Big Creek during the Depression was only half the story of this era: maintaining production and export of massive amounts of electricity was the other half. During these years of the 1930s, the Big Creek System's annual production of kilowatt hours of electrical energy was consistently near or over the two-billion figure (SCE 1934:3, 1937:3, 1938:2, 1940:2). To maintain this level of production, routine maintenance, additions/improvements, and experimental/special development work were all required. A review of the great volume of such work would be repetitious and, in any case, unnecessary here. Only a few representative samples are required to make the general point that such work was constantly going on—even during a slow era. In 1936, for example, experimental and development work consisted of the following:

> At Big Creek #2 we had our first experience with the use of dry ice, which was used for shrinking the new bucket bolts in on Unit #2 during the re-bucketing of that unit. The old bucket bolts wer [*sic*] all

pressed out with a hydraulic press. It was found that by applying a small amount of heat to the lugs the pins would start at about 160 tons, whereas without heat 200 tons were required. Our press, although designed for 200 tons pressure, springs excessively when such a pressure is reached. It was possible to shrink the pins .0035" in about three hours. The pins were made .002" larger than the holes. The hole in the wheel disc was warmed with an oxy-acetylene torch, thereby gaining .0015" in addition to the shrinkage of the pin. The pins slipped in easily after the bucket lugs were heated. It was found that about 30 sec. was the limit of time before the pins would start to get tight.

On the left hand wheel of Unit #2 at B.C.#2A new Pelton #10 buckets were installed. New design nozzle assemblies with contracting tip needles were installed on both turbines of this unit. The new throat rings and needle tips being of stainless steel. Mr. Woodman has given full details in his report. Efficiency tests made on this unit after the installation of the new buckets, nozzles and needle assemblies etc. were quite disappointing to all concerned.

Reference has already been made to the portable radio sets, one of which was placed at Florence Lake late last fall and the other in the dispatcher's office at Big Creek #3. They have been satisfactory at times especially at night but not satisfactory in the day time between Florence Lake and the dispatcher's office [SCE 1937:4–5].

In 1936, maintenance and improvements ("Additions and Betterments") for the Big Creek System consisted of the following:

Big Creek #1

1. Installation of new governor trips on Allis Chalmers Units.
2. Installation of Warren Master Clock in gallery.
3. Completion of new Club House.
4. Painting 60" flow line.
5. Installation of new 24" by-pass valve at Huntington Lake Intake.
6. Dam #2 was back-filled on the down stream side and about 7,000 cu.yds. added to Dam #3.
7. Construction of new sectionalizing house near east end of Dam #2 and rerouting of cables.

Big Creek #2-2A

1. Relocation of governor position selsyn indicators.
2. Relocation of Venturi Meters.
3. Purchased two new General Electric arc welding machines.
4. New scaffold and supports constructed for intake structure Dam #5.
5. Changed insulator pins on forebay control line.
6. Installed new governor trips on Units #3 and 4.
7. Addition of new rubber runners on floors.
8. Replacement of generator meter registers and watt hour meters.

Big Creek #3

1. Installation of ball bearing flyball assemblies on all main governors.
2. Completion of replacement of all rubber covered wire in switch garden circuits with lead covered cable.

3. Painting of four cottages; their garages, dormitory, five and ten stall garages.
4. Painting of penstock surge pipes.
5. Concrete retaining wall near west end of Power House was repaired.
6. Equipped last two 11 kv. generator oil switches with Deion grids.
7. Large hole for drainage was cut through the wall near #4 Unit location.
8. Commenced rewiring main switchboard panels.
9. Re-shingled roofs of three cottages and dormitory.
10. Commenced construction of one new cottage and alterations of dormitory to provide quarters for two families.
11. Replaced old hydraulic grease rams for turbines with a portable Alemite unit.

Big Creek #8

1. Replacement of cast iron gear wheels at Dam #6 with steel.
2. Strengthened foundation by filling several open chambers beneath turbine floor with concrete [SCE 1937:15–17].

The above list is indicative of the great volume of maintenance and replacement work which was ongoing throughout this quiet era.

War and Early Postwar Years, 1940–1946

Rehearsals for World War II were ongoing during the 1930s when the Japanese invaded Manchuria and China, Italy invaded and conquered Ethiopia, and Spain was embroiled in a civil war in which Germany, Italy, and the Soviet Union were all seriously involved. The rehearsals became a full-scale world war officially in September 1939, and with Germany's successful blitzkrieg against France and its allies in May–June 1940 they were put into practice. These distant events, in what was in effect a world-wide struggle for supremacy, soon began to influence life and work at Big Creek. A draft law was passed in Washington, D.C. in mid-1940, and people began to fear sabotage by the nation's enemies. As the 1940 report of the Northern Division of Edison's Hydro Generation Department, headquartered at Big Creek, expressed it:

> Due to general unsettled conditions, guard service was established at Big Creek in July. Six guards, deputized by the Fresno County Sheriff but on Edison Company pay roll, patrol the Big Creek area. Certain restrictions have been placed on closed areas and other areas have been posted as semi-restricted areas.
>
> Registration for military service through the recent draft will affect the personnel of the division in some instances. At the end of the year no setup had been made to provide additional men to replace those who may be drafted. Some early action should be taken because it requires time to train men for powerhouse work. We have been operating for a long time with a minimum crew and too many of our present operating men, even now, have limited experience [SCE 1941:6].

During the 1940–1947 years, war-related events provided the most drama at Big Creek. A few days after the Japanese attack on Pearl Harbor (in which Ed Winter, a former member of the Big Creek "family," was killed) the United States Army moved into the Big Creek area with a detachment of troops. The soldiers placed a road block near Toll House to control access to the Big Creek area and its important hydroelectric plants (SCE 1942:9). The army stayed in the area for only a few months, however, being replaced by the California National Guard in February 1942 (SCE 1943:10). The state guards remained stationed in the Big Creek area to help protect the project until 1944, when both the Edison Company guards and the state guards were released from this duty (SCE 1945:6). Details about guard activities exist for 1943, and were probably typical for the entire war. In 1943 the 31 Edison guards, alone or in pairs, patrolled around each powerhouse and switchyard, at Big Creek town and its warehouse area, at Shaver Lake Dam and gate house, and at Huntington Lake and Florence Lake dams (SCE 1944:1–2).

The U.S. Army, California National Guard, and Edison guards were never reported to have fired a shot in anger or arrested any potential saboteur. However, six lives were lost at Huntington Lake in December, 1943, when a B-24 Liberator Bomber crashed into the lake. The pilot, bombardier, and four others were on board (SCE 1944:2). The bodies of these six men were not recovered until September 1956, when Huntington Lake was drawn down for dam repairs. The plane wreckage was left in the lake at that time (SCE 1956:2).

The war situation also influenced the number and quality of employees at Big Creek, since both the draft and enlistments took some of the best-trained men for the armed forces. Total employees in the Northern Division (including four small hydroelectric plants on the Kaweah and Tule rivers as well as Big Creek, the latter having by far the most employees) were as follows during this era:

12/31/1940 - 154
12/31/1941 - 164
12/31/1942 - 153
12/31/1943 - 159
12/31/1944 - 136
12/31/1945 - 147
12/31/1946 - 161

(Data from SCE 1941:4, 1942:4, 1943:5, 1944:8, 1945:8, 1946a:3, 1948:3)

The limited number of employees sometimes made it difficult to keep work crews filled with qualified men. By late 1941, first-class machinists and electricians were scarce, and Big Creek was also short of experienced operators. Equipment maintenance and overhauls had to be limited during the war years due to this factor (SCE 1942:7, 1943:7, 1945:8).

Despite a shortage of personnel, the work of maintaining and improving the five Big Creek power plants continued during the war and immediate postwar years. The 1943 *Annual Report* for the Northern Division gave the following account of work completed or planned for that year, and serves as an example of the work conducted at Big Creek during World War II:

During the year 1943 a total of 117 General Work Orders was handled in this Division, and of this amount 68 were physically completed during the year. As of December 31, 1943, there were 49 work orders physically incomplete, leaving a carryover of approximately $151,395.00 necessary to complete these jobs in 1944. Of this total, 27 work orders, totaling $44,660.00 is on work orders issued to cover plant additions and/or retirements, and $30,905.00 to cover operating expense on the same work orders. . . .

The carryover figure consists mainly of the following work:

Description	Operating Expense	Additions and/or Retirements	Total Amount Required to Complete
Shaver Lake			
Construct stamping device		125.00	125.00
Florence Lake			
Install Telemark--Camp 60		1,025.00	1,025.00
Big Creek #1 Hydro Plant			
Replace penstock incline	3,000.00	23,200.00	26,200.00
Replace buckets, #1 Unit	17,300.00	2,100.00	19,400.00
Install voltage regulator		None	None
Install oil alarm switches		160.00	160.00
Install piping for fire hydrants		210.00	210.00
Big Creek #2 Hydro Plant			
Install Kelman oil switch		300.00	300.00
Replace 10 current transformers		1,600.00	1,600.00
Big Creek #8 Hydro Plant			
Remove muck from tailrace and provide draining facilities	1,400.00	400.00	1,800.00
Big Creek #3 Hydro Plant			
Install disconnect switches		None	None
Install 60 cycle runner and oil system	400.00	400.00	800.00
Purchase and install generator windings	6,840.00	5,160.00	12,000.00
Install upper bus capacitor		1,100.00	1,100.00
Construct road into switchgarden		1,500.00	1,500.00
Build and install new type C.C.P.P.	75.00	3,325.00	3,400.00
Revise voltage regulator circuits	790.00	100.00	890.00
Construct reinforced concrete dike		250.00	250.00
Big Creek #2A Hydro Plant			
Install CA relays		700.00	700.00
Remove and retire incline hoist and equipment	1,100.00	1,950.00	3,050.00
Retire incline		50.00	50.00
Huntington Lake			
Drill cores, install recorder	350.00		

Description	Operating Expense	Additions and/or Retirements	Total Amount Required to Complete
Big Creek #1 Hydro Plant			
Purchase and install bearing thermometers	160.00		
Repair incline	1,800.00		
Dry out auto-transformers	10,500.00		
Clean domestic water pipe lines	300.00		
Big Creek #2 Hydro Plant			
Repaint doors and windows, Str. #220	1,250.00		
Annual overhaul	6,500.00		
Big Creek #8 Hydro Plant			
Repair runner No. 2A	650.00		
Annual overhaul	8,900.00		
Big Creek #3 Hydro Plant			
Replace 220-kv. bushings	30,000.00		
Annual overhaul	1,500.00		
Flame clean exterior of 18-foot pipe at Tunnel outlet	2,600.00		
Big Creek #2A Hydro Plant			
Repaint doors and windows, Str. #220	440.00		
Replace governor gears	305.00		
Annual overhaul	5,750.00		

(Extracted from SCE 1944:3-5)

It should be noted that data in the annual reports do not always segregate the Big Creek System from four other and much smaller hydroelectric plants which were also part of Edison's Northern Division. Thus, the overall figures concerning the total number of work orders and the dollar amount needed to complete the work listed above refer to the Big Creek System together with the four other small hydroelectric plants on the Kaweah and Tule rivers. However, the latter four hydroelectric plants represent a small percentage of the total Northern Division, producing an average of only about three percent of the total power generated during these years. The Big Creek power plants, therefore, accounted for about 97% of all electric power generated by the Northern Division during this period (SCE 1941:3, 1942:4, 1943:4, 1945:5, 1947b:6).

The best efforts at maintenance and improvement in hydroelectric facilities can sometimes be negated by acts of nature—such as floods or falling rocks. Such was the case in April 1946, when Powerhouse No. 1 was damaged more severely than any power plant in the Northern Division had ever been. The culprit was a huge boulder, loosened by the winter rains and snows and freed by the spring thaw, which rolled down the hillside, rupturing the No. 2 penstock. Before this incident was over, a large bulldozer had to be used to remove boulders weighing several tons from the generator floor of Powerhouse No. 1. This bulldozer even suffered the ignominy of becoming mired in the four-to-six-foot-deep mud, sand, and gravel mixed with huge boulders (SCE 1947b:3). The 1946 *Annual Report* of the Northern Division related this dramatic incident as follows:

April 6, 10:40 P.M. No. 2 penstock ruptured after being struck by a boulder which rolled off the hillside a couple of hundred feet below the upper penstock valve house.

The boulder bounced along on No. 1 and No. 2 penstocks for approximately 250' to the point of rupture, as soon as the trouble was ascertained, all upper penstock valves were closed from the switchboard. The heavy flow of water with the boulders off the hill side smashed in the doors at the west end of the generator room, filling the generator room with boulders and debris to a maximum depth of 6 feet. It was two feet deep at the west stairway to the switchboard gallery. Boulders were stacked against No. 1 unit governors making it impossible to close the power needles. This unit could not be stopped until the penstock was drained. The brakes were applied to No. 4 unit and the L.H. Side of No. 2 unit. It was impossible to reach No. 2 R.H. brake. Gravel was ground into the windings of both No. 1 and No. 2 generators, making complete rewind jobs necessary. The R.H. Bearing and shaft on No. 1 unit was badly scored. The icehouse type door at the west end of No. 1 and 2 lower penstock valve room was smashed and the gateroom filled with debris, a boulder struck the guard and regulating valves at the west end of of. [*sic*] the 900# exciter header, breaking a nipple that connected these valves to the header, another boulder broke the stem off of the by–pass valve on the R.H. Lower penstock valve. Water from the gateroom leaked around the door into No. 1 and 2 rheostat room, through the spare exciter room to the basement. The filter press room in the basement had water and debris to a depth of 25 inches. Debris entered the tool room at the west end of the plant through a small ventilator some eight feet above the generator floor level. It was seventeen inches deep in this room and approximately 8 inches deep in the west hallway and Station Light and Power Room. The area north of the powerhouse filled in to a Maximum depth of 10 feet. Mud and sand came over the top of the gateroom roof broke several windows and filled the lower 6.6 K.V. buss [*sic*] cells to the top of the bus bars (westend). A sand bag barrier was set up to keep water out of the switchboard gallery.

Considerable damage was done to No. 1, 2 and 3 penstocks. Large dents in the upper sections of No. 1 and 2 penstocks and several broken piers on No. 3 penstock. The latter was forced out of line by large boulders leaning against the pipe.

Work was started immediately to get the plant ready for service. Some water was by–passed through No. 4 unit relief valves for the lower plants, but this was too dangerous as there was no governor oil pressure to hold the plunger valves in open position. About fourty second feet of water was released through the blow off valve on the Big Creek syphon (H.P.S. Conduit). Opening the sluice gates at the bottom of dam No. 1 was considered but this idea was given up as impractical as it is known that considerable debris has accumulated over them during the past 33 years.

In order to expedite the removal of debris from the plant the west gallery stairway was removed and the "22" cat shoved rocks and mud out into the main generator floor where the "Big Cat" shoved it on out of the west door.

The replacing of the broken section on No. 2 penstock and the patching of No. 1 and No. 2 penstocks, where badly dented, was done by the Western Pipe and Steel Co. No. 3 penstock was reconditioned by our own crew. Our maintenance crews worked long hours with shovels, firehose and bulldozers, to get No. 3 and 4 units back in service as quickly as possible. The debris was dug from No. 4 generator pit, the current transformers in the pit were removed for cleaning and drying and returned to position. This unit was tested and put back in service at 4:18 P.M., on April 8th. The overhaul on No. 3 generator continued while No. 3 penstock piers were replaced and the pipe realigned. This penstock was filled and the unit on the line on April 18th.

The new stator winding which was installed on No. 2 generator in December 1945, was removed retaped and installed on No. 1 generator, in the meantime the stator was removed from No. 2 generator and the stator from the G.E. Condenser at Eagle Rock Sub-station was brought up and installed. Repairs to No. 2 penstock were completed April 27, and the penstock filled the following day. The unit was on the line on May 6. This penstock was drained again on May 11, in order to replace three sheared rivits [*sic*], this was done by drilling, tapping and installing boiler makers bolts. The rewinding of No. 1 generator with retaped coils from No. 2 generator was completed and the unit on the line 12:31 A.M. on June 3. This brought B.C. No. 1 back to full capacity [SCE 1947b:2–4].

Near the end of the war years, the oil needed to run Southern California Edison's steam plants became scarce due to the priority needs of the armed services. In order to replace this shortfall of oil, and perhaps due to other, longer-range considerations, Edison decided to divert water from a number of the smaller creeks in the Florence Lake region into Florence Lake and Ward Tunnel. The first notice of Edison's intention to divert the smaller streams was a July 12, 1945, telegram to the Federal Power Commission in Washington, D.C., asking for a license amendment to allow such diversions (Mullendore 1945). A Forest Service Special Use Permit was also applied for at about the same time (Trowbridge 1945). The key state regulatory body, the Railroad Commission of the State of California, was also contacted. The Railroad Commission's order granting Edison permission to undertake these diversions provides the best summary of the location and nature of these small creek diversions:

OPINION AND ORDER

Southern California Edison Company Ltd., in this application, requests the Railroad Commission to issue a certificate of public convenience and necessity for the construction and operation in Fresno County of dams and accessory equipment to divert the waters of six small streams tributary to the South Fork of the San Joaquin River into Florence or Huntington Lake Reservoirs.

The proposed installations are divided into four separate units:

(1) Hooper, North Slide, and South Slide Creeks will be diverted by three concrete and masonry dams and connecting pipe lines into Florence Lake.
(2) Tombstone Creek will be diverted into Florence Lake by a masonry dam and another pipe line.

(3) Crater Creek will be diverted by a concrete dam, ditch, and natural channel into Florence Lake.
(4) Bolsillo Creek will be diverted into the existing Ward Tunnel, connecting Florence Lake Reservoir with the Huntington Lake Reservoir, by means of a rock and earth-filled dam and a vertical tunnel.

The company states that upon the construction of said diversion works it is estimated that a noncoincidental total maximum flow of 167 second feet will be diverted for use through existing power houses, that 55,600,000 kilowatt hours of electric energy will be derived annually therefrom, and that the total cost of the aforesaid diversion works will not exceed $412,400.

A segregation of estimated maximum flow to be diverted, the cost, and dam and pipe-line statistics are tabulated below:

	Dam			Pipe Line, etc.		Est. Max.	
	Height	Length	Material	Size	Length	Cu.Ft./Sec.	Cost
Hooper & Slide Creeks				Pipe Line			
Hooper Creek	30'	159'	Concrete	34"	13,200'	77)	
North Slide Creek	5'	22'	Masonry)	12"	1,100'	7)	$329,475
South Slide Creek	5'	22'	Masonry)			7)	
Tombstone Creek	5'	26'	Masonry	14"	2,500'	16	46,085
				Ditch			
Crater Creek	9'	21'	Concrete	-	760'	40	5,000
				Tunnel			
Bolsillo Creek	6'	54'	Rock & Earth	10-12"	400'	20	15,485
			Miscellaneous				16,355
			Total				$412,400

The waters to be diverted as described above will be used to augment the output of five hydroelectric stations now owned and operated by the company. The additional production and its relationship to the installed capacity and 1944 plant output as reported in Edison Company's annual report is shown in the following tabulation:

Big Creek Plants	Installed Capacity Kw	Net. Gen. 1944 M-Kwh	Est. Add. Annual M-Kwh	% Increase in Est. Ann. Output
No. 1	67,000	440,341	7,990	1.81
No. 2	57,750	384,951	6,810	1.77
No. 2-A	80,000	319,180	10,250	3.21
No. 3	75,000	278,494	22,470	8.08
No. 8	54,000	622,039	8,080	1.30
Total	333,750	2,045,005	55,600	2.72

> From the foregoing estimate it is clear that the construction of the diversion works herein proposed will develop a comparatively large amount of additional energy with a relatively small investment [California Railroad Commission 1945:1–2].

Although final permits were not approved until December 1945, preliminary work on the small stream diversion was begun by a contractor, the Macco Construction Company, at the end of August 1945. At that time, Macco Construction moved into existing Edison facilities at Florence Lake. These facilities consisted of two bunk houses, a cook house, lighting plant and small warehouse. To house additional men, five tents with wooden floors were erected in an area adjacent to the warehouse. Meals for up to 77 men were served at the Edison Company cookhouse (SCE 1947a:2).

Due to inclement weather conditions, Macco Construction shut down the project and withdrew from the Florence Lake country in December 1945. The road over Kaiser Pass was open by late May of 1946, and Macco returned to Florence Lake with a 20–man crew in early June 1946. All work was then completed by June 30, 1946 (SCE 1947a:1).

The April 1946 penstock break and completion of the small stream diversions were the last important events of the Depression/World War II/early postwar period. As the economy began to boom in the years following the war, the demand for electricity again rose in southern California. This in turn caused Southern California Edison to search for ways and means to substantially increase production at Big Creek.

Renewed Expansion, 1947–1960

The decade and a half which began in 1947 was as active in the area of construction of new hydroelectric facilities as the 1930–1946 period had been passive. The spark plug for this new building effort was, as always, the expansion of population and economic activity in southern California. This increase in demand for electricity stimulated new construction at Big Creek. Work between 1947 and 1949 was limited to expansion and improvement of already existing powerhouses. However, in 1949 work began on Powerhouse No. 4, and from this time until completion of Mammoth Pool Powerhouse in 1960, construction of new facilities was nearly constant.

Unit 4 of Powerhouse No. 3, 1947–1948

When Powerhouse No. 3 was constructed during the early 1920s the building was designed to accommodate one additional unit, and expansion of this powerhouse's capacity was the easiest way for Edison to quickly increase its output of electric power. Addition of a fourth unit in 1947–1948 involved some concrete work on and within the powerhouse building, a new penstock line, a new Francis turbine, and a new generator.

Of the tasks needed to bring Unit 4 on line, the most difficult was building a new penstock line. This effort involved reconstruction of the old incline railroad used to install the original three penstocks in 1922–1923, excavation of a new penstock line, and installation of about 1350 feet of penstock pipe. A new standpipe (air vent) was also required (SCE 1946b:n.p.).

Work within Powerhouse No. 3 involved tearing out part of the foundation and at least part of one wall. The north and east sides of the building were also expanded (SCE 1947c:n.p.). The Francis turbine installed as a key part of the new unit was a Pelton rated at 45,500 horsepower at 450 RPM. The generator was a Westinghouse rated at 35,000 kva (Allis–Chalmers Manufacturing Company n.d.:n.p.; SCE 1955b:n.p.).

About the same time Unit 4 was being added to Powerhouse No. 3, a new concrete and steel machine shop was built on the bank of Mill Creek southeast of this powerhouse. This machine shop was completed in May 1947 (SCE 1948:3).

Other work in 1947–1948 mainly involved rebuilding and upgrading the support buildings needed for major new powerhouse construction already being planned. During 1948, for example, the following construction took place:

> The new commissary was completed and occupied in May.
>
> A new wash house, showers and toilets, together with a septic tank and sewer system, were constructed at Florence Lake camp in the fall.
>
> A new relief quarters at Huntington Lake for the dam tender was 90% completed before storms stopped the work.
>
> The old carpenter shop was retired and dismantled, and the equipment set up in a portion of the Big Creek warehouse.
>
> Excavation work was completed and construction under way in the late fall for the new hospital and guest house structures at Big Creek #1. The work was being done by contract [SCE 1949:3–4].

Other construction and maintenance work during 1948 follows:

> The U.S. Forest Service furnished the material and our crew rebuilt the bridge over the Mono–Bear Siphon, a short distance above the River at Mono Hot Springs.
>
> The rebuild of Camp 7 Hill road and a crossing over the 2A Penstock were accomplished during the latter part of the year.
>
> New diversion dams were constructed on Chinquapin and Camp 62 Creeks, along with new steel welded pipe lines to the Camp 62 Adit. This work completes the replacement of all the old wood–stave pipe lines in the Florence Lake area.
>
> Late in the year the upper end of No. 3 Penstock at Big Creek #1 was relocated and encased in a concrete envelope. This work was done by contract.

The construction of the new 220 Kv. switch gardens for the Big Creek No. 1 and No. 2 Plants started during the summer and progressed throughout the remainder of the year. This work was being done by contract.

The new Transportation Department garage was completed and occupied late in the year. The old garage building was dismantled to make room for the new switch garden [SCE 1949:3–4].

Construction of Powerhouse No. 4, 1949–1951

Construction of Powerhouse No. 4 from 1949 to 1951 involved the same massive mobilization of labor and materials that had been so characteristic of the 1911–1929 years. The steps involved—building the dam, drilling two tunnels, laying the penstock, constructing a powerhouse building, and installing new equipment—were also similar. The key difference is that a powerhouse and its associated features built less than 50 years ago cannot—except under exceptional circumstances—qualify as significant under the National Register of Historic Places criteria. The main interest in Powerhouse No. 4—and other power plants built even more recently—is the fact that its construction added a more modern plant to the Big Creek Hydroelectric System. Therefore, it is not necessary to recount in depth the construction story of Powerhouse No. 4 and its associated features; a summary statement will suffice.

While it was part of the original plans of John S. Eastwood during the first years of this century, construction of Powerhouse No. 4 was not economically feasible until the late 1940s. By 1948 Edison had decided to build the new 84,000-kilowatt powerhouse. Bechtel Corporation and Morrison-Knudsen Company, Inc., a joint venture, were contracted to do the engineering and construction work in conjunction with Edison personnel (SCE 1951b:n.p.). With a project cost of about 20 million dollars (Electrical West 1951:76), construction went on from late 1948 until mid-1951. Statistics and construction data were summarized in a 1951 Edison publication:

DAM:

Concrete gravity type; maximum height 248 ft.; crest length 891 ft. Four 40-ft.x30-ft. radial gates at spillway with capacity of 100,000 c.f.s. Reservoir storage capacity 35,000 acre feet. Supervisory control on one spillway gate and both intake gates. Drainage area 1,292 sq. mi. Dam construction period: July 5, 1949–February 28, 1951.
Concrete volume (dam):239,487 cu. yd.

TUNNELS:

Horsehow section, 24-ft. nominal diameter. Six-inch min. concrete invert, reinforced concrete lining at portals Tunnel No. 1, 2,405 ft. in length, connection by 570 ft. of 15 1/2 ft. diam. welded steel pipe to Tunnel No. 2, 8,106 ft. in length.

Construction Period:

Tunnel No. 1: Sept. 22–Dec. 23, 1949.

Tunnel No. 2: Sept. 23, 1949–Sept. 22, 1950, setting a record for construction of a hard-rock tunnel of this size.

SURGE CHAMBER:

Restricted orifice type, 200 ft. in depth, varying in diameter from 55 ft. to 40 ft.; 10 ft. diameter at concrete orifice.

PENSTOCKS:

Welded steel pipe, 15-ft diameter, 631 ft. long, supported by ring girders; branching to two 10 1/2-ft. diameter pipes, each 186 ft. long, encased in reinforced concrete.

Pipe fabricated and rolled at Vernon and Fresno plants of Consolidated Western Steel Co., and at Salt Lake City by Chicago Bridge & Iron Co.

POWER PLANT:

Building 82 ft. x 135 ft. x 88 ft. (Height), of reinforced concrete. Compact design—gross volume of powerhouse 7.4 cu. ft. per kw. of installed capacity.

Turbines: Two 57,500 hp. Francis type, manufactured by Pelton Water Wheel Co.

Generators: Two 42,000 kva., 11.5 kv., 60 cycles, 3-phase, 257 rpm.
No. 1—by Allis Chalmers
No. 2—by General Electric Co.

Powerhouse construction and equipment installation:
Start of foundation excavation—December 6, 1949
Start of turbine-generator installation—December 6, 1950
No. 1 unit in service—June 12, 1951
No. 2 unit in service—July 2, 1951
(SCE 1951b:n.p.).

The dam built as the forebay for Powerhouse No. 4 was called Dam No. 7, which created Redinger Lake (named for David H. Redinger) on the main San Joaquin River. Since a certain amount of water had to be passed through or over this dam to maintain fish populations in the river below, a small "fish water" turbine and generator unit was installed in the dam to generate power from this water as well. This unit, a Francis-type turbine manufactured by Pelton and a generator manufactured by the Elliot Company, went into operation in late 1951 (SCE 1985b:n.p., 1985c:10).

Plant Modernization and Maintenance, 1949–1960

Beginning during the period when Powerhouse No. 4 was under construction and continuing throughout the 1950s, a program of plant modernization and intensified maintenance of the entire Big Creek Hydroelectric System was instituted. This modernization and maintenance program had the dual aim of maintaining and increasing levels of production. The following excerpts from several Northern Hydro Division *Annual Reports* give examples of the nature of overhauls and upgrades at each Big Creek plant during this period:

Big Creek No. 1

Units Nos. 1, 3 and 4 were overhauled during the year, and Unit No. 2 is scheduled for overhaul early in 1951. During the overhaul of Unit No. 3, in November and December, new fabricated buckets, Woodward cabinet-type governors, and new wheel pit baffles were installed. A broken bucket bolt, occurring on Unit No. 4, required replacement on May 9th.

Plant modernization, which progressed throughout the year 1949, was completed during the early part of this year. Tie line load control and carrier current protection installations are approximately 90 per cent complete. The new Division office building was occupied on April 16th. Dedication ceremonies were held in the new club house on June 10th, at which time many of the Company management officers were introduced. Additions to the Division communication system consisted of, converting the village telephone system to dial operation, installation of the radio transmitter in the power house, and the use of direct carrier channels for Los Angeles communication. The radio repeater station, erected on Kaiser Pass, was not put in service this year [SCE 1951a:1–2].

Unit No. 4 was reconstructed during the month of January. Major work consisted of the installation of new wheel discs and hubs, buckets, upper and lower housings, needle assemblies, and inlet pieces. Routine overhaul was performed on Unit No.s [*sic*] 3 and 4 in December, and routine overhaul of Unit No.s [*sic*] 1 and 2 is scheduled for January of 1953.

The program of separating the governor oil system from the bearing oil supply is in progress. New inhibited oil was installed in the "B" and "C" phase of units of the No. 2 transformer bank [SCE 1953:1].

The Big Creek No. 3 incline hoist was moved, reconditioned, and adapted to replace the Big Creek No. 1 hoist which was destroyed by lightning. The enclosure structure, also demolished by the lightning bolt, was rebuilt with an all metal structure on a concrete foundation. The haul drum was outfitted with one inch diameter flexible steel cable [SCE 1963a:1].

Big Creek No. 2–2A

During the early part of the year, Unit No. 1 was overhauled and converted to 60 cycle operation, which resulted in an efficiency gain of 2–1/2% at full load. Subsequent cracking of the new buckets installed at this time necessitated the addition of reinforcing ribs to improve stress characteristics. Overhaul of Units 3 and 4 found all in good order. Inspection of Units 5 and 6 found the buckets to be wearing considerably—new buckets are scheduled to be installed during the year 1951. At the end of the year, Unit No. 2 overhaul and conversion to 60 cycle operation were in process. Also, the stator iron was being re-stacked because of its having been burnt during arcing ground tests at the start of overhaul.

Throughout the year a number of Magnaflux and strain gauge investigations were conducted on the buckets of Units 1 and 2 to determine resultant stresses.

Modernization of the plant by the Bechtel Corporation progressed throughout the year, and was 93% complete at the end of December. Items of note were, completion of the new 220 Kv. switchyard, modification of the transformer banks, shielded cable installations, completion of the isolated phase bus, and abandonment of all 150 Kv. equipment.

Two 750 KVA, three phase transformers were added to the 11 Kv. substation to handle the Big Creek No. 4 construction load.

A new Woodward cabinet type governor was installed on Unit No. 5. Similar installations on the other units are scheduled for 1950 and 1951 [SCE 1950:2–3].

Overhaul of all units was completed during the course of the year. New cabinet type governors were installed for Units Nos. 2, 3 and 6. Rebuild of both Units Nos. 5 and 6 for 60 cycle operation, which entailed the installation of new water wheels and wheel housings, was completed during the year. In November, failure of the Unit No. 3 generator winding necessitated a rewind of the stator with Class "A" coils from Spare Parts stock. Shop and Test Department personnel assisted in the rewind work. Periodic Magnaflux inspection of the water wheel buckets of Units Nos. 1, 2, 5 and 6 was made during the year. The flaws and progressive cracking, observed in the buckets of Units Nos. 1 and 2, led to the installation of new cast steel buckets for Unit No. 2 in November, and the ordering of new buckets for Unit No. 1 [SCE 1952:2].

The Big Creek No. 2 incline hoist was retired and sold. Removal was by contract personnel [SCE 1953:2].

Plant operation continued satisfactory throughout the year. Outages were taken on generating equipment to perform short overhauls and make routine inspections. A failure of two field coils occurred on No. 1 unit. New water wheel buckets were placed in service on No. 3 Unit, and integrally cast wheels were installed on No. 6, and the left side of No. 5 unit. One integral wheel on each unit is thirteen percent chrome [SCE 1956:3].

The cost of converting Big Creek No. 8 for automatic operation, and supervisory control from Big Creek No. 2–2A was estimated at $200,000. The cost of converting Big Creek No. 2–2A to one man plant operation was estimated at $37,500. Consequently, in view of identical savings in operating personnel labor cost and the desirability of operating Mammoth Powerhouse by supervisory control from Big Creek No. 8, the conversion of Big Creek No. 2–2A has been approved for early 1959 [SCE 1959:1].

Big Creek No. 3

All four units were over-hauled during the year. New seal rings were installed in Units Nos. 1, 2 and 3, and shaft wearing sleeves were replaced on Units Nos. 1 and 4. The Unit No. 2 turbine was rebuilt with a new lower liner plate, a rebuilt upper liner plate, renovated wicket gates from Unit No. 1, and new seal rings. Also installed for Unit No. 2 was a new cabinet type governor and a lower penstock valve of the roto-type.

Concurrent with the forming of the Big Creek No. 1-Piedra-Vestal 220 Kv. Line, the 220 Kv. switchrack positions, of the latter line, were disconnected and rearranged to provide the Big Creek No. 3-4, 220 Kv. connection and removal of the Big Creek No. 3-1, 220 Kv. line position. The lighting and single phase power circuits were renewed throughout the 220 Kv. switchyard. Clamping ring repairs were made on the oil leaks of two 220 Kv. O.C.B. bushings. The ground disconnect installation to the lower 220 Kv. bus was completed during the latter part of the year. Completion of the Big Creek No. 4 project made it possible to remove the temporary transformer bank that was furnishing supplemental power to the Saginaw 11.0 Kv. Line. The Communication Department installed a new automatic dial telephone system for the village [SCE 1952:3].

The 1952 annual output, 842,025,000 KWH, was 8.5% over that of 1951, and is the greatest annual output recorded since start of operation.

Major overhaul work was performed on Unit No. 3 which consisted of the installation of rebuilt wicket gates, new liner plates, new field poles, and a new lower penstock valve of the roto-plug type. Annual maintenance of Units No. 1, 2, and 4 was routine. A new cabinet type Woodward governor was installed for Unit No. 1 which completes the new governor installation program at this plant [SCE 1953:3].

At Big Creek No. 3, major maintenance items included field coil boxing repairs and field collar replacement on No. 2 generator and the rebuild of the No. 4 turbine [SCE 1961b:3].

Big Creek No. 8

Overhaul of Unit No. 1 included, the installation of new upper and lower seal ring inserts, new Woodward cabinet-type governor, and a new voltage regulator. The stator was rewound and the field pole insulation was renewed. Overhaul of Unit No. 2 was routine except for the installation of new upper and lower seal ring inserts [SCE 1951a:3-4].

Both units were overhauled during the year, with only routine work being performed on Unit No. 1. During the overhaul of Unit No. 2, major work consisting of installing a new cabinet type governor, and a new lower guide bearing was performed. The upper and lower seal rings were renewed. While balancing Unit No. 2 it was ascertained that the generator sole plates were loose, which resulted in removal of the stator to grout the sole plates and install new and added generator dowels.

High potential test of the Unit No. 2 generator leads caused failure of one of the "C" phase leads. Temporary replacement was made, and the installation of new cable for all three phases is scheduled for 1953 [SCE 1953:3].

Operation of the plant was normal throughout the year. Routine overhauls were performed on both units during October. A new Class B winding was installed in No. 2 Unit in February to replace the original winding. The field poles were removed and the coils reinsulated in Alhambra. A new cast steel thrust block was fitted to the shaft to replace a worn cast iron block. Considerable difficulty was experienced in balancing the rotor upon assembly, with a thrust bearing failure occurring during this period. The unit was returned to service on March 12. Patch repairs were made to restore the coal tar coating to about 25 percent of the area in the upper 1,250 feet of penstock during the outage on this unit [SCE 1956:3].

The above list of overhauls and upgrades during the late 1940s and throughout the 1950s indicates the high level of attention the Big Creek powerhouses and their equipment received during this era.

Vermilion Valley Reservoir, 1953–1954

A constant theme in the history of the Big Creek System has been development of additional water sources and storage areas. In May 1953, construction began on another storage dam, located on Mono Creek almost seven miles north of Florence Lake. This was the Vermilion Valley Dam and Reservoir which, when completed in mid-October 1954, was renamed Lake Thomas A. Edison (SCE 1955a:1). The new dam was an earthen type, 4320 feet long at the crest, 160 feet high, 800 feet wide at the base, and containing 5,400,000 cubic yards of fill. The reservoir, which had a storage capacity of 125,000 acre-feet of water, drained into Huntington Lake through the Mono-Bear Siphon and Ward Tunnel (Bechtel Briefs 1957:9). The additional water stored in this reservoir substantially increased annual capacity of the Big Creek Hydroelectric System.

Portal Powerhouse, 1955–1956

As electric power demands continued to increase in southern California, Edison searched for ways to develop additional generation capacity from the Big Creek System. One obvious way was to build a small power plant at the exit from Ward Tunnel. This plant would use the low head between Florence Lake and Huntington Lake to generate power. The Bechtel Corporation was hired to do the engineering and construction in cooperation with Edison personnel. Named "Portal" for its location at Ward Tunnel exit, construction began on this power plant in June 1955. By late November when winter conditions forced suspension of the work, Bechtel had excavated the tailrace, finished the forebay dam, laid down concrete for the powerhouse structure, and installed part of the penstock. In late June 1956 work was continued, and the power plant was completed by the end of November 1956. From its inception, Portal plant was automatic, being operated from

Powerhouse No. 1. The plant was small, using a 13,410 horsepower Francis turbine to move a generator with a 10,000 kilowatt capacity (Bechtel Briefs 1957:8; McGraw-Hill 1960:93).

Mammoth Pool Dam and Powerhouse, 1958–1960

The final phase of active construction between 1947 and 1960 was the building of Mammoth Pool Dam and Powerhouse. Like Powerhouse No. 4, the Mammoth Pool project went back to original plans of John S. Eastwood which were drawn during the first years of this century. The dam and powerhouse were both to be located on the main San Joaquin River, astride the Fresno/Madera county line.

Work on the Mammoth Pool project began in January 1958. Construction involved building a huge earthen dam on the main San Joaquin River, and an eight-mile-long tunnel to bring impounded water to a large, automatic outdoor power plant lower down the river. A small "fish water" generator was also installed at this dam, using water bypassed through the dam (for the purpose of maintaining fish life in the river below) to generate additional electricity.

Construction continued during 1958 and 1959. By early 1960, the plant was complete and two 63,000-kilowatt generating units using Francis turbines went on line. From the outset of operation, these units were controlled from Powerhouse No. 8 (Krauch 1958:B-1; SCE 1959:1). Completion of the Mammoth Pool project brought total investment in the Big Creek System to $214 million (Krauch 1958:B-1).

Social History of the Postwar Years, 1945–1960

During the first years of new construction in the Big Creek region, the number of employees working at Big Creek and nearby camps increased dramatically. In addition, contractors who were hired to do much of the new construction work brought hundreds of additional men into the area. The presence of so many people required an expansion of facilities—a key theme during the 1947–1955 years. By the mid-1950s, however, automation and the drive to cut costs caused the size of the work force again to decline. With fewer personnel, Southern California Edison could cut back and close down some of the facilities it had maintained for decades, focusing its efforts once again on maintaining services for a smaller community.

Larger Work Force Brings Changes: Late 1940s to Early 1950s

Beginning in the late 1940s, Southern California Edison began to increase the number of people working in the Big Creek area, an increase accomplished in two ways. First, the company hired more permanent and temporary employees directly on their payroll; for example, the number of regular employees of Edison's Northern Division (including all of the Big Creek System as well as the Kaweah and Tule plants) jumped from 147 in 1945 to 230 in 1952—an increase of 56 percent (SCE 1946a:2, 1952:3). At the same time, the company negotiated contracts with outside firms whose employees worked indirectly for Edison on specific projects. During the late 1940s, one such firm, the Macco Construction Company of Paramount, California, had as many as 150 men working at one time on various construction and maintenance projects in the Big Creek area (Rawhauser 1949).

With the sudden arrival of so many new employees and their families, Edison immediately faced a number of difficulties. The first, and most critical, was a shortage of adequate housing. Despite the many employee residences built by Edison over the years, company housing in the area was limited. Not only were there fewer houses than required, but many available houses were badly in need of repair. Similarly, privately owned residences built under U.S. Forest Service permits at Big Creek were few and mostly in poor condition. In fact, in May 1950 the Forest Service informed Edison that it wished to get rid of the old Big Creek townsite and its structures which were described as "sub-standard as regards sanitary and fire protection facilities" (Davenport 1950). Southern California Edison conducted several studies of the housing situation and its implications in regard to attracting quality employees. The following quotation from a memorandum written in September 1951 indicates the conclusion of a 1951 housing report:

> There are presently 43 employes requesting houses of which 31 are married and are either separated from their families, commuting unreasonable distances, or living in undesirable quarters. Added to this, there are 14 unfilled jobs which are bound to be filled in part by married men.
>
> A large proportion of the 14 vacancies now existing at Big Creek are due to personnel leaving on account of the unavailability of housing. We have also found it to be very difficult in recent months to fill the positions in the skilled trades. Good prospects for these positions have refused the job opportunities presented when the housing shortage was made known to them [Werden 1951].

Edison did its best to rectify the housing situation as quickly and efficiently as possible. From 1945 to 1955, the company built over 75 new resident cottages for its employees; the majority of these were located at powerhouses No. 1 and No. 3 (SCE 1947b:6–7, 1950:2, 1953:1). During this same period, numerous repairs and improvements were made to existing houses. In many cottages at Powerhouse No. 3, these repairs included replacement of rotten wooden foundations with cement (SCE 1952:3). Other types of housing, such as guest houses and boardinghouses, were also constructed during this period. In 1949, Edison had only one old guest house at Big Creek. By 1953, there were two new guest houses, a modern kitchen facility was added to the old guest house, and an old hospital was converted into a dormitory (SCE 1950:2, 1953:2, 1954:2).

Along with the problem of housing additional employees came the related problem of feeding and caring for them and their families. Edison dealt with this problem in two ways: by providing more meals to employees at the boardinghouses, and by increasing the number of items available to employees and their families at the company-owned and operated commissary. While in 1945 a total of 23,829 meals were served in boardinghouses at powerhouses No. 1, No. 2, and No. 3, the number had risen by 1949 to 70,594 (including meals served to contract workers at the Florence Lake boardinghouse) (SCE 1946a:6, 1950:3). Although the number of meals served at Big Creek area boardinghouses would never again reach the 1949 high, it is interesting to note that, for the entire period from 1945 to 1955, Edison operated the boardinghouses at a rather substantial loss, indicating the company's commitment to providing such services to their employees.

In 1948, Edison opened a new commissary at Big Creek town. A description of the commissary and its merchandise is provided in the following quotation from the Northern Division's 1949 *Annual Report*:

> The Commissary continued to operate in the new quarters, and we have continued to hear favorable comments upon the service. A drug sundry section was added during the year, stocking approximately eighty items from tooth brushes and bobby pins to Alka-Seltzer and writing paper. These articles have met with good acceptance and very favorable comments from the customers. Early in the year some business was lost to a new local store which opened with attractive prices, however, most of this business has returned [SCE 1950:4].

Like Edison's boardinghouses, the commissary consistently ran at a loss throughout the late 1940s and early 1950s. Nevertheless, the company continued to operate and expand its commissary's goods and services, recognizing the advantage it offered employees.

Providing adequate housing and other necessities were not the only difficulties that Edison faced as a result of a larger work force at Big Creek: the Big Creek area also lacked the medical, educational, and recreational facilities necessary to support additional employees and their families. The improvement of medical facilities began in 1946 when the position of resident doctor was re-established for the community. In 1948, work began on construction of a new hospital building in the town of Big Creek which opened its doors to patients the following year (SCE 1950:2). Dr. Walter H. Buel served as resident physician from 1946 to 1950, establishing a private practice along with the company one. In February 1950, he was replaced by Dr. Phil C. Engelskirger, who would continue to practice at Big Creek for nearly 10 years (SCE 1950:4, 1961b:4).

Growth in the number of employees at Big Creek brought subsequent growth in the number of children needing an education. Attendance at the elementary school at Powerhouse No. 1 increased from an average of 55 students in the spring of 1948 to approximately 90 by the following fall (SCE 1949:5). This increase in students meant that more teachers had to be hired and new educational facilities constructed. In 1952, a new gymnasium was built at the elementary school in Big Creek, and the next year, additions were made to the classroom structure, which was also renovated. At Chawanakee Elementary School, near Powerhouse No. 3, new classrooms and a gymnasium were built in 1953. At this time, there were approximately 140 students attending the Big Creek and Chawanakee elementary schools (SCE 1954:7; TCR Field Data 1986).

Edison's larger work force not only brought changes in the medical and educational facilities of the area, it also increased the need for suitable recreational facilities. The tradition of the recreation hall established by the company for their employees in the 1920s continued with completion of a new employee clubhouse at Powerhouse No. 1 in June 1950 (SCE 1951a:1-2). While Powerhouse No. 3 did not get a new clubhouse, in 1952 a portion of the basement beneath the area's boardinghouse was converted into a recreation room, and the clubroom annex was renovated (SCE 1953:3). Basketball and baseball became popular sport pastimes for residents of the Big Creek area in the early 1950s. Basketball games were held in the newly constructed gymnasiums of the local schools, and Edison erected flood lights at the Big Creek baseball diamond so ball games could be played in the evening (SCE 1953:2; TCR Field Data 1986).

While it was working hard to provide the conveniences necessary for a larger work force, Southern California Edison Company was also proud of its many accomplishments at Big Creek, and wanted to convey a positive image of the area to employees and the general public. To this end, the company began a number of programs in the late 1940s aimed at bolstering the project's positive image. In 1948, a public relations program at Big Creek was initiated by Edison. Distinguished visitors and other interested parties were invited to tour existing power plants and related facilities. Company representatives were sent out to visit organizations and to present programs on various features of the Big Creek project. It was soon found that visitors were especially interested in seeing the construction project at Powerhouse No. 4 (SCE 1949:6). In 1951, Division Superintendent Ralph T. Enloe reported that there had been some 950 visitors to the project area, and that "the public relations highlight of the year occurred on October 12, when President Mullendore and the Company Directors acted as host for a group of San Joaquin Valley newspapermen and business leaders, during a luncheon and guided tour of the completed Big Creek No. 4 power plant" (SCE 1952:7).

As the public relations program at Big Creek continued, Edison started programs which they hoped would add to the charm and natural beauty of the Big Creek area, supporting the project's positive image. In 1949, the company began landscaping Powerhouse No. 1's residential area. This project was so extensive that it was not completed until the spring of 1951 (SCE 1950:2). Another important program was the timberland and reforestation operation which began in 1950, later to evolve into a scientific timberland management operation covering 20,000 acres acquired from the Fresno Flume and Lumber Company (SCE 1983b:[5]). Both of these programs worked to support the positive image of Southern California Edison and its Big Creek project.

Cutting Back and Settling Down: 1955 to 1960

Beginning in the mid-1950s, Edison started to cut back on the number of employees at Big Creek by gradually decreasing the number of operators at each powerhouse. As examples, one-man-per-shift operation was instituted at Powerhouse No. 1 in 1955; the total operating crew at Powerhouse No. 2/2A was reduced from nine to five in 1958; and Powerhouse No. 3 was reduced to one-man-per-shift operational status during 1961 (SCE 1955a:3, 1959:1, 1961b:2).

With fewer people at work, Edison soon found that they had more than enough housing and other support facilities available for their employees. Older, outdated structures no longer needed to be renovated to serve employees; they could now be abandoned and torn down. Such was the case in 1955 when six older cottages were razed, allowing the land to return to natural growth (SCE 1956:2). That same year, the old Big Creek Hotel was dismantled and turned into a playground for the Big Creek elementary school (SCE 1956:8). Starting in 1953, fewer meals were served at employee boardinghouses, forcing temporary closure of the Powerhouse No. 3 facility and permanent closure of Powerhouse No. 2/2A (SCE 1954:1-2). Even the cookhouse at Powerhouse No. 1 served fewer meals beginning in 1958, and in 1961, it reported serving 1290 fewer meals than the previous year (SCE 1962:4).

For those employees who remained at work in the Big Creek area, Edison continued to provide the benefits to which they had grown accustomed. Company housing was still available, and a number of improvements were made on these residences which it was hoped would cut future costs. A program was begun in 1957 to add asbestos shingles to the exteriors of cottages and garages to reduce the need for maintenance. The company estimated that an annual savings of $12,000 would be realized when the program was completed; also the shingles, as added insulation, would reduce cottage heating requirements (SCE 1958:3). Minor changes were also made in guest accommodations and boardinghouses. The *Annual Report* for 1958 stated that as a result of improvements in living quarters at Florence Lake, the morale of the crew stationed at the lake had risen (SCE 1959:n.p.).

Along with housing, Edison continued to provide employees with many other conveniences. Despite continued losses, boardinghouses at Florence Lake, powerhouses No. 1 and No. 3, and the commmissary at Big Creek were still in operation (SCE 1956:2). Also, excellent educational facilities continued to be offered for the children of Edison employees. In 1958, $325,000 was spent on improvements to the Big Creek and Chawanakee elementary schools. Three years later, construction was begun on a swimming pool and sewage disposal plant at the Big Creek school (SCE 1962:5). Recreational facilities were also kept in operation for employees. In the late 1950s, Edison allowed the Big Creek Gun Club (an organization of approximately 35 adults, most of whom were Edison employees) to use Sulphur Meadow at Shaver Lake for civilian marksmanship training and recreation (Bickel and Blain 1959). Medical facilities were also readily available to employees. Dr. Engelskirger remained as resident physician at Big Creek until 1960, when he was replaced by Dr. William Hayden. Dr. Hayden later explained that he was "not very good at keeping track of time" because he "came up here [to Big Creek] in 1960 to fill in for a three week relief period—and somehow it turned into 25 years" (Rose 1986:15).

Since construction of additional employee residences and support facilities was no longer a critical concern, Southern California Edison could focus its efforts on other projects in the Big Creek area. Beginning in 1957, the company began an experimental trout-raising facility at Powerhouse No. 1 which turned out to be quite a success. As a result of the experiment's first year, about 7000 catchable rainbow trout were planted for benefit of the fishing public in Big Creek area waters (SCE 1958:1). With the success of the first year, Edison decided to continue the program. By 1960, a trout farm was in full operation, both for scientific research and for continued supplementation of the natural fish supply in local streams and lakes (SCE 1983b:[5]). Undoubtedly, this program added to recreational use of the Big Creek area.

By the 1960s, the social climate of the Big Creek area was fairly quiet and settled. Edison employees were still the recipients of a number of company benefits, but since the number of employees was static, additional support facilities were not necessary. Consultants who recalled this period described it as a "family time" (TCR Field Data 1986). As Dr. Hayden later commented, the biggest advantage to living in the Big Creek area during this time was that it was "a good place to raise a family" (Rose 1986:16). The family atmosphere continued at Big Creek, and Southern California Edison concentrated its efforts on maintaining services necessary for a smaller community.

Production Again: 1960s and 1970s

Southern California Edison's *Annual Report* for 1960 stated that with completion of the Mammoth Pool project "there are no immediate plans for future hydro-electric plants on the system as virtually all presently economically feasible sites have been developed" (SCE 1961a:8). Big Creek was again going into a period when efficient production was paramount. This was not all, however: in spite of the renewed construction program from 1947 to 1960, Big Creek and its hydroelectric power had ceased (even before 1960) to be the backbone of Edison's electrical generation efforts. Although the capacity of the Big Creek System had expanded during those years, the demand for power in Southern California had expanded even faster. To meet the increased demand, Edison was forced to rapidly increase its steam-plant capacity. In 1951, the capacity of Edison's steam plant and its hydro plant (mostly Big Creek) was almost identical. By 1960, however, Edison's steam-plant capacity was close to four times that of its company-owned hydroelectric facilities (SCE 1961a:12–13). In terms of percentages of total company output, steam power went from 50.4 percent in 1951 to 83.9 percent in 1960. In 1960, company-owned hydroelectric plants (mostly Big Creek) provided only 14.5 percent of the total Edison output (SCE 1961a:12–13).

While much less important in terms of total company capacity and annual output, Big Creek's hydroelectric power was much cheaper and more easily brought on line than steam-generated power, and therefore played a key role in "peaking" or building on the power-base generated by the company's steam plants ". . . to yield the lowest cost incremental generation over any given period . . ." (Electrical West 1960:12). Down to the present moment, the Big Creek System has been important for this function. Depending on the abundance of rain and snow in any given year, Edison's hydroelectric output has ranged from a high of 18.9 percent to as low as only 2.4 percent of total company output during the 1961–1979 period, and the same general range continued into the 1980s (SCE 1970:14–15, 1980:31–32, 1986:52–53).

These facts meant that Big Creek, while an important element of the Edison network, was no longer at center stage. This role was occupied (during the 1960s and 1970s at least) by the drive for new energy technologies (such as nuclear power), and by construction of transmission systems which could bring electrical energy in from such distant sources as the Pacific Northwest (hydro power) and New Mexico (coal-fired steam plants). Thus, the Big Creek Hydroelectric System was relatively less important during this era.

Construction Again: 1978–Present

From the beginning of its hydroelectric history, what has happened at Big Creek has been closely connected with what has transpired in distant places, such as in the Los Angeles area (for electrical demand); in New York (for capital to construct the first two powerhouses); and on the national and world-wide scenes (during the Depression and World War II period, for example). This connection to and dependency on outside economic and political forces became even more clear during the mid and late 1970s, when the skyrocketing price of oil caused Edison's leaders to look again at the possible costs and benefits of additional hydroelectric power sites in the Big Creek area. As Edison's 1981 *Annual Report* expressed it:

Until recently, it has been presumed that all cost-effective hydro sites had already been developed. As other fuel costs have climbed, however, more and more small hydro projects have become feasible [SCE 1982:4].

The first step in developing additional power capacity at Big Creek was an expansion of Powerhouse No. 3 by building an addition onto the powerhouse and installing a new penstock and a fifth generating unit. This work was begun in 1978 and completed in 1980 (SCE 1979:6, 1984:5, 1985a:Chap. 1, 3-6). At the same time, the Balsam Meadow generating station was proposed, although construction did not begin until 1983. This project uses the water flow between Huntington and Shaver lakes to generate power. The tunnel built during the late 1920s to connect Huntington and Shaver lakes and to supply water for Powerhouse No. 2A is diverted near its outlet on the North Fork of Stevenson Creek to an underground power plant built below a forebay at Balsam Meadow (SCE 1982:4, 1983a:4). This plant, nearing completion during this study, began operation in December 1987 as Edison's largest hydroelectric power plant (200 megawatts). It will be an unstaffed plant, under remote control from Powerhouse No. 1 (SCE 1984:6).

During the early 1980s, two other small increases in the Big Creek System's capacity were made. In 1981-1982 an increase of seven megawatts was achieved by upgrading Unit No. 1 and No. 2 of Powerhouse No. 4. In addition, in 1982 a small, 40-kilowatt fish-water generator was installed at Shaver Lake Dam (SCE 1982:4, 1983a:4).

Finally, during the mid-1980s, planning was initiated for a massive expansion of the Big Creek System. Installation of five new units at five existing power plants was projected. Although design engineering has not been completed, the major expansions contemplated at each powerhouse are as follows:

Powerhouse No. 2A

- a new tunnel
- a new powerhouse structure
- a third turbine and generator
- enlarge existing tunnel
- two new penstocks
- a new transformer and isolated phase bus

Powerhouse No. 8

- a new powerhouse structure
- a third turbine and generator
- a new penstock
- a new surge tank
- a new transformer and isolated phase bus

Mammoth Pool Powerhouse

- a new powerhouse structure
- a third turbine and generator
- a new penstock
- a new transformer and isolated phase bus

Powerhouse No. 3

- a new powerhouse structure
- a sixth turbine and generator
- a new penstock
- a new intake structure, tunnel, and surge chamber
- a new transformer and isolated phase bus

Powerhouse No. 4

- a new powerhouse structure
- a third turbine and generator
- a new penstock
- a new transformer and isolated phase bus

In addition, completion of this project would involve extensive rebuilding of the transmission system and possibly a new transmission line as well (SCE 1984:3–6, 1985a).

The large scope of this proposed expansion of the Big Creek Hydroelectric System is indicated by its cost (estimated at over $500,000,000) and the amount of power (about 500,000 kw.) that it would add to the System (SCE 1984:iii, 16). The projected cost is almost twice as high (in inflated dollars, of course) as what it cost originally to build the existing System. The additional capacity amounts to about two–thirds of the current capacity (763,000 kilowatts as of 1983–1984) of the Big Creek Hydroelectric System (Electrical World 1983–1984:82).

Such a dramatic construction project would, of course, potentially affect the integrity of the older hydroelectric powerhouses (No. 2A, No. 3, and No. 8) and related features involved in this expansion. To evaluate the significance of such changes, it is first necessary to determine if any of the older (over 50 years old) sites or features of the Big Creek Hydroelectric System qualify for the National Register of Historic Places.

CHAPTER 8

NATIONAL REGISTER OF HISTORIC PLACES
SIGNIFICANCE EVALUATION

This chapter puts the Big Creek Hydroelectric System in historical perspective through a significance evaluation of its historic features. The evaluation involves applying the various criteria of the National Register of Historic Places (NRHP) to the Big Creek System.

Any NRHP significance evaluation involves a number of overlapping logical steps. First, the appropriate historic theme must be chosen and a determination made as to whether the cultural resource in question is a good representative of this theme. Second, a determination must be made regarding both the period of time when the resource may have been historically significant, as well as the level (local, state, or national) of significance. Third, the category of historic property (district, site, building, structure, or object) must be decided upon and its physical boundaries defined. Finally, the NRHP significance criteria must be applied to the resource and its level of integrity determined. Only when each of these steps has been followed can a proper determination be made as to whether the cultural resource in question is eligible and should be nominated to the NRHP.

Theme and Period:
A Classic Hydroelectric System, 1911–1929

The major theme appropriate to the Big Creek Hydroelectric System is engineering and technological history, and its period of significance is 1911 to 1929. The Big Creek power complex is the premier example of a California hydroelectric system during those years. The NRHP considers properties less than 50 years old as significant only in exceptional circumstances; therefore, those features of the Big Creek System younger than 50 years old will not be defined as significant here. In order to illustrate the importance of Big Creek historic features over 50 years old, it is necessary to briefly review the history of hydroelectric development in California. This history has two main phases: the era of pioneer individual powerhouses, and the era of hydroelectric systems which developed the power potential of entire watersheds.

Era of Pioneer Powerhouses, 1889–1909

The United States' first successful hydroelectric plant was put into operation near Portland, Oregon, in 1889 (Downing n.d.:511–512, 549; Galloway 1922:1846). By 1891, this technology had been transferred to California. During that year, this state saw its first hydroelectric plant on San Antonio Creek near Pomona, and the era of pioneer California powerhouses had begun (Downing et al. n.d.:517, 594). Expansion was constant over the next two decades. As the years went by, hydroelectric development emphasized larger and larger plants with bigger generators and water wheels (turbines), higher heads, longer transmission lines, and higher transmission voltages. California was the leader in these developments in the western United States, which in turn frequently led the world " . . . in almost every feature of hydroelectric development" (Gallison 1923:91). As one close observer of western and world hydroelectric developments remarked in 1905, " . . . the progress made in this art in California during the last decade is so remarkable as to attract the attention of engineers the world over" (Doble 1905:75). California was, as *Electrical World* observed in 1912, " . . . the great center of development, the world's laboratory of brilliant and successful experiments" (quoted by Hughes 1983:265).

While some notable exceptions exist, hydroelectric facilities during this pioneer period generally tended to be isolated plants; that is, only the most favorable site on a particular watershed was developed by building a single plant. This was because of economic realities (the levels of demand and capital available) and the level of technological development characteristic of this era. Plants built during these years were also few; for example, between 1889 and 1894 an average of only a little over one plant a year was constructed in the entire western United States. During the remaining years of the 1890s this figure had jumped to an average of eight plants a year, and during the first decade of the new century, to over eleven a year.

At the same time, generator and turbine sizes, head, transmission distances and line voltages were constantly increasing. For example, during the 1889–1894 period the highest head was less than 500 feet, maximum kilowatt capacity was only 750, maximum line voltage was only 10,000 volts, and the longest transmission was only 28 miles. By 1910, these maximum figures were almost 2000 feet of head, 40,000 kilowatt capacity, 100,000 volt transmission lines, and 160 miles distance (Downing et al. n.d.:594–600).

Another key trend, evident by 1910, was the increasing attempt at full, systematic, and complete development of a given watershed. This was due to the increasing demand for electric power, especially in California—a state experiencing a boom in population and economic growth. This demand created profit potentials sure to attract the large amounts of capital needed to fully develop a given watershed with a chain of powerhouses.

Era of Hydroelectric Systems, 1910–Present

By 1910, the pioneer era of hydroelectric development was over and a new period was beginning—an era of refinement and expansion of basic principles set down during the pioneer years. The already established trends toward more and larger plants, higher heads, longer transmission lines, and higher voltages have continued during the years since 1910. The key change has been the move toward complex and carefully interconnected hydroelectric *systems* on a given watershed. Thus, during this era, chains of powerhouses were built on the Feather River, the Willow Creek/San Joaquin River watershed, Pit River, Klamath River, Mokelumne River, Kings River, Bishop Creek, Yuba River, and the Big Creek/San Joaquin River watershed.

During the period of its NRHP significance (1911–1929), the Big Creek Hydroelectric System was by far the most important such complex in California, and was important even on a national and world-wide scale. Its place among other California hydroelectric systems is illustrated by the following series of tables which cover a wide variety of significant features of California hydroelectric systems: these include head, generator, and water wheel capacity; transmission voltage; transmission distance; dams; and length of tunnels. In all these indexes of the importance of systems and individual power plants, the Big Creek System and its various components stand out as the premier system of the era. In 1919, for example, Big Creek powerhouses No. 1 and No. 2 appear on every statistical table (usually at or near the top), ranking the most powerful and largest of California power plants at the time. In 1929, all five Big Creek plants appear on one or another of these tables, and powerhouses No. 2A and No. 3 are usually at or near the top positions. No other system or individual power plant approaches Big Creek in these listings; the closest is Pacific Gas and Electric's Pit River System, with six listings on tables 2–F through 2–J (covering 1929), compared with 21 listings for the Big Creek System on this same series of tables.

Tables 2–K and 2–L offer information regarding dams from an official register of large United States dams compiled by the U.S. Committee of the International Commission on Large Dams. These tables give us some perspective on the five large historic dams constructed to impound water for the Big Creek System. These are the three main Huntington Lake dams, Shaver Lake Dam, and Florence Lake Dam. The first four were gravity dams, which are less common in California than earth and rock–fill dams but still more common than multi–arch dams. Table 2–K lists, in the order in which they were constructed, all 27 large gravity–type dams built in California, from the date the first was constructed until 1929. As this table illustrates, two of the Huntington Lake dams and the Shaver Lake Dam were among the largest gravity dams built in California during these years. Shaver Lake Dam had the longest crest of any California gravity dam built between 1889 (when the first such dam was completed) and 1929. Huntington Lake Dam No. 2 had the second longest crest. Shaver Lake Dam and Huntington Lake Dam No. 1 were among the highest, and both dams formed lakes that were among the largest California lakes created by gravity dams during those years (Table 2–K).

The same register of dams also offers comparative information on Florence Lake's multi–arch dam. Table 2–L lists and offers data on California's multi–arch dams between 1909 (when the first such dam was completed) and 1929. As was the case with the Huntington Lake dams and Shaver Lake Dam, the Florence Lake Dam was not a pioneer. It was, however, one of the largest of its time in capacity and height, and was by far the largest in length of crest (Table 2–L).

Finally, Table 2–M offers data on records in transmission line voltage and distance, as well as tunnels. During the 1913–1925 period, the Big Creek System was a world leader in transmission line voltage (the first system in the world to transmit at 150,000, then 220,000 volts) and also set two world records in size of water tunnels (Table 2–M).

For the period of its significance (1911–1929), the Big Creek Hydroelectric System represents an outstanding example of the theme of engineering and technological history. It was by far the most important California hydroelectric system of this era, and drew the attention of engineers worldwide.

California was in turn the recognized nationwide leader in hydroelectric development. During this era, California's only rivals for national pre–eminence in this field were the states of New York, Washington, and Alabama. None of these states had a development during the 1911–1929 years which compared with Big Creek. The important developments at New York's Niagara Falls, for example, took

TABLE 2-A

CALIFORNIA'S HIGHEST HEAD HYDROELECTRIC PLANTS--1919

(Based on Downing et al. n.d.:594-601;
Federal Power Commission 1941:14-21;
U.S. Department of Energy 1982:41-54)

Plant	Head (ft.)	Owner Company*	Date of Construction	Watershed
Big Creek #1	2,131	SCE	1913	Big Creek-San Joaquin River
Mill Creek #3	1,905	SCE	1903-1904	Mill Creek
Big Creek #2	1,858	SCE	1913	Big Creek-San Joaquin River
Rush Creek	1,810	N-CE	1916	Rush Creek
Tule River	1,532	SJLandP	1913	Tule River
De Sabla	1,531	PGandE	pre-1909	Big Butte Creek
Stanislaus	1,498	PGandE	1908	Stanislaus River
Electra	1,466	PGandE	1905	Mokelumne River
Wishon	1,410	PGandE	1910	Willow Creek-San Joaquin River
Drum	1,375	PGandE	1913	Bear River

* SCE - Southern California Edison
NCE - Nevada-California Electric
SJLandP - San Joaquin Light and Power
PGandE - Pacific Gas and Electric

TABLE 2-B

LARGEST KILOWATT CAPACITY FOR CALIFORNIA PLANT GENERATORS (Total Plant)--1919

(Based on Downing et al. n.d.:594-601;
Federal Power Commission 1941:14-21;
U.S. Department of Energy 1982:41-54)

Plant	kW Capacity	Owner*	Date of Construction
Big Bend	52,000	PGandE	1908, 1914
Stanislaus	28,900	PGandE	1908
San Francis- quito #1	28,125	LA WandP	1917
Big Creek #1	28,000	SCE	1913
Big Creek #2	28,000	SCE	1913
Drum	20,000	PGandE	1913
Electra	20,000	PGandE	1905
Kern River #1	16,000	SCE	1907
Colgate	14,200	PGandE	1901
Coleman	13,200	PGandE	1911

* PGandE - Pacific Gas and Electric
LA WandP - Los Angeles Department of Water and Power
SCE - Southern California Edison

TABLE 2-C

LARGEST AVERAGE KILOWATT CAPACITY FOR INDIVIDUAL GENERATORS, CALIFORNIA HYDROELECTRIC PLANTS--1919

(Based on Downing et al. n.d.:594-601; Federal Power Commission 1941:14-21; U.S. Department of Energy 1982:41-54)

Plant	kW Capacity	Owner Company*	Date of Construction
Big Creek #1	14,000	SCE	1913
Big Creek #2	14,000	SCE	1913
Wise	10,000	PGandE	1917
Halsey	10,000	PGandE	1916
Copco #1	10,000	C-O P	1918
Big Bend	10,000	PGandE	1908
Drum	10,000	PGandE	1913
Stanislaus	8,500	PGandE	pre-1909
Deer Creek	5,500	PGandE	1908
Coleman	4,400	PGandE	1911

* SCE - Southern California Edison
PGandE - Pacific Gas and Electric
C-O P - California-Oregon Power

TABLE 2-D

LARGEST AVERAGE HORSEPOWER FOR CALIFORNIA
PLANT TURBINES (WATER WHEELS)
(Total Plant)--1919

(Based on Downing et al. n.d.:594-601;
Federal Power Commission 1941:14-21;
U.S. Department of Energy 1982:41-54)

Plant	Horsepower	Owner Company*	Date of Construction
Big Bend	97,000	PGandE	1908, 1914
Stanislaus	64,000	PGandE	1908
San Francis-quito #1	48,000	LA WandP	1917
Big Creek #2	44,400	SCE	1913
Big Creek #1	44,000	SCE	1913
Drum	34,000	PGandE	1913
Electra	30,000	PGandE	1905
Wishon	24,400	PGandE	1910
De Sabla	22,000	PGandE	1906
Coleman	21,000	PGandE	1911

* PGandE - Pacific Gas and Electric
LA WandP - Los Angeles Department of Water and Power
SCE - Southern California Edison

TABLE 2-E

LARGEST AVERAGE HORSEPOWER FOR INDIVIDUAL IMPULSE WATER WHEELS, CALIFORNIA HYDROELECTRIC PLANTS--1919

(Based on Downing et al. n.d.:594-601; Federal Power Commission 1941:14-21; U.S. Department of Energy 1982:41-54)

Plant	Horsepower	Owner*	Date of Construction
Big Creek #2	22,200	SCE	1913
Big Creek #1	22,000	SCE	1913
Wise	18,700	PGandE	pre-1919
Copco #1	18,600	C-O P	1918
Big Bend	18,500	PGandE	1908, 1914
Halsey	18,000	PGandE	1916
Drum	17,000	PGandE	1913
San Francisquito #1	16,000	LA WandP	1917
Stanislaus	14,000	PGandE	1908
Rush Creek	8,000	N-CE	1916

* SCE - Southern California Edison
PGandE - Pacific Gas and Electric
C-O P - California-Oregon Power
LA WandP - Los Angeles Department of Water and Power
N-CE - Nevada-California Electric

TABLE 2-F

CALIFORNIA'S HIGHEST HEAD HYDROELECTRIC PLANTS--1929

(Based on Downing et al. n.d.:594-601;
Federal Power Commission 1941:14-21;
U.S. Department of Energy 1982:41-54)

Plant	Head (ft.)	Owner Company*	Date of Construction	Watershed
Bucks Creek	2,561	PGandE	1928	Bucks Creek-North Fork Feather River
Big Creek #2A	2,418	SCE	1928	Big Creek-San Joaquin River
Balch	2,336	PGandE	1927	Kings River
Big Creek #1	2,131	SCE	1913	Big Creek-San Joaquin River
Eldorado	1,910	PGandE	1924	American River
Mill Creek #3	1,905	SCE	1903-1904	Mill Creek
Spring Gap	1,865	PGandE	1921	Stanislaus River
Big Creek #2	1,858	SCE	1913	Big Creek-San Joaquin River
Rush Creek	1,810	N-CE	1916	Rush Creek
San Gorgonio #1	1,773	N-CE	1923	San Gorgonio River

* PGandE - Pacific Gas and Electric
SCE - Southern California Edison
N-CE - Nevada-California Electric

TABLE 2-G

LARGEST KILOWATT CAPACITY FOR CALIFORNIA PLANT GENERATORS
(Total Plant)--1929

(Based on Downing et al. n.d.:594-601;
Federal Power Commission 1941:14-21;
U.S. Department of Energy 1982:41-54)

Plant	kW Capacity	Owner*	Date of Construction
Big Creek #2A	80,000	SCE	1928
Big Creek #3	75,000	SCE	1923
Pit River #3	72,900	PGandE	1925
Moccasin	70,000	CandC SF	pre-1929
Big Creek #1	67,000	SCE	1913
Caribou	60,000	PGandE	1921
San Francis-quito #1	58,000	LA WandP	1917
Big Creek #2	57,750	SCE	1913
Pit River #1	56,000	PGandE	1920
Big Creek #8	54,000	SCE	1921

* SCE - Southern California Edison
PGandE - Pacific Gas and Electric
LA WandP - Los Angeles Department of Water and Power
CandC SF - City and County of San Francisco

TABLE 2-H

LARGEST AVERAGE KILOWATT CAPACITY FOR INDIVIDUAL GENERATORS, CALIFORNIA HYDROELECTRIC PLANTS--1929

(Based on Downing et al. n.d.:594-601; Federal Power Commission 1941:14-21; U.S. Department of Energy 1982:41-54)

Plant	kW Capacity	Owner*	Date of Construction
Big Creek #2A	40,000	SCE	1928
Balch	31,000	PGandE	1927
Pit River #1	28,000	PGandE	1920
Big Creek #8	27,000	SCE	1921
Big Creek #3	25,000	SCE	1923
Pit River #3	24,300	PGandE	1925
Caribou	20,000	PGandE	1921
Bucks Creek	20,000	PGandE	1928
Big Creek #1	19,500	SCE	1913
Moccasin	17,500	CandC SF	pre-1929

* SCE - Southern California Edison
PGandE - Pacific Gas and Electric
CandC SF - City and County of San Francisco

TABLE 2-I

LARGEST HORSEPOWER FOR CALIFORNIA PLANT
TURBINES (WATER WHEELS),
(Total Plant)--1929

(Based on Downing et al. n.d.:594-601;
Federal Power Commission 1941:14-21;
U.S. Department of Energy 1982:41-54)

Plant	Horsepower	Owner*	Date of Construction
Big Creek #2A	124,400	SCE	1928
Big Creek #3	122,700	SCE	1923
Big Creek #1	108,600	SCE	1913
Moccasin	100,000	Cand C SF	pre-1929
Pit River #3	99,000	PGandE	1925
San Francis- quito #1	96,200	LA WandP	1917
Big Creek #2	93,600	SCE	1913
Caribou	90,000	PGandE	1921
Pit River #1	80,000	PGandE	1920
Big Creek #8	79,000	SCE	1921

* SCE - Southern California Edison
CandC SF - City and County of San Francisco
PGandE - Pacific Gas and Electric
LA WandP - Los Angeles Department of Water and Power

TABLE 2-J

LARGEST AVERAGE HORSEPOWER FOR INDIVIDUAL TURBINES (WATER WHEELS), CALIFORNIA HYDROELECTRIC PLANTS--1929

(Based on Downing et al. n.d.:594-601; Federal Power Commission 1941:14-21; U.S. Department of Energy 1982:41-54)

Plant	Horsepower	Owner*	Date of Construction
Big Creek #2A	62,200	SCE	1928
Big Creek #3	49,000	SCE	1923
Balch	44,000	PGandE	1927
Pit River #1	40,000	PGandE	1920
Big Creek #8	39,500	SCE	1921
Bucks Creek	35,000	PGandE	1928
Pit River #3	33,000	PGandE	1925
Big Creek #1	31,300	SCE	1913
Caribou	30,000	PGandE	1921
Moccasin	25,000	CandC SF	pre-1929

* SCE - Southern California Edison
PGandE - Pacific Gas and Electric
CandC SF - City and County of San Francisco

TABLE 2-K

INTERNATIONAL COMMISSION ON LARGE DAMS
REGISTER OF MAJOR CALIFORNIA GRAVITY DAMS, 1884-1929

(Based on Mermel 1963:2-50)

Dam	Height (ft)	Length of Crest (ft)	Capacity (acre-ft)	Date of Construction
Loon Lake	35	650	8,000	1884
Sweetwater	128	700	27,639	1888
Searsville	88	260	952	1890
La Grange	131	280	500	1894
Williams	70	87	160	1895
Colgate	47	175	40	1904
Van Arsdale #1	52	290	700	1907
Utica	52	330	2,400	1908
Big Bend Intake	61	370	600	1910
Twin Lakes Park	50	85	30	1910
Crystal Springs	154	600	45,587	1911
Big Creek #1 (later Huntington Lake)	132	800	52,000	1913
Lake Spaulding #2	40	110	74,488	1913
Lake Spaulding #3	27	90	74,488	1913
Mendocino #3	49	254	85	1915
Alpine	134	524	9,210	1917
Huntington Lake #1 (Big Creek #1 enlarged)	170	1,335	89,766	1917

Table 2-K (cont.)

Dam	Height (ft)	Length of Crest (ft)	Capacity (acre-ft)	Date of Construction
Huntington Lake #2	120	1,862	89,766	1917
Huntington Lake #3	152	666	89,766	1917
Savage (Lower Otay)	176	750	56,326	1919
Devil's Gate	130	310	4,567	1920
Barrett	192	750	44,863	1922
Lake Hemet	147	324	14,000	1923
Mulholland	208	933	4,034	1924
Shaver Lake	198	2,169	135,175	1927
Camp Far West	62	365	5,000	1928
Pardee	385	1,350	222,000	1929
Spicers Meadows	53	250	3,800	1929

TABLE 2-L

INTERNATIONAL COMMISSION ON LARGE DAMS
REGISTER OF MAJOR CALIFORNIA MULTI-ARCH DAMS, 1909-1926

(Based on Mermel 1963:16-42)

Dam	Height (ft)	Length of Crest (ft)	Capacity (acre-ft)	Date of Construction
Hume Lake	64	650	1,410	1909
Bear Valley	92	360	72,167	1912
Los Verjels	60	310	1,830	1915
Gem Lake	112	688	17,604	1916
San Dieguito	51	650	1,131	1918
Murray	114	864	6,085	1918
Lake Hodges	136	616	22,550	1918
Lake Eleanor	70	1,260	27,600	1918
Webber Creek	94	350	1,275	1924
Little Rock	164	578	4,300	1924
Green Valley	68	260	250	1925
Florence	154	3,156	64,574	1926
Big Dalton	170	490	1,194	1929

TABLE 2-M

RECORDS IN TRANSMISSION LINE VOLTAGE,
TRANSMISSION LINE DISTANCE, AND TUNNELS

(Based on Downing et al. n.d.:594-601;
SCE 1923a:1-2, 1928a:6-7)

Date	Plant/System	Feature
1901	Colgate	60,000 volt transmission line; 142 miles
1908	Big Bend	100,000 volt transmission line; 155 miles
1913	Big Creek	150,000 volt transmission line; 241 miles
1923	Big Creek	220,000 volt transmission line; 241 miles (first tranmission line in world at this voltage)
1920-1925	Big Creek	Florence Lake (Ward) Tunnel, 13.5 miles long; longest water tunnel of its size (15x15 ft) in the world
1922-1923	Big Creek	No. 3 Tunnel, 5.6 miles long; longest tunnel of its size (21x21 ft) in the world

place before and just after the turn of the century (Martin and Coles 1922:133–134). In any case, by the early 1960s all the older generating plants at Niagara had been completely replaced with new, larger, and more efficient units (Gilliam 1979:303). Other early New York hydroelectric developments were much smaller than Big Creek. The largest such development during the 1911–1929 years was Rochester Gas and Electric Company's Station Number 5, whose largest unit (built in 1927; the plant's two smaller units were built in 1917) was only 15.8 megawatts (Gilliam 1979:304). In contrast, the Big Creek development built nine units of 15.8 megawatt size or larger during the 1911–1929 years (Gilliam 1979:52–53).

The State of Washington, on the other hand, had at least 11 hydroelectric units of this size (15.8 MW or larger) constructed during the 1911–1929 years. These were not part of one integrated and sustained development, however, and Washington's largest single unit was only 29 megawatts, a size exceeded by six of the Big Creek units (Gilliam 1979:52–53; 413–420).

Hydroelectric development in Alabama represents a similar case. The largest of the hydroelectric units constructed in this state during the 1911–1929 years was smaller than the largest units at Big Creek, and the several large developments of this state were not part of a single integrated system as was the case with Big Creek (Gilliam 1979:14–15). As Frank E. Bonner—a leading expert in hydroelectric development during the late 1920s—concluded in 1927:

> California's preeminent position in the water-power field is further evidenced in many other phases of the industry. The exceptionally high heads, great tunnels, huge storage dams, and large size impulse units are unequalled anywhere in America. Likewise the vast interconnected transmission systems operating at record-breaking voltages have made superpower a reality in this state [Bonner 1927:11].

In his 1927 publication on the water power of California, Bonner also concluded—as has been concluded here—that the most notable such development in California was the ". . . immense Big Creek project of Southern California Edison . . ." (Bonner 1927:18).

Category, Boundaries, and Level of Importance: A Discontiguous District of Statewide and National Significance

The NRHP recognizes these categories of historically significant properties: districts, sites, buildings, structures, and objects. A district is the most appropriate category for the Big Creek Hydroelectric System, as this is a distinguishable entity with a distinct character and coherence. It has a significant concentration of buildings and structures directly connected with hydroelectric developments during the 1911–1929 years. The buildings and structures included within the Big Creek Hydroelectric District are distinguishable from those surrounding it by their age and integrity. All of the buildings and structures within the district date from the 1911–1929 era, are related to the hydroelectric developments of those years, and have reasonably good integrity. Those buildings and structures that lie outside the district fail these tests. The district is thus discontiguous, with spatially discrete, non-significant areas separating those judged to be significant. Put another way, there are many buildings and structures that are part of the modern (post-1930) Big Creek System but do not contribute to the significance of the Big Creek Hydroelectric District; thus, they are considered to be outside the district's boundaries. The boundaries of this district should be drawn to include the following buildings and structures:

<u>Dams</u>
Huntington Lake Dams No. 1, No. 2, No. 3
Florence Lake Dams No. 4, No. 5, No. 6
Shaver Lake Dam

<u>Tunnels</u>
Florence Lake (Ward) Tunnel
Tunnels No. 2, No. 3, No. 8

<u>Powerhouses</u>
Powerhouses No. 1, No. 2. No. 2A, No. 8, No. 3

<u>Penstocks, Incline Railroads, and Surge Chambers</u> for
Powerhouses No. 1, No. 2, No. 2A, No. 8, No. 3

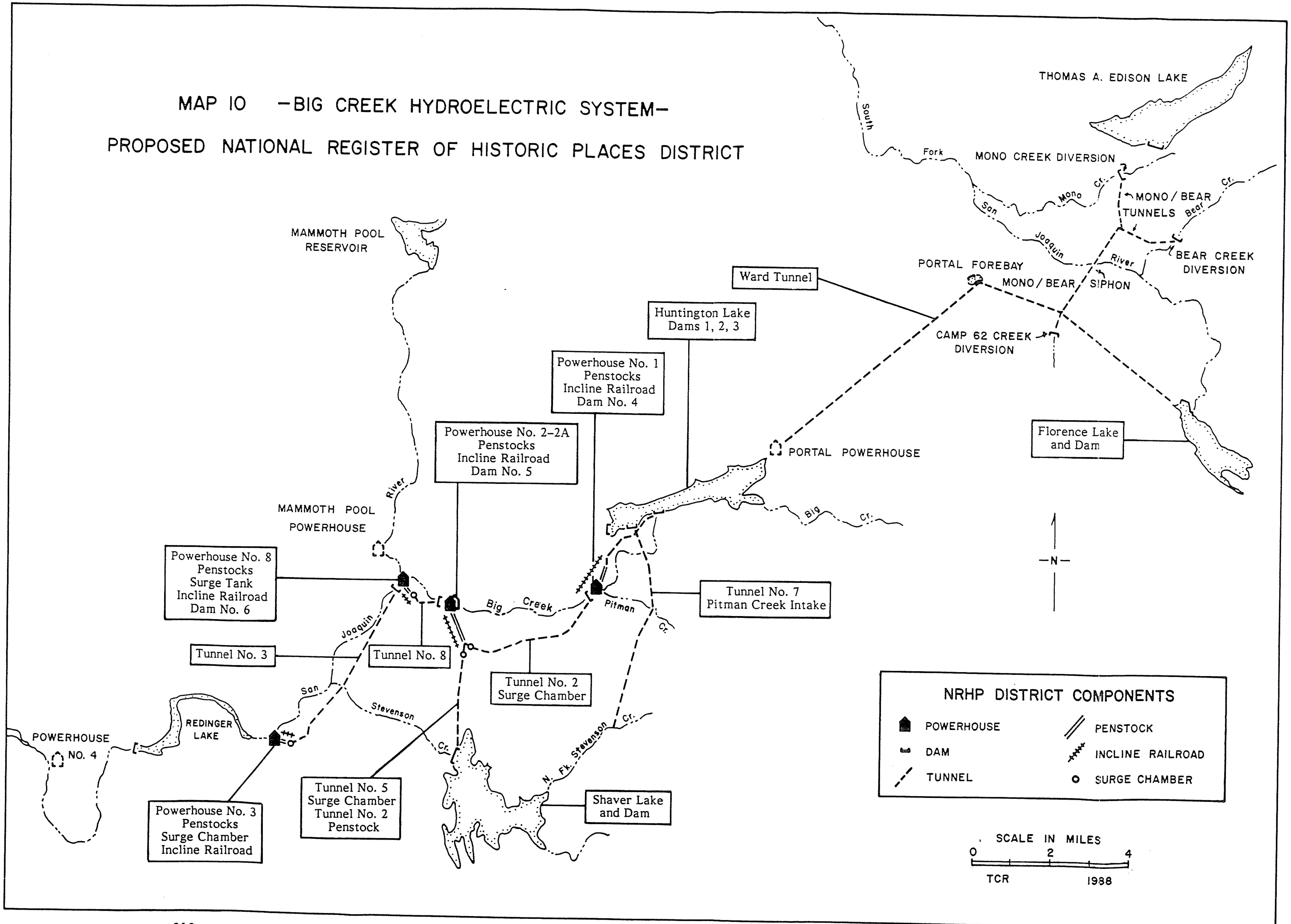
<u>Transmission Lines to Los Angeles</u>
(built in 1911-1929 period)

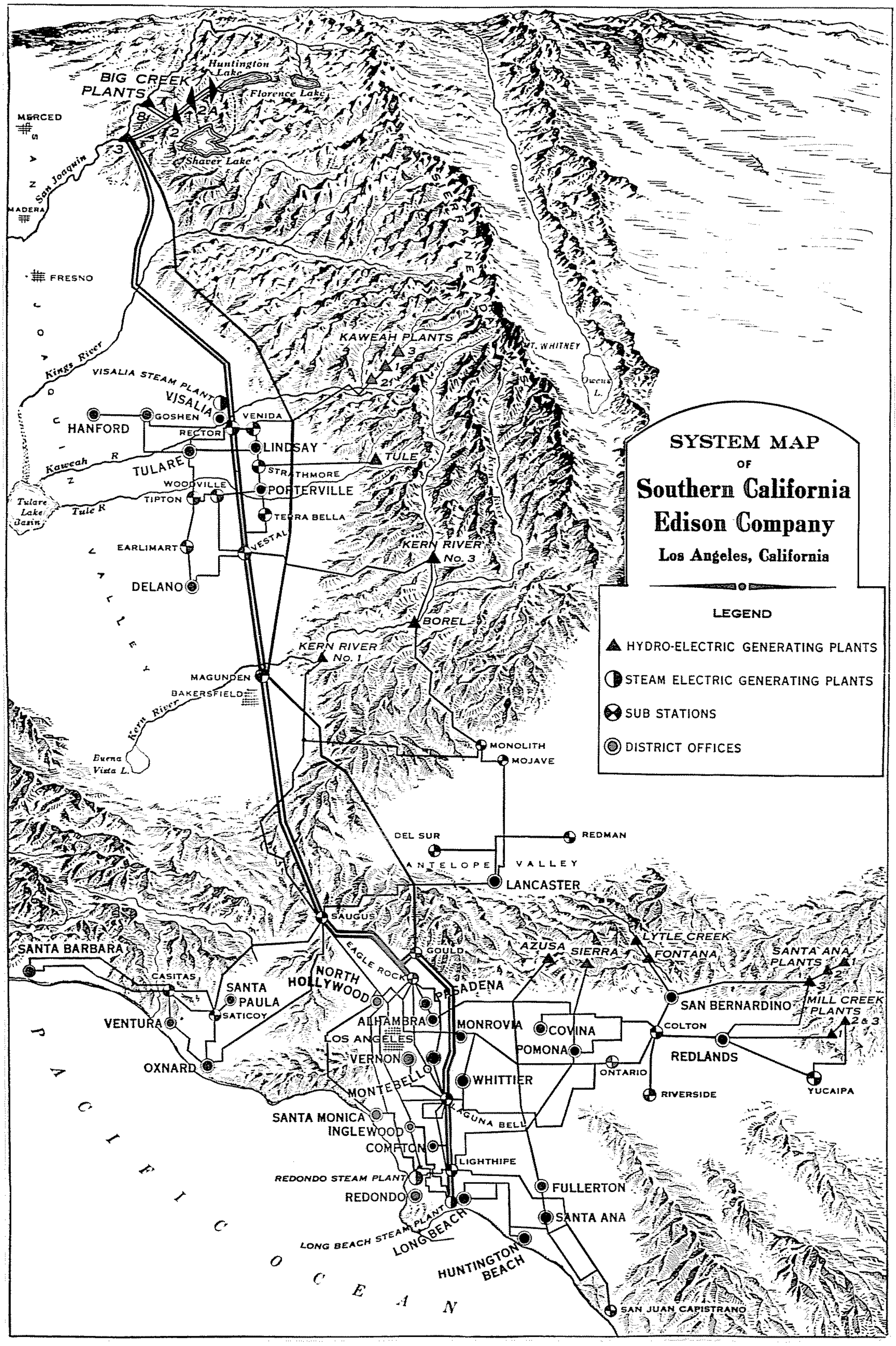
The above-named components possess integrity, and the relationships between them are substantially unchanged since their period of significance. Collectively, they represent the basic design features which convey the historic appearance and function of this important Hydroelectric System (Map 10, Map 11).

This district recommendation does not consider the significance or contributing/non-contributing status of the many residential and support buildings associated with the development of the System. The present study addressed only the major engineering and technological components of the System. Evaluation of these structures would require field-level inventory, assessment of history and integrity, and analysis of significance of the buildings relative to the proposed district.

Level of Significance

The Big Creek Hydroelectric District is of both statewide and national significance. As discussed and documented in some detail above, this System well represents an important theme in California history, and outstandingly represents this theme for the 1911-1929 years. There are also many connections between the construction and operation of the Big Creek System and the development of the Los Angeles area: key people associated with the Big Creek System were important figures in the history of this part of the state. Furthermore, since California was the national leader in water power development during this period, understanding the history of this district can help in understanding the history of hydroelectric development as a national phenomena.


MAP 10 —BIG CREEK HYDROELECTRIC SYSTEM—
PROPOSED NATIONAL REGISTER OF HISTORIC PLACES DISTRICT
THOMAS A. EDISON LAKE
MONO CREEK DIVERSION
South Fork
Mono Cr.
MONO / BEAR TUNNELS
Bear Cr.
San Joaquin River
BEAR CREEK DIVERSION
PORTAL FOREBAY
MONO / BEAR SIPHON
Ward Tunnel
CAMP 62 CREEK DIVERSION
Huntington Lake Dams 1, 2, 3
MAMMOTH POOL RESERVOIR
Powerhouse No. 1 Penstocks Incline Railroad Dam No. 4
Powerhouse No. 2–2A Penstocks Incline Railroad Dam No. 5
PORTAL POWERHOUSE
Florence Lake and Dam
River
Big Cr.
MAMMOTH POOL POWERHOUSE
Powerhouse No. 8 Penstocks Surge Tank Incline Railroad Dam No. 6
Big Creek
Pitman Cr.
Tunnel No. 7 Pitman Creek Intake
N
Joaquin
Tunnel No. 3
Tunnel No. 8
Tunnel No. 2 Surge Chamber
San
Stevenson Cr.
NRHP DISTRICT COMPONENTS
POWERHOUSE
DAM
TUNNEL
PENSTOCK
INCLINE RAILROAD
SURGE CHAMBER
POWERHOUSE NO. 4
REDINGER LAKE
N. Fk. Stevenson Cr.
Powerhouse No. 3 Penstocks Surge Chamber Incline Railroad
Tunnel No. 5 Surge Chamber Tunnel No. 2 Penstock
Shaver Lake and Dam
SCALE IN MILES
0 2 4
TCR 1988



MAP II -PROPOSED NRHP DISTRICT- 1928 BIG CREEK TO LOS ANGELES TRANSMISSION CORRIDORS

Big Creek Hydroelectric District and NRHP Significance Criteria

Part 60.6 of Chapter I of Title 36 of the Code of Federal Regulations outlines the criteria for evaluation of properties for possible inclusion in the NRHP. The key section reads as follows:

> The quality of significance in American history, architecture, archeology, and culture is present in districts, sites, buildings, structures, and objects of State and local importance that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and
>
> a) That are associated with events that have made a significant contribution to the broad patterns of our history; or
> b) That are associated with the lives of persons significant in our past; or
> c) That embody the distinctive characteristics of a type, period, or method of construction, or that possess high artistic value, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
> d) That have yielded, or may be likely to yield information important in prehistory or history [36CFR60.6].

National Register significance criteria, then, have two main aspects: Importance (as defined by [a] through [d] above), and Integrity. The Big Creek Hydroelectric District will be discussed as it relates to each of these in turn.

Importance

The Big Creek Hydroelectric District qualifies for the NRHP under criteria a, b, and c. It is ". . . associated with events that have made a significant contribution to the broad patterns of our history; . . ." These events were the planning, construction, and operation of a large, complex, and interrelated power System which served and helped make possible the development of a huge urban territory—the Los Angeles metropolitan area. Thus, in this case, the engineering and technological history of hydroelectric development has evolved in interdependence with the building of a major urban center. This series of events has made a significant contribution to the broad patterns of our history.

The Big Creek Hydroelectric District is also ". . . associated with the lives of persons significant in our past; . . ." These individuals are John S. Eastwood, Henry E. Huntington, and George C. Ward. Each of these men was involved in a distinctly different but central aspect of the project. John S. Eastwood—one of the pioneer hydroelectric and dam engineers of California—spent a number of years planning the development of the Big Creek System. He lived in the Big Creek area during several summers, doing the survey work and basic calculations upon which the entire development of the Big Creek Hydroelectric System would eventually be based. His grand-scale vision, the ability to conceptualize and plan for the implementation of one of the world's great engineering projects of the early twentieth century, was indispensable.

Henry E. Huntington, one of California's leading capitalists during the early decades of this century, was the key financier behind the project. His wealth, connections, and ambitions—both for this project and the development of the Los Angeles area—made possible the initial construction of the Big Creek System.

George C. Ward managed the complex engineering and construction operations during the great expansion of the 1920s. Since this was one of the largest such operations in world history up to that point in time, he became well known in engineering and construction circles.

Finally, the Big Creek Hydroelectric District embodies the "distinctive characteristics" of a type, period, and method of construction. It illustrates and enhances understanding of hydroelectric systems as well as the kind of construction characteristic of such systems. Both the building types (for example, powerhouses of functional design) and arrangment of the elements in powerhouse interiors are distinctive. In addition, distinctive construction techniques were employed, such as the use of incline railroads.

Integrity

Evaluation of the integrity of a historic property is the starting point in proving that the property in question is really a *historic* one. As a recent National Park Services publication expressed it:

> Integrity is the authenticity of a property's historic identity, evidenced by the survival of physical characteristics that existed during the property's historic or prehistoric period. If a property retains the physical characteristics it possessed in the past then it has the capacity to convey association with historical patterns or persons, architectural or engineering design and technology, or information about a culture or people [USDI, National Park Service 1982:35].

As outlined in the NRHP criteria listed above, integrity has seven aspects. The degree of integrity of any specific property typically varies, depending upon which of the seven aspects is in focus. But it is usually assumed that, in order to be determined significant, a candidate property must not be totally lacking in any one of the seven categories. Thus, integrity is thus not an all or nothing question. Changes may have been made to a property, damaging part of its integrity, but other aspects of its integrity may be fully intact and the property may still be historically significant. Integrity, then, is frequently a matter of degree. A property's importance also enters into such calculations, since in practice the more important a given historic property is, the more it can undergo a loss of integrity and still qualify for the NRHP. The key questions to ask (based on a National Park Service publication) in regard to each of the seven aspects of integrity relating to hydroelectric facilities are as follows:

> Location—Is the significant property still at its original site? If part of a complex of buildings, are the key original buildings still present and in their original locations?

Design—Does the property retain the essential design elements of its class? The main design elements, the focus of interest in a hydroelectric system, are the hydraulic system (dams, tunnels, surge chambers, and penstocks); the generation system (the key elements being water turbines, governors, exciters, generators, and transformers); and the transmission system (including switchyards and transmission lines). Have any of these main design elements been destroyed or seriously altered from the original?

Setting—Has the character of the place where the property is located been changed? Have there been important alterations in the immediate surroundings of the key elements of this hydroelectric complex? Have any of the original, key buildings been torn down? Have such changes fundamentally affected the relationship of the property to its setting?

Materials--Have the original materials (physical elements combined to form productive tools or other things useful in cultural life) of historic importance associated with the property been substantially altered by reconstruction or replacement? If so, are the new materials equivalent to or compatible with the original?

Workmanship—Does physical evidence of the early craftsmen's labor, skill, and knowledge remain? Have the methods—including technology—of combining materials to make an industrial artifact useful in a hydroelectric power system remained the same? Have repairs and replacements been made using new techniques of workmanship?

Feeling and Associations—Does the property communicate a sense of what it was like during its historic period? Is there a direct link between the property and the event or person which makes it significant? Feeling and association are present only if the five other integrity attributes are also present to a reasonably high degree (Chamberlin 1983:16; National Park Service 1982:35–37).

While all of these seven integrity attributes are important, integrity of location, design, workmanship, and materials are especially crucial for a historic hydroelectric system. This is true because what is of particular interest in a hydroelectric complex are the technological aspects, the engineering and industrial techniques used to create and transmit electrical power. This is the central theme which makes hydroelectric complexes interesting and historically significant. Lack of integrity of location, materials, or basic design could make a historic hydroelectric system ineligible for the NRHP. As a 1982 National Park publication expressed it in a specific example:

> A mid-19th century water-powered mill important for its association with the industrial development of a locality would not be eligible if it had been moved or if substantial amounts of new materials had been incorporated, or if it no longer retained even basic design features that conveyed its historic appearance or function [USDI, National Park Service 1982:42].

Integrity of the Big Creek Hydroelectric District

Interviews with knowledgeable observers is one method for determining the integrity of a historic but still functioning property. This method was used in this case to help arrive at conclusions about the integrity of the Big Creek System. Eugene Griffiths, who has worked at Big Creek since 1946 and was supervisor of maintenance in 1986, was interviewed in depth about the integrity of the main components of the Big Creek System (Griffiths 1986). Griffiths has worked for decades on maintaining and upgrading the main elements of the Big Creek powerhouses, and he knows the System in detail.

As pointed out above, integrity is not an all–or–nothing question, but rather a matter of degree. Such is the case with the Big Creek Hydroelectric District. An analysis of the Big Creek district against each aspect of integrity results in the overall conclusion that the integrity of this district, while nowhere near perfect, is reasonably good. This analysis follows for each of the integrity aspects, ranking each on a scale of excellent, good, fair, and poor.

Location--The key original buildings (powerhouses specifically) as well as dams, tunnels, penstocks, and transmission lines are all in their original locations. The Big Creek district thus has excellent integrity of location.

Design--The main design elements of the historic Big Creek district are intact with only a few modifications. The original 1911–1929–era design for the hydraulic system (dams, tunnels, surge chambers, and penstocks) is almost entirely intact. The few changes in the hydraulic system involved the addition of two new generating units (in 1947–1948 and 1978–1980) at Powerhouse No. 3. These changes at Powerhouse No. 3 also represent the only basic design changes in the Big Creek generation system. The transmission system also retains its basic design. In short, the integrity of design of the Big Creek System has been retained; there have been only isolated and relatively minor alterations. On this scale, the design integrity of the Big Creek System should be ranked as good.

Setting--The basic character of the region immediately surrounding the Big Creek Hydroelectric District has remained much as it was during the 1911–1929 years. The region, part of a mountainous area of the southern Sierra, has seen two types of changes since 1929. First, new power plants and related facilities have been built in the region, several of them automatic, open–air plants. Secondly, recreation–oriented development at Shaver and Huntington lakes has been substantial in recent years. These developments have not seriously altered the setting for the Big Creek Hydroelectric District, however, since most of the district is physically removed by a number of miles (and often locked gates) from the scenes of these developments. Thus, integrity of setting is also ranked as good.

Materials--There have been more changes in the Big Creek Hydroelectric District in regard to materials than in location, design, and setting. For example, virtually every powerhouse has had new water wheels (turbines) and generator windings installed. The new materials are equivalent to the originals, however, and their appearance is virtually identical to the original.

Furthermore, in almost all cases, the shafts and cores of the turbines and generators are original. Dams, surge chambers, and penstocks are also mainly original; however, the governors at all the powerhouses are of 1950s vintage. Transformers are virtually all less than 50 years old, since transformer technology has changed rapidly over this period. The transmission towers, on the other hand, are mostly original equipment. The main buildings of the System—the five powerhouses—have not been rebuilt and so maintain their original materials. In sum, in the case of materials there is a mixed case—some new, but much that is old. The integrity of materials for the Big Creek Hydroelectric District, therefore, must be ranked as fair.

Workmanship—As in the case of materials, workmanship is also a mixed case. Much physical evidence remains (in key buildings, within the powerhouses, in the dams, tunnels, penstocks, and transmission lines) of the early craftsmen's labor, skill, and knowledge. All of the Big Creek district's historic plants are not yet automatic; they still have operators present. At the same time, new tools and techniques have been used to maintain and repair the key elements of the Big Creek Hydroelectric District over the past 50 years. For example, in recent years, a magnaflux inspection has been used to inspect water wheels (turbine) buckets, whereas, in the past, magnifying and strong light were used. Similarly, a hydraulic jenny jack has been used recently to remove bolts on water wheels, whereas in the past a striking ram was used. A final example regards waterway trash rakers: formerly, hand-operated rakes were used exclusively; now, electric-powered trash rakes are used. Other examples of changes could also be cited, but the effect is the same. Workmanship is a mixed case, and integrity in this area must be ranked only as fair.

Feeling and Association—A visitor to the Big Creek Hydroelectric District will find that this historic district does communicate a sense of what it was like during its historic period. There are direct and visible links between this property and the people and events that make it significant. This aspect of integrity for the Big Creek district must be ranked as good.

In sum, the overall integrity of the Big Creek Hydroelectric District is fair to good. Due to its great importance, the fact that the System's integrity is not in the good to excellent range should not be the controlling factor. For this outstanding example of the art and science of hydroelectric engineering, fair to good integrity is sufficient to qualify for the NRHP.

Conclusions and Management Recommendations

This NRHP evaluation suggests that the Big Creek Hydroelectric System is an excellent representative of the theme of engineering and technological history during the 1911-1929 period. The historic parts of this System are recommended as being best seen as a discontiguous district of statewide significance. This district is considered by the investigators to have adequate integrity to qualify for the NRHP under criteria a, b, and c.

If the State Historic Preservation Officer and the Keeper of the National Register concur with this evaluation, and if it is determined that Southern California Edison Company's Big Creek Expansion Project (BiCEP) would seriously impact the integrity of powerhouses No. 2A, No. 3, and No. 8 and their related features, a mitigation program should be planned and implemented. Participants in the development of such a full-scale mitigation program should minimally include cultural resource specialists representing Southern California Edison Company, the State Historic Preservation Office, and the Sierra National Forest.

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1912 Big Creek Road Will End at Pinnells. January 29, p. 12.

1912 New Railroad Will Boom Mountain Resorts. January 30, p. 3.

1912 Laborer Is Found Dead On Trail. January 30, p. 7.

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1912 Big Creek Road Grading Starts. February 13, p. 7.

1912 Big Creek Road Grading Rushed. February 21, p. 7.

1912 Fourteen Hundred Men Rush Work on Monster Big Creek Project. March 11, p. 5.

1912 The Big Creek Road Now Looks Like Railroad. March 27, p. 7.

1912 Work Progressing on Big Creek Railroad. April 3, p. 16.

1912 Big Creek Track Extends Nine Miles. April 19, p. 7.

1912 Big Creek Road Will be Ready for Traffic by July 1. May 23, p. 1–2.

1912 Walks In Sleep; Falls Down Cliff. May 23, p. 20.

1912 10 Miles of Track To Be Laid on New Railroad. June 22, p. 24.

1912 Big Creek Railroad Ready by July 10th, Construction of Dam and Power Plant is Next Undertaking. July 3, p. 3.

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APPENDIX

The following tables (A–D), maps (A–E), and figures (A–E) provide a baseline description of the Big Creek Hydroelectric System as it existed in 1928. This, then, is the System at the end of the period of significance, at the time when the first phase of development had been completed. These data are adapted or drawn directly from SCE sources as noted.

TABLE A

MAJOR EQUIPMENT IN BIG CREEK POWERHOUSE NO. 1, 1928

(Adapted from SCE 1928b:B9–7–B12–6)

GENERATORS

Unit Nos. 1, 2 and 3
3 – G. E. Co. Alternating Current Generators

Unit No. 4
1 – Westinghouse Alternating Current Generator

Exciter Nos. 1 and 2 (Unit Nos. 1, 2, and 3)
2 – G. E. Co. Direct Current Generators

Exciter No. 3 and Spare (Unit No. 4)
2 – Westinghouse Direct Current Generators

HYDRAULIC

Unit Nos. 1, 2 and 3
1 – Allis Chalmers Hydraulic Turbine;
Double Overhung Type, Single Jet, Impulse Wheel with Relief Valve,
Type F1, Static Head 2131 ft.

Unit No. 4
1 – Pelton Hydraulic Turbine;
Double Overhung Type, Single Jet, Impulse Wheel with Relief Valve,
Static Head 2131 ft.

Exciter Turbines
2 – Allis Chalmers Hydraulic Turbines;
Single Overhung, Type B1, Single Jet, Impulse Wheel,
Head 1900 ft.

TRANSFORMERS

East and West Line Banks, each 52,500 Kva.
6 – G. E. Co. Single Phase, Auto Transformers

Bank Nos. 1 and 2, each 17,500 Kva.
7 – G. E. Co. Single Phase Transformers

Bank No. 3, 17,500 Kva.
3 – G. E. Co. Single Phase Transformers

TABLE B

MAJOR EQUIPMENT IN BIG CREEK POWERHOUSE NO. 2, 1928

(Adapted from SCE 1928b:B9–7–B12–6)

GENERATORS

Unit Nos. 1, 2, 3, and 4
4 – Westinghouse Alternating Current Generators

Exciter Nos. 1 and 2 (Units 1, 2, and 3)
2 – Westinghouse Direct Current Generators

Exciter No. 3 (Unit No. 4)
1 – Westinghouse Direct Current Generator

HYDRAULIC

Unit Nos. 1 and 2
2 – Allis Chalmers Hydraulic Turbines;
Double Overhung Type, Single Jet, Impulse Wheel,
Type F1, Static Head 1858 ft.

Unit Nos. 3 and 4
2 – Pelton Hydraulic Turbines;
Double Overhung Type, Single Jet, Impulse Wheel,
Static Head 1858 ft.

Exciter Nos. 1 and 2 Turbines
2 – Allis Chalmers Hydraulic Turbines;
Single Overhung Type, Single Jet, Impulse Wheel,
Type B1, Static Head 1680 ft.

EXCITER MOTORS

Emergency Motor for Exciter No. 1
1 – Westinghouse Induction Motor

Emergency Motor for Exciter No. 2
1 – Westinghouse Induction Motor

TRANSFORMERS

East and West Line Banks, each 17,500 Kva.
6 – G. E. Co. Single Phase Auto Transformers

Bank Nos. 1, 2, 3, and 4, each 17,500 Kva.
13 – Westinghouse Single Phase Transformers

TABLE C

MAJOR EQUIPMENT IN BIG CREEK POWERHOUSE NO. 3, 1928

(Adapted from SCE 1928b:B9-7-B12-6)

GENERATORS

Unit Nos. 1, 2 and 3
3 - Westinghouse Alternating Current Generators

Station Generators
2 - Westinghouse Alternating Current Generators

Unit Nos. 1, 2 and 3, Exciters
3 - Westinghouse Direct Current Generators

Station Generator Exciters
2 - Westinghouse Direct Current Generators

HYDRAULIC

Unit Nos. 1, 2 and 3, Turbines
3 - Wellman-Seaver-Morgan Turbines;
Single Runner, Vertical Francis Type, with
30" Mechanically Operated Relief Valves,
Capacity 80% of full load Penstock Flow,
Static Head 830 ft.

Station Generator Turbines
2 - Pelton Hydraulic Turbines

TRANSFORMERS

Bank Nos. 1 and 2, each 55,500 Kva.
7 - Westinghouse Single Phase Transformers

TABLE D

MAJOR EQUIPMENT IN BIG CREEK POWERHOUSE NO. 8, 1928

(Adapted from SCE 1928b:B9–7–B12–6)

GENERATORS AND TURBINES

Unit No. 1
1 – G. E. Co. Alternating Current Generator

1 – Wm. Cramp and Sons,
Ship and Engine Building Co., Turbine;
Reaction Type, 680 ft. Head

1 – G. E. Co. Direct Current Generator (Exciter)

Station Generator No. 1
1 – G. E. Alternating Current Generator

1 – Allis Chalmers Mfg. Co. Turbine;
Impulse Type, 750 ft. Head

TRANSFORMERS

Main Power Transformer Bank, 60,000 Kva.
4 – G. E. Co. Single Phase Transformers

APPENDIX

The following tables (A–D), maps (A–E), and figures (A–E) provide a baseline description of the Big Creek Hydroelectric System as it existed in 1928. This, then, is the System at the end of the period of significance, at the time when the first phase of development had been completed. These data are adapted or drawn directly from SCE sources as noted.

TABLE A

MAJOR EQUIPMENT IN BIG CREEK POWERHOUSE NO. 1, 1928

(Adapted from SCE 1928b:B9–7–B12–6)

GENERATORS

Unit Nos. 1, 2 and 3
3 – G. E. Co. Alternating Current Generators

Unit No. 4
1 – Westinghouse Alternating Current Generator

Exciter Nos. 1 and 2 (Unit Nos. 1, 2, and 3)
2 – G. E. Co. Direct Current Generators

Exciter No. 3 and Spare (Unit No. 4)
2 – Westinghouse Direct Current Generators

HYDRAULIC

Unit Nos. 1, 2 and 3
1 – Allis Chalmers Hydraulic Turbine;
Double Overhung Type, Single Jet, Impulse Wheel with Relief Valve,
Type F1, Static Head 2131 ft.

Unit No. 4
1 – Pelton Hydraulic Turbine;
Double Overhung Type, Single Jet, Impulse Wheel with Relief Valve,
Static Head 2131 ft.

Exciter Turbines
2 – Allis Chalmers Hydraulic Turbines;
Single Overhung, Type B1, Single Jet, Impulse Wheel,
Head 1900 ft.

TRANSFORMERS

East and West Line Banks, each 52,500 Kva.
6 – G. E. Co. Single Phase, Auto Transformers

Bank Nos. 1 and 2, each 17,500 Kva.
7 – G. E. Co. Single Phase Transformers

Bank No. 3, 17,500 Kva.
3 – G. E. Co. Single Phase Transformers

TABLE B

MAJOR EQUIPMENT IN BIG CREEK POWERHOUSE NO. 2, 1928

(Adapted from SCE 1928b:B9–7–B12–6)

GENERATORS

Unit Nos. 1, 2, 3, and 4
4 – Westinghouse Alternating Current Generators

Exciter Nos. 1 and 2 (Units 1, 2, and 3)
2 – Westinghouse Direct Current Generators

Exciter No. 3 (Unit No. 4)
1 – Westinghouse Direct Current Generator

HYDRAULIC

Unit Nos. 1 and 2
2 – Allis Chalmers Hydraulic Turbines;
Double Overhung Type, Single Jet, Impulse Wheel,
Type F1, Static Head 1858 ft.

Unit Nos. 3 and 4
2 – Pelton Hydraulic Turbines;
Double Overhung Type, Single Jet, Impulse Wheel,
Static Head 1858 ft.

Exciter Nos. 1 and 2 Turbines
2 – Allis Chalmers Hydraulic Turbines;
Single Overhung Type, Single Jet, Impulse Wheel,
Type B1, Static Head 1680 ft.

EXCITER MOTORS

Emergency Motor for Exciter No. 1
1 – Westinghouse Induction Motor

Emergency Motor for Exciter No. 2
1 – Westinghouse Induction Motor

TRANSFORMERS

East and West Line Banks, each 17,500 Kva.
6 – G. E. Co. Single Phase Auto Transformers

Bank Nos. 1, 2, 3, and 4, each 17,500 Kva.
13 – Westinghouse Single Phase Transformers

TABLE C

MAJOR EQUIPMENT IN BIG CREEK POWERHOUSE NO. 3, 1928

(Adapted from SCE 1928b:B9–7–B12–6)

GENERATORS

Unit Nos. 1, 2 and 3
3 – Westinghouse Alternating Current Generators

Station Generators
2 – Westinghouse Alternating Current Generators

Unit Nos. 1, 2 and 3, Exciters
3 – Westinghouse Direct Current Generators

Station Generator Exciters
2 – Westinghouse Direct Current Generators

HYDRAULIC

Unit Nos. 1, 2 and 3, Turbines
3 – Wellman–Seaver–Morgan Turbines;
Single Runner, Vertical Francis Type, with
30" Mechanically Operated Relief Valves,
Capacity 80% of full load Penstock Flow,
Static Head 830 ft.

Station Generator Turbines
2 – Pelton Hydraulic Turbines

TRANSFORMERS

Bank Nos. 1 and 2, each 55,500 Kva.
7 – Westinghouse Single Phase Transformers

TABLE D

MAJOR EQUIPMENT IN BIG CREEK POWERHOUSE NO. 8, 1928

(Adapted from SCE 1928b:B9-7-B12-6)

GENERATORS AND TURBINES

Unit No. 1
1 – G. E. Co. Alternating Current Generator

1 – Wm. Cramp and Sons,
Ship and Engine Building Co., Turbine;
Reaction Type, 680 ft. Head

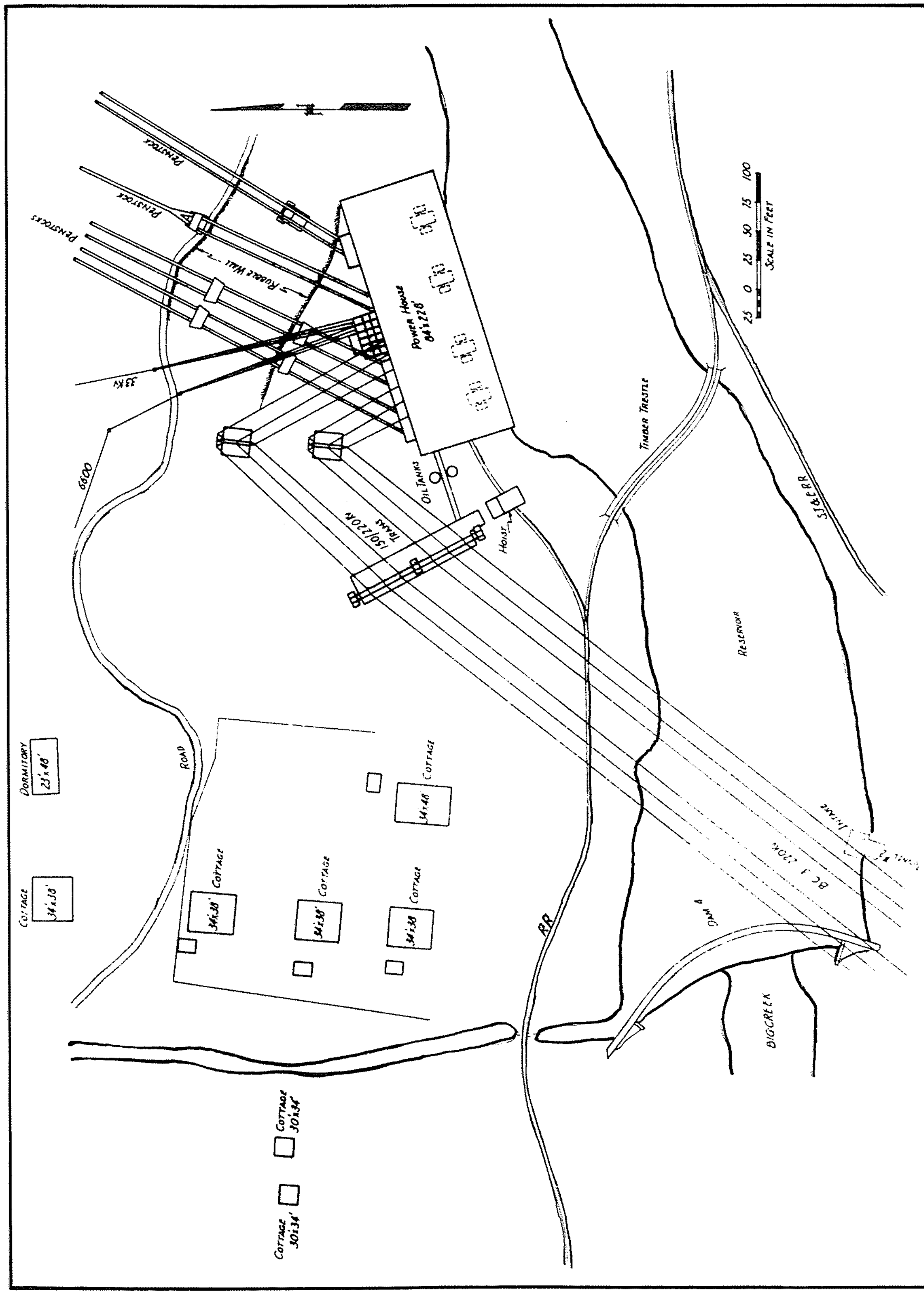
1 – G. E. Co. Direct Current Generator (Exciter)

Station Generator No. 1
1 – G. E. Alternating Current Generator

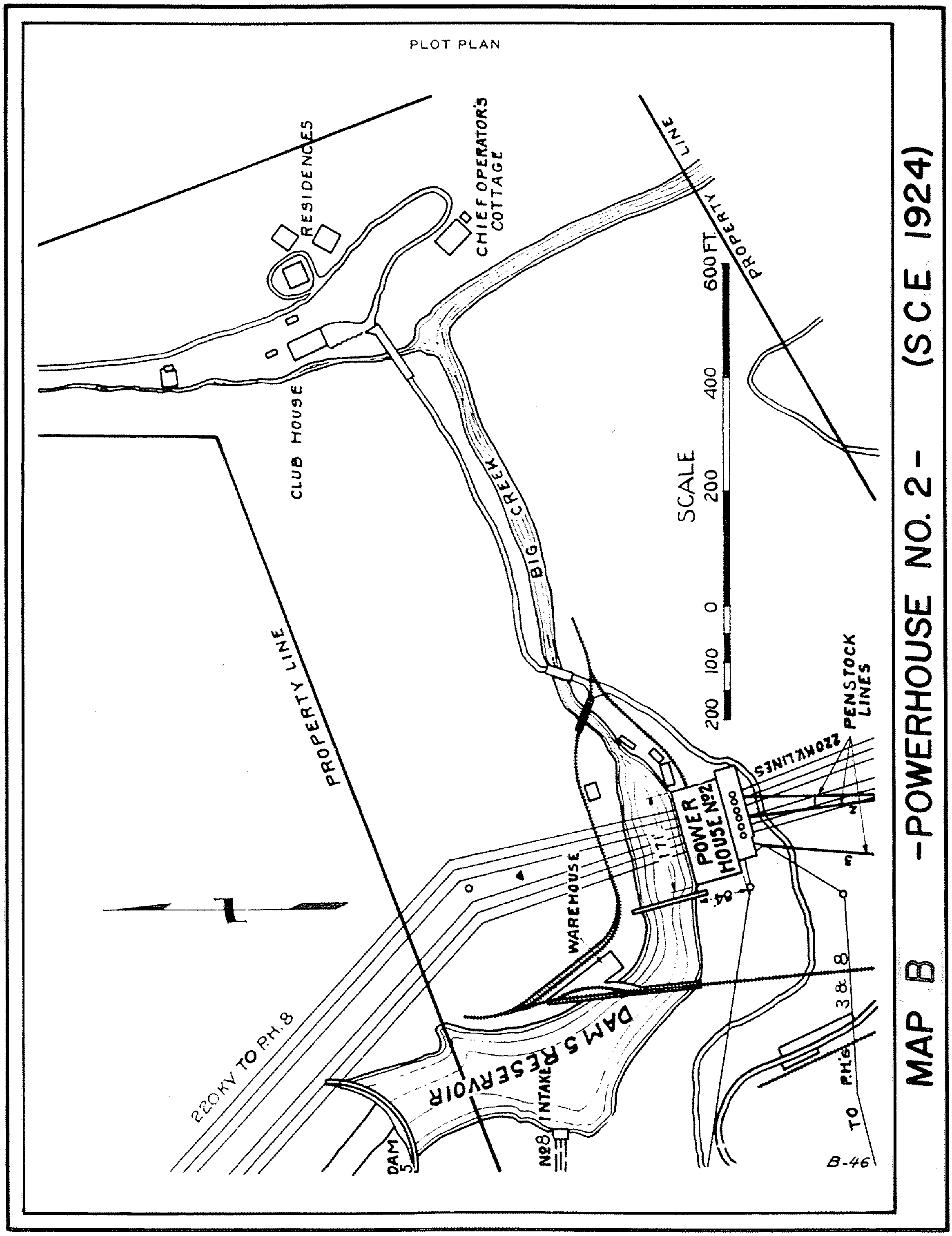
1 – Allis Chalmers Mfg. Co. Turbine;
Impulse Type, 750 ft. Head

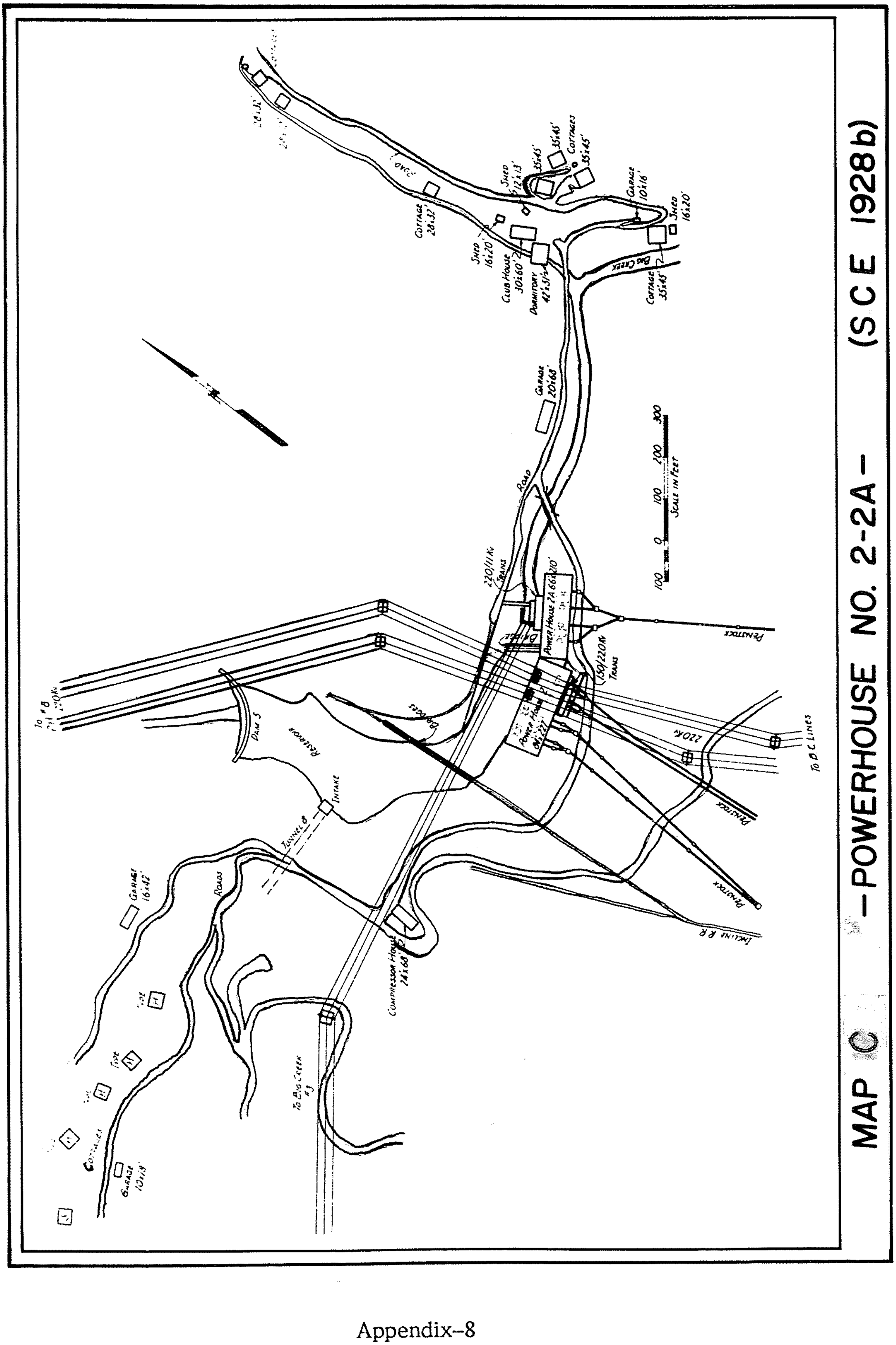
TRANSFORMERS

Main Power Transformer Bank, 60,000 Kva.
4 – G. E. Co. Single Phase Transformers

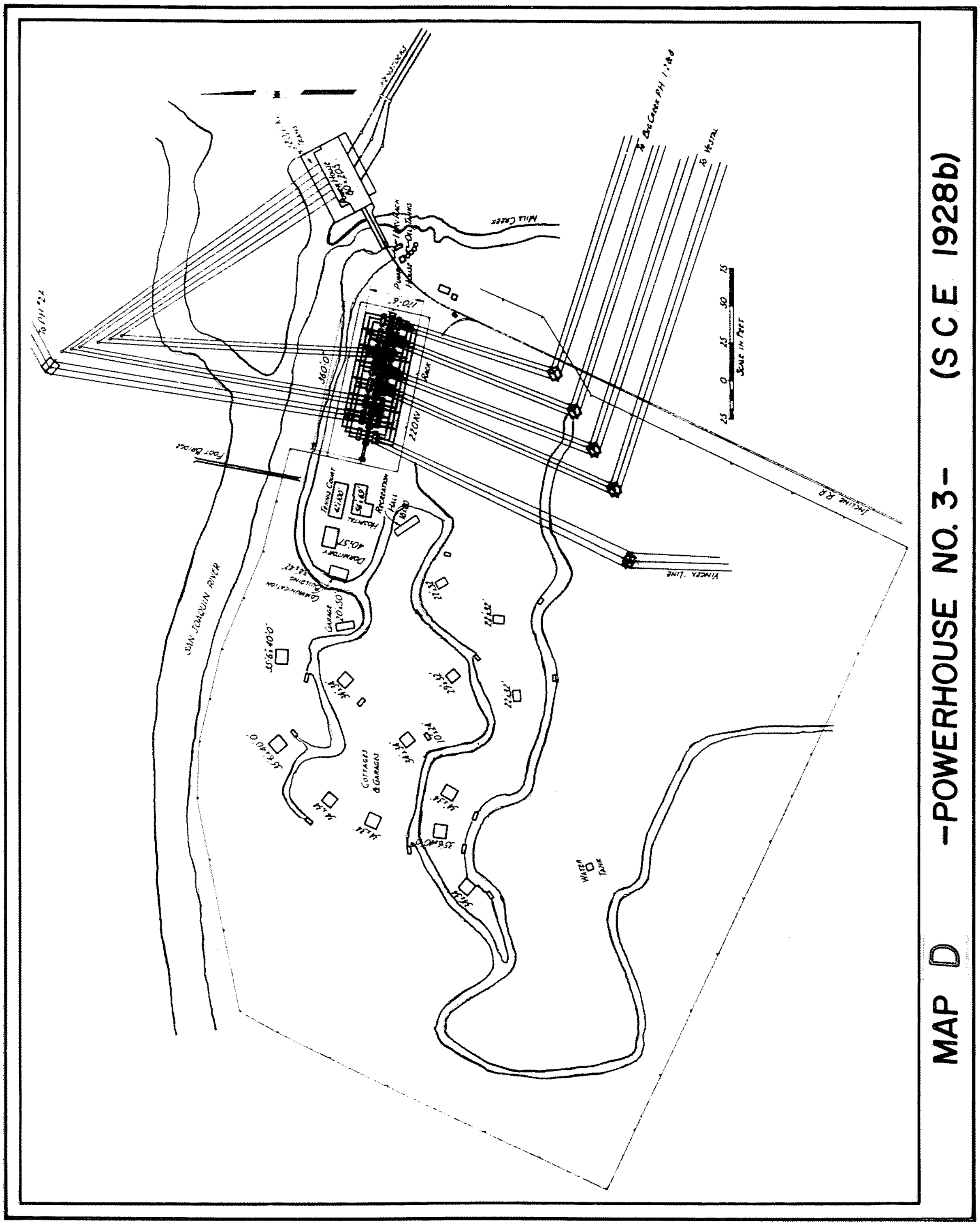


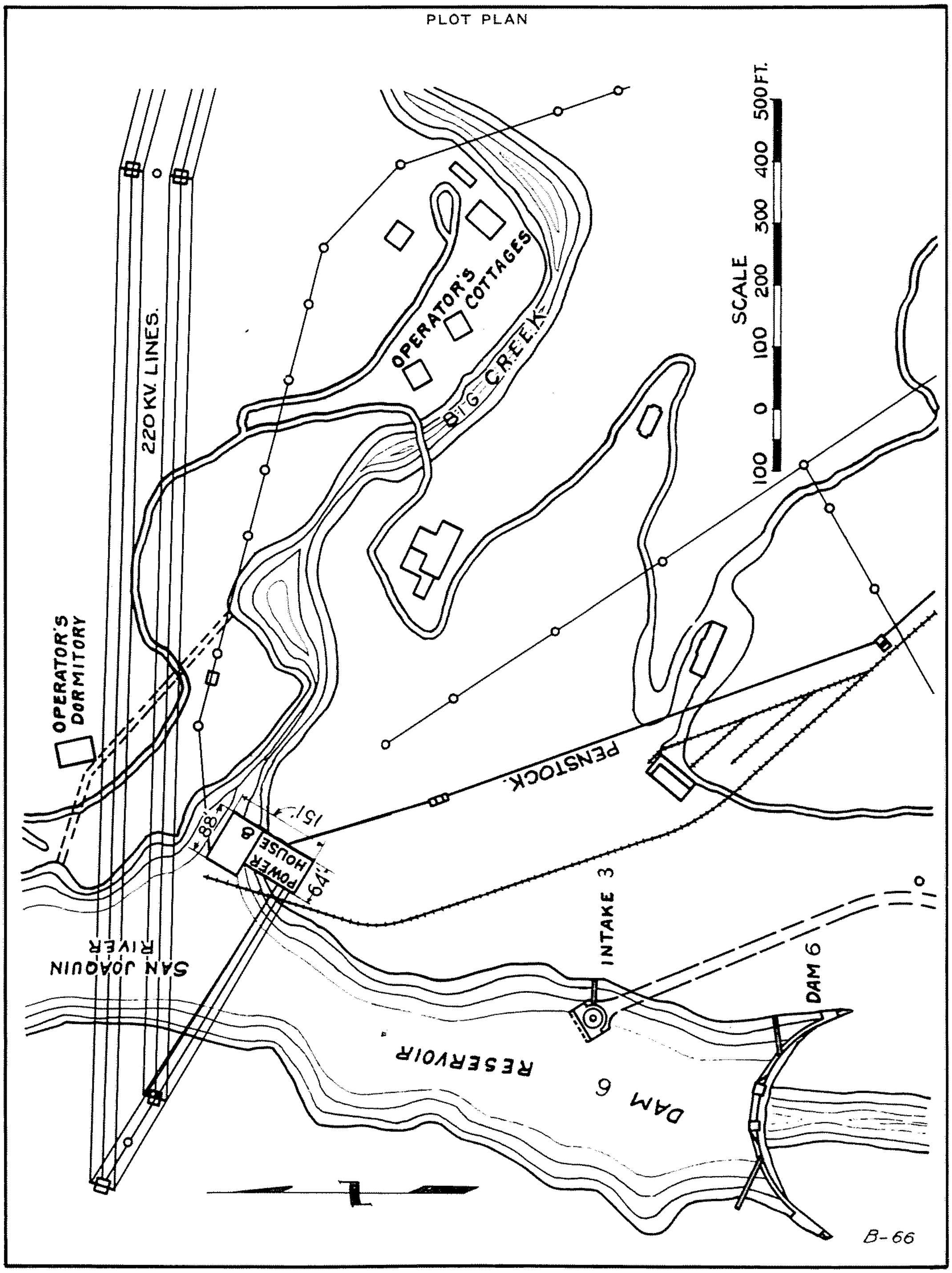
MAP A -POWERHOUSE NO. 1- (SCE 1928b)


PLOT PLAN
RESIDENCES
CHIEF OPERATOR'S COTTAGE
PROPERTY LINE
CLUB HOUSE
BIG CREEK
SCALE
200 100 0 200 400 600 FT.
PROPERTY LINE
PENSTOCK LINES
220KV LINES
POWER HOUSE Nº2
WAREHOUSE
220 KV TO P.H. 8
DAM 5 RESERVOIR
DAM 5
Nº8 INTAKE
TO P.H. 6
3 & 8
B-46
MAP B -POWERHOUSE NO. 2- (SCE 1924)



MAP C —POWERHOUSE NO. 2-2A— (SCE 1928b)


MAP D -POWERHOUSE NO. 3- (SCE 1928b)
SAN JOAQUIN RIVER
Foot Bridge
Mill Creek
Incline R.R.
Vincent Line
To Big Creek PH 1 & 8
To Vestal
Tennis Court
Hospital
Dormitory
Recreation Hall
Communication Building
Garage
Cottages & Garages
Water Tank
220 KV
Scale in Feet
25 0 25 50 75



MAP E -POWERHOUSE NO. 8- (SCE 1928b)

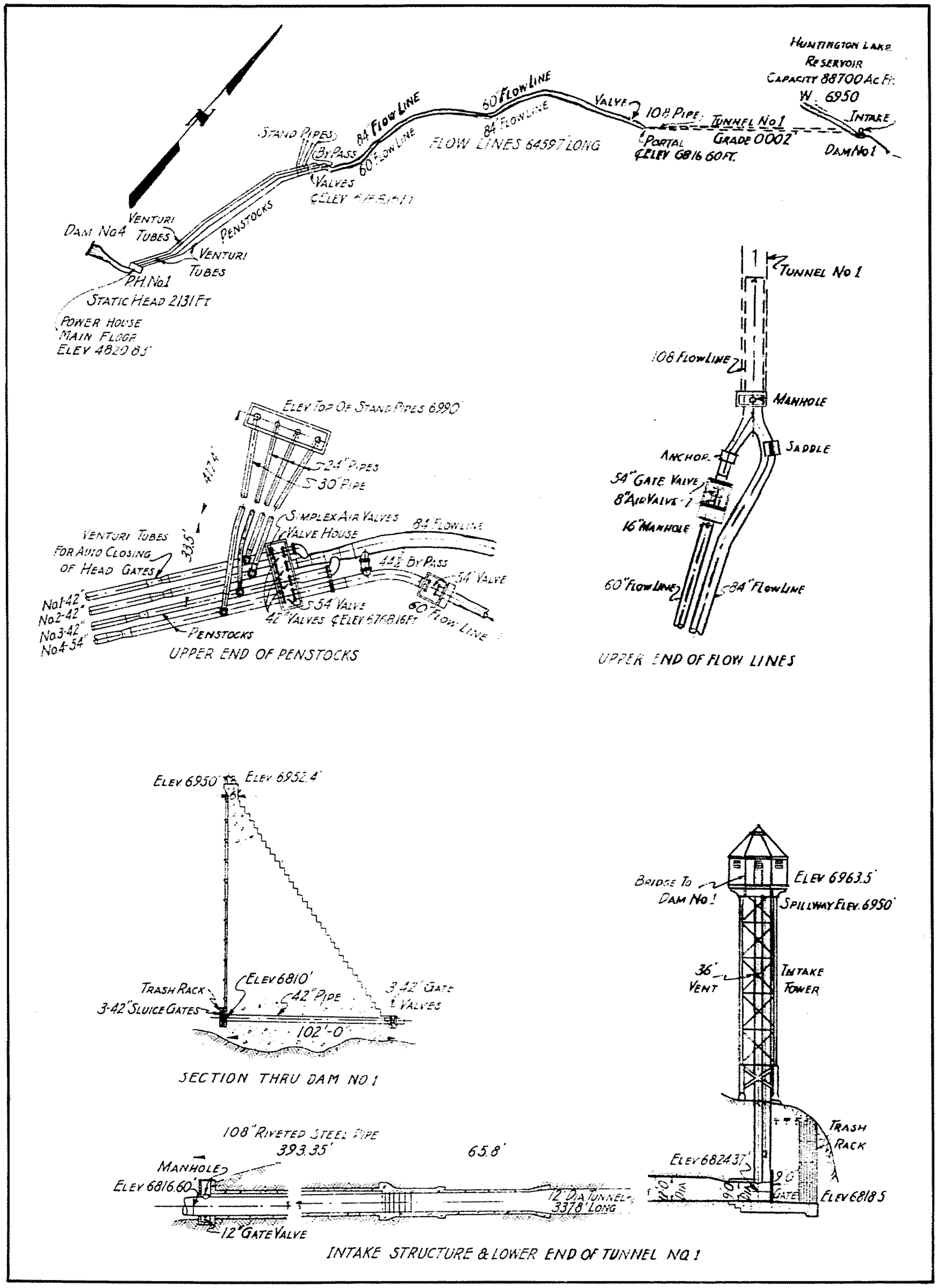


Figure A Powerhouse No. 1 hydraulic plan with details of Dam No. 1, tunnel and penstocks (SCE 1928b:B9–3).

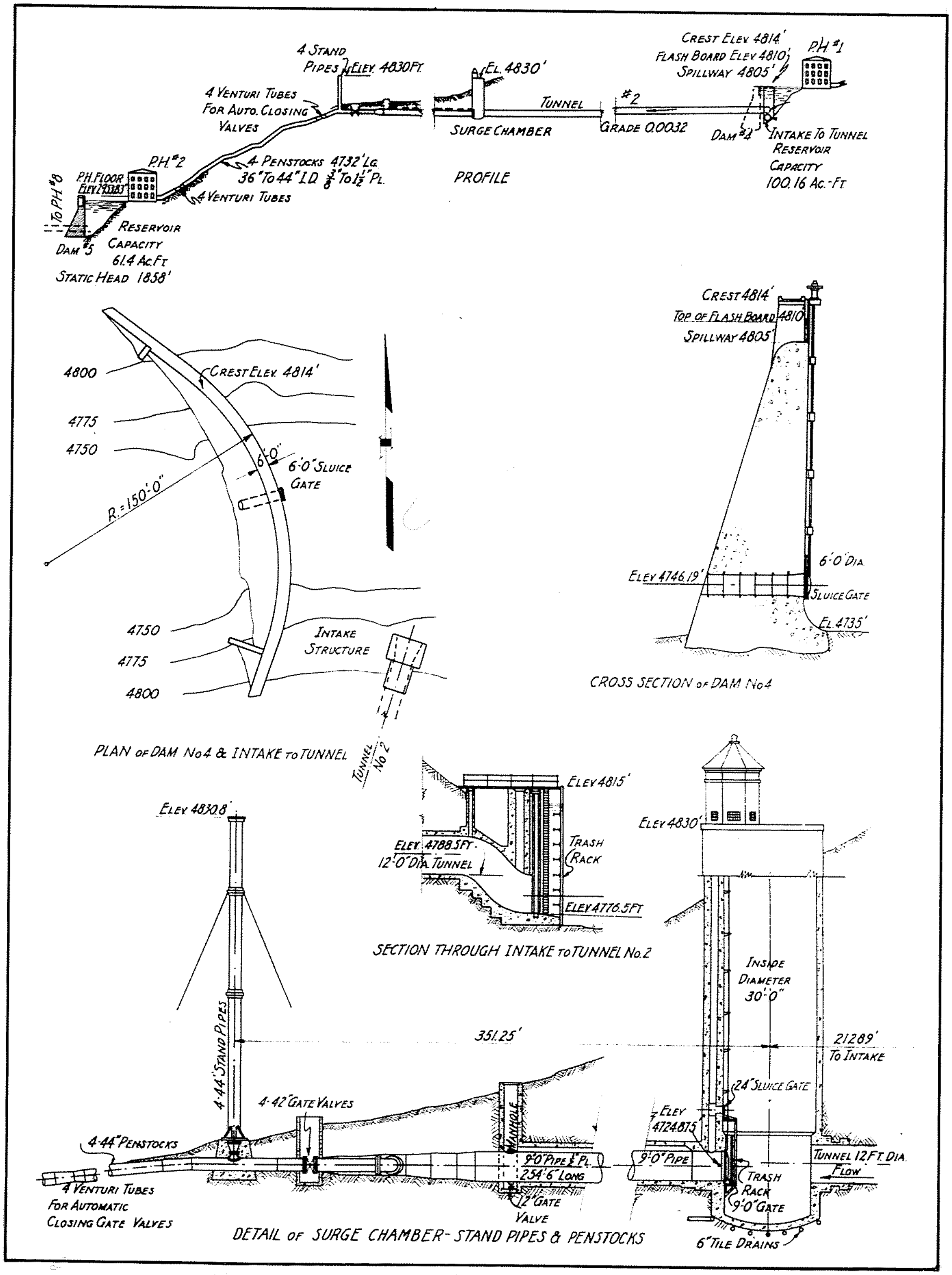


Figure B Powerhouse No. 2 hydraulic plan with details of Dam No. 4, Tunnel No. 2, intake and standpipes (SCE 1928b:B10–3).

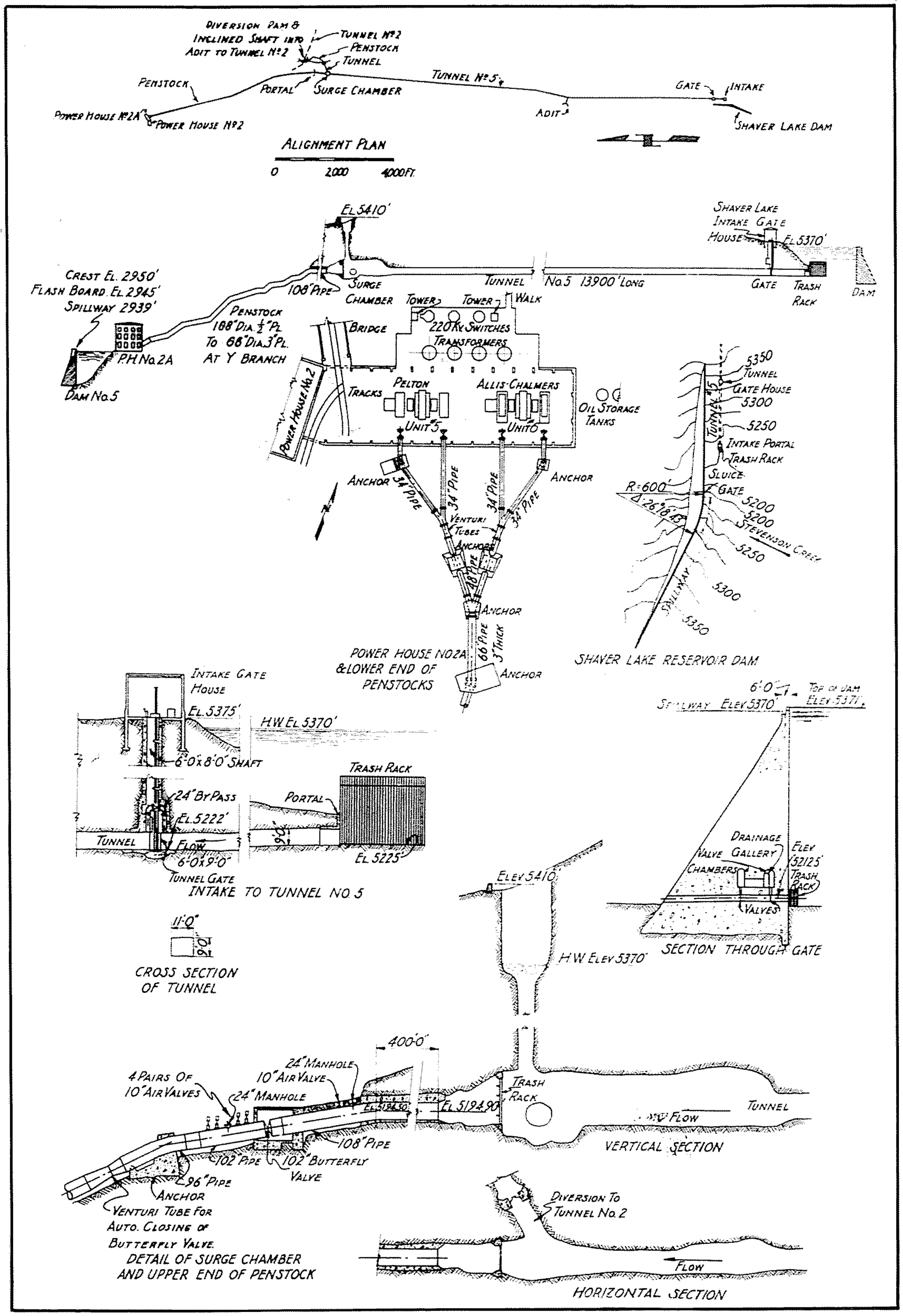


Figure C Powerhouse No. 2A hydraulic plan with details of Tunnel No. 5, Shaver Lake Dam, and intake and generating units (SCE 1928b:B10–6).

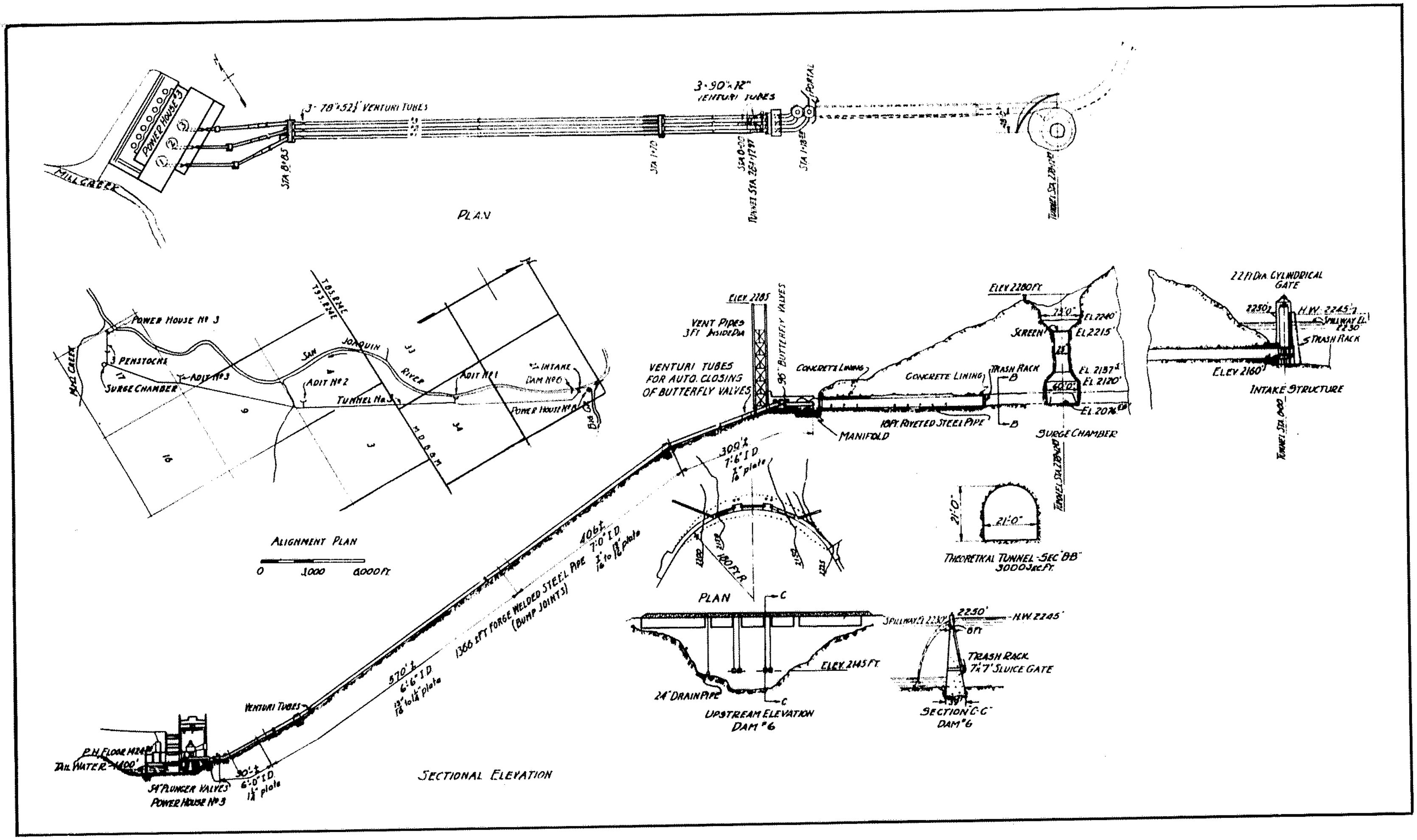


Figure D Hydraulic plan for Dam No. 6, Tunnel No. 3, and Powerhouse No. 3 (SCE 1928b:B11–3).

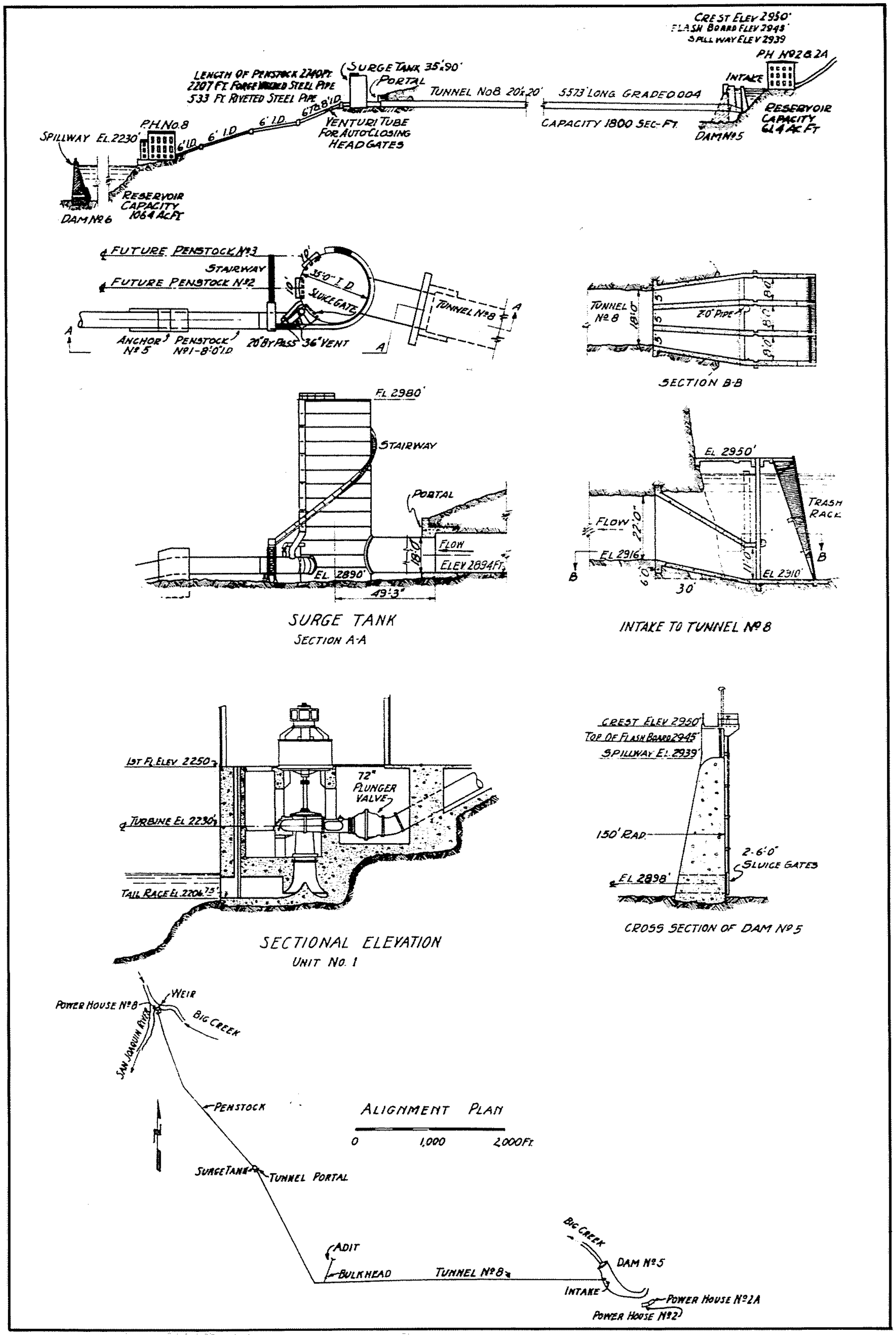


Figure E Hydraulic plan for Dam No. 5, Tunnel No. 8, and Powerhouse No. 8 (SCE 1928b:B12-2).