IMPERIAL IRRIGATION DISTRICT

INFORMATION

IMPERIAL IRRIGATION DISTRICT

SEPTEMBER, 1925

TO THE ASSESSMENT PAYER
AND WATER USER:

The District Board announced some time ago its intention to effect an economy program the aim of which was to be the saving of all unnecessary expenditures, the checking up of District operations and mangement, and the placing of proper authority to each department so that maintenance and operation of the District would be more efficiently worked out. This brief outline, issued after five months have elapsed under the new plan, is submitted to you for your earnest consideration.

In following its plan, the Board has made these changes:

Removed the Irrigation District shops from Calexico to Imperial and placed them under a first class master mechanic.

Removal of District offices from Calexico to Imperial arranged for to take place about October 1st.

Elimination of Calexico and Brawley East Divisions with a corresponding elimination of office forces, thereby cutting the number of divisions from six to four.

Removed chief engineer, consulting engineer, two irrigation engineers, construction foreman, and other high salaried men whose services are no longer essential to the efficient operation of the District and in consequence reducing the overhead practically $100,000 annually.

Made purchasing agent responsible to the Board for all materials, auto truck fleet, commissary and live stock, with instructions to reduce material stock heretofore carried on hand in large quantities, and to reduce overhead expense wherever possible.

Replaced office of chief engineer with office of general superintendent whose duties require close supervision of operation of the system. He is directly responsible to the Board.

Taken in the order named above, these changes have already shown some remarkable savings and because the Board has fixed responsibilities definitely with specific instructions as to what is expected, there will be a continuance of savings annually, as the plan completes itself.

A glance at conditions in the new shops at Imperial will prove that the economy measures are being effective there. When the master mechanic assumed charge on April 1, 1925, there was an accumulation of unfinished work on hand that would, according to the shop foreman, take three months to complete even if no additional work were brought in. There were 69 men on the payroll at that time.

What actually took place was the completion of all unfinished work in one month, during which time all current work was taken care of promptly. The shop force was reduced from 69 men to 41 men on August 1, 1925. The master mechanic reports that he is finding no difficulty in keeping pace with the work.

The shop payroll for March, 1925, before the new program was instituted, was $9,707.82, paid by the District. The July 1925 payroll for the shops (after the economy program was in effect) was $6,759.84, which included the salary of the master mechanic, not included in the March 1925 payroll for the shops.

Not only was the regular shop work taken care of since April 1, but much additional work incidental to the construction of the buildings at Imperial has been done. This extra work includes pipe work for the new offices, welding and numerous shop jobs required from time to time to speed up construction of the District buildings. It also includes construction of a new type of dredge known as the Clark dredge which is to be used in maintenance and drainage work.

One instance showing reduction in costs is seen in the saving in the construction of main frames for Ruth dredges. The March records show that a main frame was built then at a cost of $351.00. In August the Imperial shop built an identical main frame at a cost to the District of $79.67, saving $271.33. That saving is not an isolated one, but is being duplicated every time the shops are called on to make a main frame. There is a saving of 300 per cent.

Machinery is now being purchased for the shops at a cost not exceeding $12,000.00 that will save in

labor alone $35,000 a year and about the same amount of money in material annually.

The matter of centralization of District offices in Imperial is purely a matter of increasing the efficiency of the executive department. Closely connected with the decision to make that change, came the decision of the Board to take inventory of the executive staff.

The office of chief engineer, paying $9,000 a year, was abolished. The Board holds that the District now requires a general superintendent rather than a chief engineer. There are no large engineering works to be built at present. What is needed is an executive, qualified to direct operations at a minimum cost. It was found that the location of the main drainage outlets is practically completed except for details. For that reason the consulting drainage engineer was relieved of further responsibility and his contract terminated. His salary was $4,500 per year. Two irrigation engineers, each getting $5,400 per year, were removed from the payroll as being no longer necessary to the proper maintenance of the system. All division superintendents now report direct to the general superintendent. Elimination of the Calexico and Brawley East Divisions cut two Division Superintendent salaries from the payroll amounting to about $7,500 annually. The resignation of the chief accountant, whose salary was $3,672 per year, was accepted and the position was not refilled, the work being turned over to other employees.

To sum the whole matter up, there has been a saving of nearly $100,000 per year effected through the cutting off of these high salaried men and the abolition of offices no longer required.

The general superintendent receives a salary of $500 per month or $6,000 a year, retaining direct charge of the Mexican Division in addition to his other duties. He is a man of wide experience in irrigation operation, having been connected with reclamation projects for many years prior to his coming to the Valley. He is directly responsible to the Board.

Reorganization of the purchasing department has resulted in a large number of savings, many of which will be more apparent at the end of the year than they are now.

The figures of the Stores and Purchasing Departments show a net saving in the payroll for April, May and June as against January, February and March 1925, of $4,703.00, or little more than $1,567.00 per month.

Significant items of savings appear in the reports of the purchasing agent. One is a saving of $840 per year in the retainer fee of the brokerage firm. Dismissal of nine men from the Imperial yards, one man from the store and one from the corral, the Imperial Yard foreman, one man from the Calexico store, reduction of the gardner's salary from $102.00 to $75 a month, are other items appearing in the reports.

The fleet of trucks operated by the District has been completely reorganized so that each truck is put to the best use. The fleet has been reduced by two trucks and excessive hiring of trucks for extra hauling has been eliminated by proper distribution of the fleet through a dispatcher.

Overhead costs have been a matter of considerable attention under the new system of purchasing. The purchasing agent reported the stock carried on hand when he took charge to be a half million dollars. Recent reports show that a reduction of stock now being effected will bring the total of the stock inventory down to less than $300,000 by January 1926. It is believed that close attention to buying will eliminate the need for huge supplies of materials in the store-rooms and will result in an attending cut in overhead costs to the District.

An inventory of the lumber yards of the District showed a large supply of odd sized timbers which could rarely be used and which constituted another source of expense. A saw was put in service and the timbers cut to standard sizes that can be used in the daily requirements of the operation department. In this manner, lumber purchases have been materially reduced and old stock made use of.

Constant study of markets and buying conditions by a competent agent of the District who has been made responsible for every purchase is already showing marked savings. An accumulation each day of apparently small savings (such items as a few cents on each case of evaporated milk or other supplies in the commissary department and the like) is resulting in a total of worth while economies.

The payrolls of the District show the following totals in 1925: January, $167,417.47; February, $166,141.38; March, $167,879.59. Since the economy move the payroll shows the following totals in 1925: April, $136,525.11; May, $143,146.65; June, $144,080.53.

The present Board has recognized that every means must be taken to bring expenditures of the District down to fall within the income from assess-

ments and water tolls. To that end the proposed budget submitted by Chief Engineer Carberry in September 1924, which called for expenditures that would have required nearly $2.00 per acre added assessment, was cut down nearly $900,000.00.

It has been the contention of the Board that the $5.00 assessment rate must not be raised and that operation costs must be kept within that limit. The books of the District showed at the end of last year practically no deficit, despite the harassment of private interests who sought through litigation to nullify actions of the Board. It is safe to prophesy that the end of the present year will see the District books again balancing without a deficit.

Records of the District show that thus far the assessment payers are receiving water service at a cost much less than the average cost under the Mutual Water companies, and it is the determination of the Board to keep those costs down to a minimum. The following tabulation will show a comparison of costs to the water user under the Mutual companies and under the District:

ASSESSMENT RATES BASED ON AN ACRE OF LAND VALUED AT $100

	1920	1921	1924	1925
I. I. D. Assessments	$1.90	$2.50	$5.00	$5.00
Average Mutual Ass'ts	2.77	2.44		
Mutual Tolls, Average	2.99	3.38		
Average District Tolls			1.00	1.00
Total	$7.66	$8.32	$6.00	$6.00

The years 1922 and 1923 were occupied with effecting the change from the Mutual companies to the District so they do not provide an accurate comparison basis.

The results that have accompanied the economy measures are adequate testimony as to the wisdom of the action of the Board. They constitute proof that the wild accusations and rumors of enemies of the administration who charge that the changes have been made purely for political reasons, are unfounded and false. It is not necessary here to go into the motives that have actuated these charges. The declaration of Judge Jamison of Modoc county who heard the case of William Brandenburg versus the Imperial Irrigation District, in which injunction proceedings to restrain the District from moving the offices and shops to Imperial were denied, will line up with the testimony of actual conditions in an indis-

putable vindication of the Board. The statement of Judge Jamison in his decision is as follows:

"As to the first ground hereinbefore set forth this court finds that there is no sufficient or satisfactory evidence produced in this case establishing any trade, political or otherwise, between the directors in the passage of said resolutions. If bad faith existed, or wrongful motives actuated the directors in the passage of said resolutions, the burden rested upon the plaintiff to prove these things, and this, in the opinion of the court, he has failed to do. On the contrary it appears that at least three of the said directors had, for a considerable period of time prior to the passage of said resolution had in contemplation the passage of both resolutions, believeing that said passage was for the best interests of this District. If any of them had any motive, hidden or otherwise, in the passage of said resolutions, other than the desire to act for the best interests of the District, such was not shown by the evidence."

Relative to the efficiency of operating the District from Imperial Judge Jamison held: "So far as the efficient handling of the affairs of the District is concerned this Court cannot see wherein there would be any loss by the removal of the general offices from Calexico to Imperial." This statement and several more showing that the best interests the District would be served by the change, came from Judge Jamison after he had taken a trip over the District and had inspected the shops at Calexico and Imperial.

Were it not that this District and this Board of Directors are the object of not only local attention, but state and national as well, due to the struggle now being waged in respect to the control and use of the Colorado River, there would be no such attack against the actions of the Board in straightening up the management of the system. The action is not an unusual one, nor is it inconsistent with the duties laid down by law. Every Director of this District has taken an oath which binds him to protect the assessment payer and water user against waste, and which requires that every means be taken to guarantee an uninterrupted water service. That is what this Board is determined to do. They solicit assistance of the assesment payers and water users in carrying out this program.

ISSUED BY THE BOARD OF DIRECTORS
September 3, 1925

Boulder Dam

Boulder Canyon Dam

Its probable effect on privately owned Electric Light and Power Companies in Southern California.

By J. T. WOODWARD

THE final passage of the Swing-Johnson Bill for the development of the Boulder Canyon, with its large power potentialities, makes an analysis of the probable effect of this development on the privately owned electric light and power companies in Southern California timely and perhaps desirable.

While the Bill does not become effective until either the State of Utah signs the Six State Compact or the State of Arizona adjusts its difficulties sufficiently to enter the Seven State Compact, it may be assumed that eventually, at least, the project will be constructed and completed.

For the purpose of this analysis it may be stated that the Boulder Canyon project will directly affect, insofar as electric power is concerned, the following Southern California companies:

Southern California Edison Company

Los Angeles Gas & Electric Corporation

The Southern Sierras Power Company and The Nevada-California Power Company (The Nevada-California Electric Corporation)

San Diego Consolidated Gas & Electric Company

The San Joaquin Light & Power Corporation may become interested in the development and sale of this power but the distance factor may preclude active identification of this company other than through a possible hook-up with the Southern California Edison Company.

Load and Market Conditions

The total load of the four companies directly interested for the year 1927 was 3,036,-143,000 K.W.H., and while the figures of the same load for 1928 have not as yet been compiled, expert opinion places the load at well in excess of 3,250,000,000 K.W.H. On the basis of a projected installed capacity of 1,000,000 H. P. at Boulder Canyon, and using a 55% load factor, the total electrical output would be about 3,500,000,000 K.W.H. annually, dependent, of course, on water conditions.

If Boulder Canyon power was available for delivery at the present time, it would unquestionably provide such a large block of surplus power as to make its profitable distribution and sale a difficult matter from the Government's standpoint, but developments of the magnitude of Boulder Canyon require years to complete. The minimum estimate of the time required to build this development is seven years from the date of the beginning of operations, but assuming the usual delays incident to the large amount of preconstruction work necessary, and any further retarding due to an appeal to the Courts by the State of Arizona, it is reasonably safe to assume that at least ten years, and possibly even fifteen years will elapse before Boulder Canyon power is available in any sizeable volume in the Southern California markets.

It may also be stated that whatever may be regarded as potential markets for power from so-called political sources, the sale of such a large block of power at rates sufficient to justify the electrical development at Boulder Canyon would be possible only with the friendly cooperation of the privately owned companies referred to.

It therefore becomes essential to analyze the situation that will confront the Southern California privately owned electric light and power companies when or immediately after this 3½ billion kilowatt hours of Boulder Canyon Power becomes available.

The annual rate of increase in the combined load of the four companies for the last few years has been approximately ten per cent a year, although some of the companies have exceeded this ratio. If the Government is in a position to definitely advise the power companies when this Boulder Canyon power will be available, they would agree to undertake no additional construction of hydro units (other than those now in progress) and confine additional capacity to low cost and flexible steam units, the construction of which could be slowed down or suspended as the situation may require. Should the date of actual delivery of power be ten or fifteen years from now, and the costs of such power compare favorably with competitive figures of power generated from other sources, the companies would unquestionably be in a position to absorb this large block of power and be very willing to do so.

Cost of Power the Vital Factor

The vital question, therefore, as to the justification of the electrical development at Boulder Canyon, lies not so much in the ability of the markets to absorb the amount actually generated, but what the distributing agencies, private or municipal, can afford to pay for it in competition with generating costs of existing plants, when the power is actually available ten or possibly fifteen years from now.

It is admitted that on the basis of existing oil fuel costs, and in some instances through use of natural gas as fuel, switchboard costs of steam generated energy in the Los Angeles territory have been brought down to less than five mills per K.W.H. on the average, with the recently installed steam units making an even better showing.

Contractual Conditions Under Swing-Johnson Bill

Under the terms of the Swing-Johnson bill, arrangements for securing Boulder Canyon power by outside agencies must contemplate either:

a. A lease of mechanical water power developed at the dam;

b. A lease of the electrical equipment to be built by the United States Government in connection with the entire development, or

c. Contracts for the purchase of power generated by the Government plants.

The bill provides that within 15 years from the execution of these contracts they must be adjusted to meet competitive cost conditions then existing, and provision is likewise made for similar readjustment in ten year periods thereafter.

Under any of the conditions above referred to the ability of the distributing agencies to enter into such leases, or contracts, resolves itself around the ultimate cost of Boulder Canyon power in the markets best able to absorb the greater proportion of it.

Analysis of Probable Power Costs at Boulder Canyon

It therefore seems essential to attempt to estimate the possible costs of Boulder Canyon power (assuming for this analysis that the United States Government will itself build the power plant) at

1. Boulder Canyon power house
2. Pacific Coast terminal points

1. *At Boulder Canyon Switchboard*

The revised figures submitted by the Siebert Committee contemplate total expenditures of about $173,500,000. From this total is to be deducted, first, the cost of the All-American Canal estimated at $38,500,000 and, second, flood control expenditures of about $25,000,000, the balance of approximately $110,000,000 to be the basis of primary amortization through power revenues. If it be assumed that Government financing would provide for this cost, the annual service charge for interest and amortization would be about 1.6 mills per K.W.H. at 4%, 1.8 mills at 4½%, and 1.9 mills at 5%, all based on a 35 year period of amortization. If there is added to the above figures, estimated operating expenses at say ¼ of a mill per K.W.H. a total switchboard cost at Boulder Canyon at least 2 mills per K.W.H. would be reflected. In view of possible fluctuations in water conditions a further expense of ¼ mill per K.W.H. is added as a safety factor.

2. *At Pacific Coast Terminal Points*

The question of the cost of delivering the major portion of this power to the large Southern California markets must take into consideration many factors, such as transmission lines, substations and transformer costs, as well as line losses result-

ing from the long distance covered. The Swing-Johnson bill as finally passed makes no provision for transmission lines, it being assumed that the association of municipalities, or the privately owned companies, or both, will provide either undivided or joint use transmission systems.

One of the original engineering reports on Boulder Canyon contemplated six double circuit transmission systems with voltages reaching 220,000 or larger. The estimates of cost of such a transmission system range from $68,000,000 to $45,000,000, depending on a large number of differing factors. If the lower amount be accepted as a basis, there would be the same necessity for operating expenses, interest and amortization, which if privately financed would be on a higher basis than if provided through Government channels. Add to the above, line and transformer and frequency changer losses, and the combined cost of delivering the Boulder Canyon power to the markets in Southern California may easily reach 1¾ mills per K.W.H., with the total cost exceeding 4 mills per K.W.H. depending in extent upon the additional cost of stand-by equipment if provided for. Under private ownership, however, adequate stand-by capacity is already installed.

Summary

Assuming, therefore, that Boulder Canyon power can be delivered in substantial volume to the Southern California markets at the end of a ten or fifteen year period, the factors then applying to the power companies named may be said to be the following:

1. In the time required to build and place in full operation the Boulder Canyon development, the territorial demand for power will undoubtedly reach a point that would necessitate additional development by the privately owned companies to a point actually in excess of the volume of power available from Boulder Canyon to Southern California.
2. A definite policy of suspending development of further hydro units, and confining such expansion to steam units that can be used for stand-bys or low cost production, will develop the demand to a point where additional power to an amount approximately that of Boulder Canyon can be easily absorbed and really needed.
3. The power companies should be in a position, as soon as all the difficulties, legal and otherwise, have been ironed out, and the beginning of construction actually made possible, to enter into a contract or contracts with the United States government on one of the three bases outlined in the Swing-Johnson bill on the best terms possible, taking into consideration competitive power costs from other sources in effect at that time.

Conclusions

Under the above conditions any unfavorable reaction towards the securities of privately owned Southern California electric light and power companies because of the Boulder Canyon development is entirely unjustified, and per contra, the stimulus already given to the industrial, agricultural, and general business conditions in the territory has and will undoubtedly be reflected in a greatly increased demand for electric energy to an extent that the companies referred to in this analysis would in any event be under the necessity of providing additional facilities more than equal to the proposed Boulder Canyon plants.

February 11, 1929.

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November, 1927.

LOS ANGELES AND THE BOULDER DAM PROJECT.

A recent press dispatch from Washington contains the statement that President Coolidge has informed Governor Dorn, of Utah, that the construction of a dam in the Colorado River at Boulder Canyon is necessary for flood protection, and also to provide water for approximately two millions of additional population for Southern California. For the purpose of discussion we are assuming that this report is correct, though we have not verified it.

We have stedfastly opposed this Boulder Dam bill as it is now drawn and proposed. At first blush the President's statement, if correctly quoted, is surprising, but let us see. It may be true that Mr. Coolidge has accepted as essential the urgency for flood protection in Southern California, and for adequate future water supply as well, but we cannot conceive that he can be in accord with the vicious political factors which have been incorporated in this bill and which have become its outstanding and objectionable features. Therefore, we do not believe that the dispatch referred to above should be construed to mean that President Coolidge has placed his approval upon this bill.

We oppose the Boulder Dam scheme upon the broad basis of our unalterable opposition to government ownership of public utilities. We seriously object to the government's engaging in industry, irrespective of the nature of the enterprise. We consider such experiments demagogical and dangerous. The Boulder Dam proposition originated in California as a proposed measure of flood protection for the Imperial Valley of California, but further, and more important, as a plan to provide a water supply for the future needs of Los Angeles. Anyone could heartily concur in the laudable wish to store the precious water and utilize its wasted worth, but the project has been so revamped and altered that it has degenerated into a political football, and as now planned includes hydro-electric power development and the distribution thereof.

The states of Colorado, Nevada, Utah, New Mexico, and Arizona are directly concerned with it, as well as the State of California. The scheme has gathered momentum and theories until it has now involved the administration of all the states concerned into a general scramble for a division of the spoils. As proposed by its demagogical adherents, it would put the Federal Government directly into the hydro-electric power business in opposition to already constituted supply; and to that principle we are unqualifiedly opposed. The unsavory wrangle over Muscle Shoals in Alabama is too recent to permit the politicians to foist another such squabble upon us.

Flood protection should be the task of the National Government. There ought to be no dispute about that; and especially so when such flood catastrophes threaten a number of the states jointly. Experience has shown that the states do not readily compromise the petty differences which arise over such matters, and Federal administration is the only plan which will achieve the wise co-operation so essential to success. But Federal outlay is another and a more debatable question, especially when it is sought to extend flood protection into a municipal water supply system and create hydro-electric power plants, now exclusively under State jurisdiction. We consider present flood prevention in the Mississippi Valley more urgent than future flood prevention in the Imperial Valley of California, but that may be a minor detail. In reply, the advocates of this project point anxiously to the Salton Sea and urge haste. In California, water is a very major detail.

The city of Los Angeles is seriously concerned about the future of her water supply. The danger of a flood in California's Imperial Valley is real, but not necessarily immediate. The urgency of additional water supply for Southern California in general and the city of Los Angeles in particular, *is* immediate. An inadequate water supply has always been the thorn in the side of that growing giant of the South Pacific coast, and the cry for more and more water for her constantly expanding population must, until satisfactorily assured, be the continuous nightmare of the city of Los Angeles.

The writer has just returned from a visit to the Pacific coast and has seen for himself, with unconcealed admiration, wonderment and respect, the expansion in size, population and industrial importance of that magic city. They make many extravagant claims in Los Angeles, but that their city may be third or even second in population by the 1940 census is not at all improbable. Undoubtedly, the

Boulder Dam project originated as the conception of fancy of some Los Angeles booster who never dreamed how the demagogue and politician, in their efforts to foist schemes and graft upon everything, would saddle upon his pet idea all the experiments in governmental ownership and control.

The Los Angeles booster is in a class all by himself. To visualize him one must come into direct contact with him and feel the influence of his radiation. He is in the flesh, the very personification of optimism, energy, and civic loyalty. For him the United States consists of two sections—first, Los Angeles, and second, the rest of the country. Without batting an eyelash he will complacently tell you that the city of Los Angeles now has 1,500,000 population and that in less than fifteen years Los Angeles will be bigger and greater than any other American city, excepting possibly New York and Chicago. He will tell you that, in ten years more, Southern California will require additional water supply to take care of the minimum of 2,000,000 more population, which his section is surely going to acquire. He knows that it cost New York, Chicago, New Orleans, St. Louis, San Francisco, Baltimore and other centres of large population many millions of dollars to obtain an adequate water supply, and he asserts that all Los Angeles desires is governmental authority to go ahead, and she will herself provide all the funds necessary. But that is not a provision of the bill.

This would be ideal could we ignore the fact that for years there has been a constant feud between Los Angeles and her rural neighbors over the question of water; it being claimed, perhaps justly, that the city had "hogged" the available water supply. Naturally, the other interested states, knowing of this Southern California vendetta, prefer to take no chances and are zealously guarding their interest in this Colorado River water supply. We in the East, where water is plentiful and seldom a problem, may not appreciate its precious scarcity in the section involved. There, water is so precious, that to permit Southern California to control and monopolize the Colorado River supply and convert it to her own use, would mean that other sections must remain permanently arid. Hence the apparently irreconcilable disagreements which have arisen. The adherents of the project have been very zealous in their efforts and have kept it before Congress for some time. They promise to vigorously press it at the coming session, despite fruitless efforts, to get all of the states concerned, in concord. The fight has engendered considerable bitterness and not a little humor. One of the most laughable incidents illustrating the animus which has resulted, is the report that a certain Southern California congressman will propose at the coming session of Congress that the State of Arizona be ousted from the Union because of the alleged dishonest attitude of the people of that State toward this scheme! Certainly that is the height of the ridiculous. It is claimed that Arizona wishes to cash in on her share of the water by levying taxation on water taken from her state. Such is the extent of the partisanship of the Southern California booster. Oh! that the citizens of some of our eastern cities—notably, our own Baltimore—would exhibit more enthusiastic civic loyalty.

Yet, Los Angeles and Southern California having utilized all the available water supply in their own state must now needs look elsewhere. And Los Angeles, in the flush of her own greatness, is necessarily much self-concerned. That the city should desire to permanently end the feud between her California neighbors and herself, is natural. It is really lamentable that the demagogues have complicated this proposition with government control, government ownership, and such other economic heresies. But it is just as lamentable that Southern California does not see the viewpoint of Arizona, Utah, and the other interested states through more generous and more conciliatory glasses.

The water feud in Southern California is an old story. If this project is carried into effect, unless iron-clad agreements satisfactory to all concerned, are entered into in advance, it would simply extend the feud beyond California's border into other states. The feud was not stifled when Los Angeles extended its corporate limits far and wide in every direction. Los Angeles is a truly great municipality. In the East we too frequently imagine that her prosperity and growth are dependent upon her great motion picture industry. That is not correct. Though Hollywood and the motion picture industry are vital factors in Los Angeles life, it is actually upon oil that the commerce of Los Angeles is founded. And since oil is a basic commodity, that greatness is permanent and will survive long after the motion picture industry dwindles—if it ever does! But Los Angeles has geographically extended her borders to an almost unprecedented area. To vie with her in territory and population, San Francisco—certainly more important industrially—now seriously talks of annexing Oakland and Berkeley and other communities across the bay. If such cities as Boston and Pittsburgh were to similarly expand their corporate limits, their populations would be doubled at once. But as it is, Los Angeles will likely pass them and others on the next census. The zealous Los Angeles booster is possibly correct when he asserts that the population of Southern California will generously expand within the next decade. But how will the Middle-Western states like that? Whence are to come these additional two millions of people? Will the states of Iowa, Illinois, Kansas, Nebraska, Missouri, Kentucky, and the entire Middle-West sit complacently by and allow Southern California to drain their communities of wealth and numbers while they and every other state contribute through taxation toward the cost of the solution of Southern California's water problems? The accession of population in Los Angeles and Southern California has been acquired from every section, but the Middle-West in general and the states of Iowa and Illinois in particular, have contributed heavily. It is said that of the population of Long Beach over sixty per cent are former Iowans. And, incidentally, while our severely restricted immigration laws, designed to mollify federated labor and maintain high wages, prevent the Middle-West from replenishing its population from

Europe through Ellis Island, thousands of Mexican peons are migrating to the border states—Texas, California, Arizona, and New Mexico, and are rapidly sowing for us the seeds of another race problem. As far as Kansas, numbers of Mexicans have drifted and settled.

And, though it be momentarily overshadowed by the sun of Los Angeles, the great Pacific Northwest will surely compete with California as the wonder domain of the future. Like Los Angeles and San Francisco, the great northwestern city of Seattle dreams of the future in terms of confident optimism. Some day, perhaps not so very far away as may now seem, when China is at peace and quiet reigns once more throughout the Orient, the Pacific will rival the Atlantic for supremacy in trade. The commerce and industry of the Pacific are an awakening reality. It is neither hope nor dream. Wealth and power are the certain destiny of our great Pacific Coast. Seattle possesses one of the wonder harbors of the world. To us in the East, her climate seems ideal; more satisfactory than the warmth of Southern California. But to the Middle-West that warmth and the lack of snows are just now more enticing. The urgent need of the Pacific Northwest is population to carry out its destiny. Our foolish immigration laws are doomed. Before long the Middle-West, the Pacific Northwest, and California must unite in a common demand that these restrictive regulations be liberalized. Indeed, from the Mississippi River to the Pacific Ocean the country needs population.

Meanwhile, let us scrutinize with magnifying glasses this scheme to dam Boulder Canyon, before we allow its vicious experiments to be foisted upon the country. By all means, as President Coolidge suggests, let Southern California secure sufficient water supply for present and future needs—her real needs, not her visions of greatness—but let Southern California foot the bill! By all means forestall future encroachment by the Salton Sea upon the prosperous Imperial Valley. But by all means, too, let us keep the Federal Government out of the light and power business.

TAX REVISION.

Tax revision, downward, a pleasant prospect for the taxpayer, is evidently to be one of the early tasks of Congress as it goes into session in December. Secretary Mellon has appeared before the Ways and Means Committee of the House of Representatives and has presented to the committee, in concrete form, a series of suggestions which the Treasury Department calculates will reduce the national tax bill approximately $225,000,000 annually. Briefly summarized, Mr. Mellon suggests—

That the corporation tax be made 12 per cent instead of the present 13½ per cent.

That the Federal estate tax levies be abandoned altogether.

That surtax rates on individual incomes between $16,000 and $90,000, be revised downward.

That corporations with a net income of not over $25,000 and with not more than ten stockholders be permitted to file returns as partnerships instead of corporations; they in reality being incorporated partnerships.

The Secretary of the Treasury also definitely sets his stamp of disapproval upon the elimination of existing auto, amusement, and other excise taxes.

We consider that the Secretary has laid down in his recommendations a basis for many desirable rectifications in the inequalities which still exist in our Federal taxation arrangement. The political parties now seem to vie with one another to see which can first secure that partisan benefit, calculable in votes, which is assumed to accrue to the party responsible for the accomplishment of tax reduction. For that reason we find quite an amount of criticism, especially in the Democratic press, of Secretary Mellon's suggestions and particularly of his limitation of maximum tax reduction to $225,000,000. The opposition party will naturally endeavor to show that the Treasury Department's conservatism in the past has resulted in entirely too low an estimate of possible reduction, and they will endeavor to accomplish compromises calculated to exceed the maximum reduction figures set by Secretary Mellon. The Secretary is assuredly conservative and cautious, but we as bankers should be the last ones to find fault with him for that. The Treasury Department, more than Congress or even the Ways and Means Committee, realizes its responsibility to the public and the necessity to obviate any chance of deficiency. It would be most regrettable if our annual treasury surplus were converted into a deficit by partisan effort to consummate tax reduction. If errors are made it were better that they be made on the side of conservatism.

There will be arguments, too, about the total elimination of Federal estate taxes. We have always considered the estate tax an unjust and indefensible penalty placed upon ability and thrift. The confiscation of a portion of an estate may be justifiable in the exigencies of war, but should be abandoned as soon as that crisis passes. It may be entirely equitable to assess a levy upon an inheritance, especially if that inheritance does not come in direct line, but to penalize the estate of a decedent for no other reason than that the estate exists, seems unfair to the point of being un-American.

Our Federal system of taxation, devised in the haste and stress of wartime days, has never been more than a makeshift. We have had ten years in which to revise it, eliminate its inequalities, and create an equitable system of orderly taxation which would reach each and every citizen proportionately. We have not done so, though each successive series of suggestions emanating from Mr. Mellon has sought to remedy some of these many inequalities. Our personal convenience would urge that nuisance taxes—automobile taxes, amusement taxes, taxation on club dues, and other such annoyances, should be eliminated; but fairness compels us to admit that such tax levies and their continuation upon our statute books actually are an eminently equitable

method of taxation. Non-essentials should bear a heavier burden than essentials. It is the consumer who should be taxed to support the government. Though disagreeable to many, the attitude of the Treasury Department in this respect is unquestionably the proper one, although it may not be the popular one.

As we come to the consideration of the problem the corporation tax we find ourselves confronted th the possibility of complications not readily vable. In certain quarters, there is also an opinion at the Treasury Department could have suggested th conservatism a 10 per cent tax on corporations stead of a 12 per cent tax, as selected. It is humors to note how the politician will twist himself ound when self interest and partisanship influence n. The corporation suddenly finds itself beended in the matter of the ratio of tax reduction many who have ever been the corporation's orn enemies, because in this instance favoring the rporation happens to be construed as opposition the party in power. The present corporation tax 13½ per cent is excessive and no longer justified. hat is now generally recognized as true. The burnsome taxation levied on the corporation was the sult of antagonistic attitude which swayed Coness during the wartime days. In a discussion of e unfairness of certain taxation then proposed, a prominent senator who was a member of the important committee considering such matters, calmly told the writer, "We know it is high but we need the money." Such was the basis of the taxation devised during the war.

The present corporation tax should undoubtedly be reduced. Perhaps Mr. Mellon's suggestion of a reduction to 12 per cent is the wise result of deep consideration of all the circumstances. If partisan opposition should succeed in consummating a reduction of this tax to 10 per cent, it would be welcome relief but complications would at once arise. It would be claimed that with the reduction in taxation the corporations should spend elsewhere the money thus saved. The railroads would be called upon to again increase wages, or if not that, to reduce transportation rates. Industrial enterprises would possibly be called upon to cut working hours or raise wages, and all sorts of industrial difficulties might arise. For that reason we heartily approve of the suggestion of the Treasury Department in this connection and believe, although the corporations may probably be entitled to greater tax relief, that the reduction advised is the proper, conservative one. Further relief could come later on when Treasury conditions justify and industrial relations are less apt to be affected.

UNITED STATES
DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

BUREAU OF RECLAMATION
ELWOOD MEAD, Commissioner
WASHINGTON

May 15, 1934.

GENERAL INFORMATION CONCERNING THE ALL-AMERICAN CANAL PROJECT, CALIFORNIA

The All-American Canal is one of the three construction features authorized under the Boulder Canyon Project Act, approved December 21, 1928, the other two being the Boulder dam and power plant. Under the terms of a contract dated December 1, 1932 the Imperial Irrigation District agreed to repay to the Government the cost of the project, not to exceed the estimated cost of $38,500,000 over a period of 40 years, without interest. The Federal Emergency Administration of Public Works has authorized an allotment of $27,000,000 and provided $6,000,000 to begin construction. This amount is for the diversion dam and main canal to Imperial Valley only, and does not include the Coachella Branch or power development. Additional funds must be provided and a separate contract made with the Coachella Valley County Water District before construction of the Coachella branch canal can be undertaken.

The purpose of the All-American Canal is to provide an adequate supply of water for the Imperial and Coachella valleys in Southern California. The canal will be built by the Bureau of Reclamation and will be self-liquidating under the Reclamation Act. In the Imperial Valley there are now approximately 500,000 acres under irrigation being served by the Imperial Main Canal which takes out of the Colorado River, a few miles below Yuma, Arizona, and runs through Mexico and back into the United Stated near Calexico. The All-American Canal will be entirely in the United States. The City of San Diego is negotiating for 155 second-feet capacity in the canal to augment its domestic water supply.

GENERAL DESCRIPTION

It is planned to divert from the Colorado River at a point about 5 miles above Laguna Dam, of the Yuma (Federal) irrigation project, in section 9, T. 15 S., R. 24 E., S.B.M., California. Preliminary plans for the Imperial diversion dam call for a structure of the floating or Indian weir type, about 1,700 feet long, which will raise the water surface of the river 22 feet. Desilting basins will be provided, with provisions for sluicing silt down the river.

The main canal to the Imperial Valley will be 80 miles long, and the branch to the Coachella Valley 130 miles. From the diversion dam to the Siphon Drop on the Reservation division of the Yuma project, where 2,000 second-feet are diverted for this project, the capacity of the canal will be 15,000 second-feet; 13,000 second-feet from Siphon Drop to Pilot Knob; and 10,000 second-feet westward from Pilot Knob for the Imperial and Coachella Valleys. The Coachella branch canal will have an initial capacity of 1,500 second-feet as it leaves the main canal.

The Imperial Dam-Siphon Drop section of the All-American Canal will be 218 feet wide at the water surface, 22 feet deep, 130 feet bottom width, and will carry an amount of water equal to 70 percent of the average flow of the Colorado River at the Boulder Dam.

CANAL LOCATION

The route of the canal follows the river closely to Laguna Dam and then parallels the present Yuma main canal to the Siphon Drop. Several washes must be crossed by culverts or siphons. From the Siphon Drop to Pilot Knob the canal follows the foothills, and bridges for the Southern Pacific Railroad, the Inter-California Railroad, the State highway, and county road will be required. Beyond Pilot Knob, at three different points and for a total distance of 14.8 miles, the canal is located near to and parallel with the international boundary.

For 10½ miles the canal line passes through the sand hills, a region covered with dunes except for a few bare spots. The deepest cut in the sand-hill area is over 100 feet and the dune sand is about 80 feet in depth. Instead of lining the canal with concrete in this sand-hill area, it appears advisable to leave it unlined and prevent sand blowing into the canal as much as possible and to remove the sand by suction dredges if necessary. The canal section through the sand hills is designed with a mean velocity of 4.5 feet per second at full capacity, which is intended to be nonscouring and nonsilting. Portions excavated in finer sand for the water section and liable to scour are to be overexcavated to a depth of 1½ feet and the space refilled with screened gravel to form a scour-resisting lining. Means of preventing sand from being blown into the canal may be by one or more of the following methods: (a) Growing vegetation on the sand in a zone on each side of the canal by irrigation from small pipe lines; (b) spraying the sand with crude oil; (c) covering the dune sand with material from the canal excavation in the mesa formation which is too coarse to be blown by the wind; (d) excavating a berm 15 feet wide on each side of the canal at the mesa floor level. By adopting these methods in operation it is expected that the quantity of sand blown or drifted into the canal will be small.

From the sand hills the canal line runs west across the East Mesa to the present East High Line canal of the Imperial district distribution system, and then through the extreme southern portion of the Imperial Valley, where it crosses 17 principal ditches and passes through the town of Calexico before it reaches its terminus, the present West Side main canal. Here the water surface is -6.7, and at this point the canal has capacity sufficient to supply lands under the West Side canal and also to furnish water for additional lands on the West Side Mesa. At this point the City of San Diego wishes to divert 155 second-feet.

COACHELLA CANAL

About 16 miles west of Pilot Knob the Coachella branch canal will take out of the All-American Canal and run in a northwesterly direction across the East Mesa. The location crosses the Southern Pacific Railroad near Iris, passes east of the Salton Sea and the Coachella Valley to a point near the town of Coachella, where it again crosses the Southern Pacific and runs southwesterly across the valley, and then south to the Riverside-Imperial county line. There are more than 160 washes crossing the Coachella Canal line, ordinarily dry, but at times of heavy rains or cloudbursts carrying floods of short duration, heavily loaded with sand and silt; these must be crossed with siphons or culverts. By combining these washes in groups by the use of training levees and diversion channels, the number of structures can be reduced to about 90. The last 47 miles of the canal will be lined with concrete.

AREAS BENEFITED

The Imperial Irrigation District, comprising 512,000 acres, has a complete canal distribution system, with about 450,000 acres in cultivation. In elevation the valley varies from 250 feet below sea level at the Salton Sea to 0 or sea level. Principal crops are alfalfa, canteloupes

lettuce, barley, corn, milo, maize and small fruits. About 30,000 carloads of canteloupes and lettuce are shipped out each season. Average crop yields are alfalfa, 7 to 10 tons per acre, or a ton to a cutting, and canteloupes, 96 crates per acre. The growing season is 365 days. In the Coachella Valley about 16,000 acres are now under cultivation, being supplied by pumping from wells. There is no general canal or lateral system in this valley, which has about 150,000 acres of irrigable lands. While there are approximately 1,000,000 acres of irrigable lands under the proposed canal, no new lands will be brought under irrigation at this time.

POWER DEVELOPMENT

There are opportunities for the development of power at Pilot Knob where 3,000 second-feet of water will be dropped back to the Colorado River, and also at several points on the main canal. The present allotment does not provide any funds for power development. Power possibilities on the canal from the diversion dam down to and including the Siphon Drop are reserved to the United States.

CONSTRUCTION PROGRESS

Bids on the first construction job will be opened at Yuma, Arizona, on June 7, 1934 for building 30 miles of canal from station 245 to station 1860. The work is divided into seven schedules and involves the excavation of 39,390,000 cubic yards of earth and 528,000 cubic yards of rock. The work must be completed in 1,300 days.

EMPLOYMENT

In making selections for employment in the Government service preference will be given, in so far as may be practicable, to qualified applicants who are legal residents of the State of California. Applications for employment on this work should be addressed to Construction Engineer, All-American Canal, Federal Building, Yuma, Arizona.

Practically all construction men, such as laborers, helpers, cooks, truck drivers, skilled mechanics, foremen, timekeepers, costkeepers, storehousemen, etc., will be employed directly by the contractors and not by the Government.

Regulations issued by the Federal Emergency Administration of Public Works, provide that in the employment of labor preference shall be given, where they are qualified, to ex-service men with dependents, and then in the following order: (a) to citizens of the United States and aliens who have declared their intention of becoming citizens, who are bona fide residents of the county in which the work is to be performed, and (b) to the same classes who are residents of the state in which the work is to be performed. Local labor required will, as far as practicable, be selected from lists of qualified workers submitted by local employment agencies designated by the United States Employment Service. Pending the designation of local employment agencies those desiring employment as laborers or mechanics on this project should list their names with the State Reemployment Director, National Reemployment Service, Room 613, State Building, San Francisco, California. Highly skilled or organized labor will not be required to register for work at the local employment agencies, but the contractor will secure such men in the customary ways through recognized trade-union locals.

OFFICE OF THE COMMISSIONER

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
WASHINGTON

June 1, 1933.

BOULDER CANYON PROJECT - QUESTIONS AND ANSWERS

DAM:

Q. Where is the Boulder Dam being built?

A. In upper Black Canyon on the Colorado River about 25 miles in an air line southeast of Las Vegas, Nev., where the river forms the Arizona-Nevada State boundary.

Q. What does the project include?

A. Construction of a dam and power plant in Black Canyon and of the All-American Canal in southern California.

Q. What are the purposes of this project?

A. Flood control and general river regulation, irrigation, silt control, power development, and domestic water supply.

Q. What will the project cost?

A. The Boulder Canyon Project Act authorizes appropriations not to exceed $165,000,000. This amount is divided as follows: Dam and reservoir, $70,600,000; power development, $38,200,000; All-American Canal, $38,500,000; interest during construction, $17,700,000. Appropriations made to date are as follows: 1930-31, $10,660,000; 1931-32, $15,000,000; 1932-33, $23,000,000.

Q. How high will the dam be?

A. Plans call for a maximum height of about 730 feet above foundation rock, which would raise the water surface of the river 584 feet. Towers and parapet ornamentations will rise 40 feet or more above the crest.

Q. How does this height compare with other dams?

A. The Boulder will be by far the highest dam in the world. Next in height is the 405-foot Owyhee in Oregon, completed in 1932.

Q. What type of dam is to be built?

A. The concrete arch-gravity type, in which the water load is carried by both gravity action and horizontal arch action.

Q. What will be the length along the crest?

A. About 1,180 feet.

Q. What will be the widths up and down stream?

A. About 45 feet at the top and 650 feet at the base.

Q. What is the volume of concrete masonry?

A. About 3,400,000 cubic yards in the dam or 4,400,000 cubic yards in the dam, power plant, and appurtenant works. This amount of concrete would build a monument 100 feet by 100 feet, and $2\frac{1}{4}$ miles in height or, if placed on the ordinary city block, would rise to a height of 1,300 feet (one-quarter of a mile). It would build a standard paved highway 16 feet wide, extending from Miami, Florida, to Seattle, Washington. For comparison, the Bureau of Reclamation has placed in dams and canal structures a total of 5,116,000 cubic yards of concrete up to June 30, 1932. Mass concrete will be placed at the rate of 100,000 cubic yards per month, with a peak placement of probably 175,000 cubic yards.

Q. What is the weight of the 3,400,000 cubic yards of concrete in the dam?

A. 7,000,000 tons.

Q. What will be the maximum water pressure at the base of the dam?

A. 45,000 pounds per square foot.

Q. How much cement will be required?

A. About 5,500,000 barrels. The daily demand might tax the capacity of any one or two cement plants. This Bureau has used 5,862,000 barrels in 27 years of construction activities.

Q. How will excess heat (approximately 40°) in the mass concrete above 72°, due to setting, be removed?

A. By embedding in the concrete a system of pipes containing 800,000 feet (150 miles) of 2-inch pipe, through which cooling water from a refrigeration plant will be run.

Q. What are the principal items of work?

A. Excavation (all classes), diversion tunnels, 2,000,000 cubic yards; excavation (common) for foundation of dam, power plant, and cofferdams, 857,000 cubic yards; rock excavation for dam foundation, 400,000 cubic yards; excavation (all classes), spillways, 1,156,000 cubic yards; earth and rock fill for cofferdams, 1,200,000 cubic yards; excavation (all classes), valve houses and intake towers, 555,000 cubic yards; concrete 4,400,000 cubic yards; drilling grout and drainage holes, 315,000 linear feet; pressure grouting, 422,000 cubic feet.

Q. How much reinforcement steel will be used?

A. About 35,000,000 pounds of bars and rails.

Q. What are the estimated quantities of other principal material?

A. Gates and valves, 21,670,000 pounds; plate-steel outlet pipes, 110,000,000 pounds; pipe and fittings, 6,700,000 pounds; structural steel, 18,500,000 pounds; miscellaneous metal work, 5,300,000 pounds; cement 5,500,000 barrels.

Q. Does the Government purchase these materials?

A. Yes. The purchasing is handled by the Bureau of Reclamation, U. S. Customhouse, Denver, Colorado.

Q. What are the geologic conditions at the dam site?

A. The foundation and abutments are rock of volcanic origin, geologically termed "andesite breccia," hard and very durable.

Q. What is the depth below low water surface of the river to foundation rock?

A. From 110 to 120 feet. It is expected to excavate to elevation 505, or 140 feet below low water surface (elevation 645).

Q. How is the site of the dam protected from water inflow?

A. By an upstream cofferdam located 600 feet below the diversion tunnel portals. This dam is an earth and rock fill structure 90 feet high, 70 feet thick at the top, with steel sheet piling driven 40 to 50 feet to rock at the upper toe. On the upstream face, there is 6 inches of reinforced concrete paving, and on the downstream face will be a layer of dumped rock. This cofferdam contains 568,000 cubic yards of earth and 157,000 cubic yards of rock. A similar cofferdam has been built just below the power plant site, which is 60 feet high and is protected downstream by a rock barrier 53 feet in height.

Q. What provision is made for unwatering the site?

A. A 187-foot shaft has been sunk from the adit to the No. 2 Nevada diversion tunnel, with a drift reaching under and across the river channel. The shaft will be equipped with pumps discharging into the diversion tunnel.

Q. What are the canyon widths at the dam site?

A. From 290 to 370 feet at low-water level, and from 850 to 970 feet at elevation 1,232, the crest of the dam.

Q. How long will it take to build the dam, power plant, and appurtenant works?

A. About six years at the present rate of progress. The contractors are allowed seven years from April 20, 1931, under their contract.

Q. How many men will be employed?

A. It is not anticipated that more than 4,000 men will be employed on the job at any one time.

Q. Who are the contractors?

A. The Six Companies, Incorporated, with headquarters at 510 Financial Center Building, San Francisco, Calif., and field office at Boulder City, Nev.

Q. What was the amount of the contract?

A. $48,890,995.

Q. Who is in charge for the Bureau of Reclamation?

A. The Chief Engineer with headquarters at Denver, Colo., represented by the Construction Engineer in charge of the field office at Boulder City, Nev.

Q. What is the construction program?

A. Diversion tunnels, start June, 1931, complete March, 1933; Cofferdam (upstream), start September, 1932, complete March, 1933; Cofferdam and rock barrier (downstream), start November, 1932, complete April, 1933, removal complete May, 1935; Excavation for dam, start September, 1932, complete July, 1933; Intake towers, start March, 1932, complete September, 1935; 37-foot penstock tunnels, start December, 1932, complete December, 1933; Install 30-foot diameter outlet pipes in upper tunnels, Arizona, start August, 1933, complete November, 1934; Nevada, start January, 1934, complete May, 1935; 19-foot penstock tunnels, start December, 1932, complete December, 1933; Install 13-foot diameter penstock pipes in branch tunnels, start August, 1933, complete August, 1937; Install 30-foot diameter outlet pipes in lower tunnels, Nevada, start October, 1935, complete September, 1936; Arizona, start September, 1936, complete August, 1937; Outlet works (canyon walls), start November, 1932, complete February, 1935; Outlet works (tunnel plugs), start October, 1935, complete December, 1936; Stoney gates (tunnel outlets, tunnels Nos. 2 and 3), complete May, 1933; Tunnel plugs (tunnels Nos. 2 and 3, penstock tunnels), start December, 1934, complete May, 1935; Tunnel plugs (tunnels Nos. 1 and 4, spillway tunnels), start June, 1935, complete November, 1935; Concrete in dam, start July, 1933, complete April, 1936; Spillways, start January, 1932, complete June, 1934; Bulkheads (tunnels Nos. 1 and 4), closed June, 1935; Trash racks (tunnels Nos. 2 and 3), complete February, 1935; Power plant, start November, 1932, complete November, 1934.

Q. What construction work was necessary before operations were started at the dam site?

A. (1) Construction of Boulder City to house both Government and contractors' employees. (2) Seven miles of 22-foot, oil-surfaced highway from Boulder City to dam site. (3) Building 22.7 miles of standard gauge railroad from the Union Pacific main line to Boulder City, and 10 miles from Boulder City to the dam site. (4) A power transmission line 222 miles long, from San Bernardino, California, to the dam site to furnish power for construction purposes.

RESERVOIR:

Q. How much water will the reservoir hold?

A. 30,500,000 acre-feet when full. An acre-foot is the amount of water that will cover 1 acre 1 foot deep. The water in the reservoir would cover the State of New York to a depth of 1 foot. The reservoir will store the entire average flow of the river for two years. Thirty and one-half million acre-feet equal 10,000,000,000,000 gallons, or about 5,000 gallons for every inhabitant on earth, or 30,000 gallons for each person in the United States.

Q. What will be the area of the reservoir?

A. 145,000 acres or 227 square miles. For comparison, Lake Tahoe in California-Nevada, has an area of 193 square miles.

Q. What will be the length and width of the reservoir?

A. It is about 115 miles by river from Black Canyon to Bridge Canyon, the limit of the backwater. The reservoir will extend up the Virgin River about 35 miles. The width varies from several hundred feet in the canyons to a maximum of 8 miles.

Q. What will be the elevation of the high-water line?

A. 1,229 feet above sea level. All lands below elevation 1,250 have been retained for reservoir purposes.

Q. How will the reservoir capacity be utilized?

A. 9,500,000 acre-feet for flood control; 5,000,000 to 8,000,000 acre-feet silt pocket; 12,000,000 to 15,000,000 acre-feet active or regulation storage.

Q. Who will operate the dam and reservoir after completion?

A. The Government will operate and maintain the dam, reservoir, pressure tunnels, outlet works, and penstocks to but not including shut-off valves at the inlets to turbine casings.

Q. How much silt will be deposited in the reservoir?

A. The estimated average volume of silt carried by the river into Black Canyon is about 137,000 acre-feet annually under present conditions, and this amount will decrease with upstream development. It is estimated that the total silt deposits in the reservoir will not exceed 3,000,000 acre-feet at the end of 50 years.

Q. Will salt deposits have an injurious effect on the water?

A. While some salt from the extensive deposits in the Virgin River Valley will go into solution, the relatively small amount should not be sufficient to cause any appreciable salinity in the water.

Q. What will be the length of the shore line?

A. About 550 miles.

Q. What is the estimated annual evaporation on the reservoir?

A. 600,000 acre-feet.

Q. Are there any private lands in the reservoir site?

A. There are 12,000 acres of private land in the Virgin and Muddy Valleys and a number of mining claims, but most of the area is Government land. All the Government land is withdrawn from entry for construction purposes. The private land is being purchased.

DIVERSION WORKS, SPILLWAYS AND OUTLET WORKS:

Q. How is river being diverted during dam construction?

A. By a temporary earth and rock fill cofferdam through four 50-foot diameter tunnels, excavated to 56 feet and lined with 3 feet of concrete (300,000 cubic yards), and driven through the rock of the canyon walls, two on each side of the river. These tunnels can carry over 200,000 second-feet of water.

Q. What is the length of these tunnels?

A. The four tunnels have a total length of 15,934 feet or 3.0 miles.

Q. After their use for river diversion, how will the tunnels be utilized in the project scheme?

A. After being plugged with concrete at locations approximately one-third their length below the inlet ends of the inner tunnels and about midway in the outer tunnels, the two inner tunnels will contain the 30-foot steel pipes connecting intake towers in the reservoir with the penstocks to the power plant and the canyon wall outlet works; and the lower portions of the two outer tunnels will be used for spillway outlets.

Q. What gate installation is proposed for the tunnels?

A. When river diversion through the tunnels is discontinued, the inlet ends of the two outer tunnels will be permanently closed with 50-foot by 50-foot bulkhead gates. Each gate with frame weighs about 3,000,000 pounds and required 42 railroad cars for shipment. At the outlet ends of the two inner tunnels, 50-foot by 35-foot Stoney gates are installed, which may be closed when it is desired to unwater the tunnels for inspection or repairs.

Q. What are the intake towers?

A. There are four reinforced-concrete towers located above the dam, two on each side of the river and about 165 feet apart in a direction parallel with the river. These towers are 75 feet in average diameter, 375 feet in height, and each tower controls one-quarter of the supply of water for the power plant turbines.

Q. How are these towers connected to the power plant and outlet valves?

A. By 30-foot diameter plate-steel pipes installed in 37-foot and 50-foot diameter concrete-lined tunnels, the 37-foot inclined tunnels connecting the upstream intake towers to the 50-foot inner diversion tunnels; and by 30-foot pipes in 37-foot tunnels leading from the downstream towers and constructed at elevation 820, above the inner diversion tunnels.

Q. What method of control is used in the intake towers?

A. Two cylindrical gates, each 32 feet in diameter, and 10 feet high, one near the bottom (elev. 894) and the other near the middle (elev. 1,045) of each tower, protected by trash racks located over the entrances to the tower.

Q. What pipes are installed in the tunnels for reservoir outlets?

A. 4,700 feet of 30-foot diameter main headers, 1,900 feet of 25-foot diameter pipes below the branch penstock tunnels to the power plant, and 2,300 feet of $8\frac{1}{2}$-foot diameter pipes in 11-foot tunnels leading to the needle valve outlets. The maximum thickness of the largest pipe is almost 3 inches.

Q. How are the 30-foot pipes connected to the power plant turbines?

A. By sixteen 13-foot diameter plate-steel penstock pipes totaling 5,600 feet in length, installed in 19-foot diameter tunnels.

Q. Who has the contract for furnishing and installing the outlet and penstock pipes?

A. Babcock and Wilcox Company of Barberton, Ohio. The contract price is $10,908,000, and the estimated weight of steel plates and castings required is 110,000,000 pounds. This 55,000 tons of steel will be formed and welded into 14,500 feet of pipe, varying from $8\frac{1}{2}$ to 30 feet in diameter, the latter to be the largest pipe ever constructed and will have walls up to $2\frac{3}{4}$ inches thick. One length of this pipe, 12 feet long and 30 feet in diameter, will be made from three steel plates, so heavy that only two plates can be shipped from the steel mill to the fabricating plant on one railroad car. Two such lengths of pipe,

welded together, comprise one erection section weighing 150 tons....heavier than many types of railroad locomotives. As the larger sizes of pipe can not be shipped by railroad, the contractors have built a fabricating plant near the dam site.

Q. What outlets are proposed?

A. Six 72-inch needle valves in each inner diversion tunnel plug outlet, and six 84-inch needle valves in each canyon wall valve house, there being one house on each side of the river at elevation 820, which is about 180 feet above river level. The valve outlets are pointed downstream at an angle of 15 degrees. Canyon wall valves will not be used except under emergency or flood conditions. Each 72-inch valve is capable of discharging a maximum of 3,670 second-feet at a velocity of about 175 feet per second.

Q. What is the total maximum capacity of these works?

A. 125,000 cubic feet per second, of which 25,000 c.f.s. is for power generation and 100,000 c.f.s. is valve discharge.

Q. What are the plans for the Arizona and Nevada spillways?

A. Each will consist of a concrete-lined open channel, about 650 feet long, 150 feet wide and 120 feet deep, with the side next to the river formed into an ogee-shaped crest. The two spillways require 625,000 cubic yards of rock excavation.

Q. How is water discharged from the spillways?

A. Through inclined shafts, 50-feet in diameter and 600 feet long, into the outer diversion tunnels.

Q. What will be the maximum water velocity in the spillway tunnels?

A. About 175 feet per second.

Q. What gate installation is proposed at the spillways?

A. Four 100-foot by 16-foot drum gates on each spillway crest controlled either automatically or manually.

Q. What is the maximum capacity of the spillways, valves and power plant?

A. 400,000 cubic feet per second. Each spillway will have a maximum discharge capacity of 200,000 cubic feet per second. Should a flood occur of sufficient volume to require the full capacity of the spillways, the energy of the falling water would be about 25,000,000 horsepower, the flow over each spillway would be about the same as the flow over Niagara Falls and the total drop would be more than three times as great.

POWER DEVELOPMENT:

Q. What will be the installed capacity of the power plant at Boulder Dam?

A. 1,835,000 horsepower (rated). For comparison, Niagara (United States) is 452,500; Conowingo 378,000 (ultimate 594,000); and Muscle Shoals 250,000 (ultimate 600,000).

Q. What is a horsepower in terms of falling water?

A. One second-foot of water falling 8.81 feet equals one horsepower at 100 per cent efficiency. A second-foot of water is 1 cubic foot, or nearly $7\frac{1}{2}$ gallons, passing a given point in one second of time.

Q. What will be the continuous firm power output?

A. About 663,000 horsepower, based on 83 per cent plant efficiency, and 10 percent maximum shortage.

Q. How much electrical energy will be available yearly?

A. Four billion three hundred and thirty million kilowatt-hours on com-

pletion of the dam (1937) and this amount, it is estimated, will decrease each year thereafter by 8,760,000 kilowatt-hours, as a result of upstream development.

Q. What is a kilowatt-hour?

A. The energy resulting from an activity of 1 kilowatt for one hour. A kilowatt is 1,000 watts. One horsepower equals 0.746 kilowatt. 663,000 (horsepower) x 0/746 x 24 (hours) x 365 (days) = 4,330,000,000 kilowatt-hours.

Q. How will the income from sale of power be used?

A. To pay all expenses of operation and maintenance of works incurred by the United States and the cost of construction of dam and power plant, with interest at 4 percent, within a 50-year period. Excess revenues above amortization requirements will be allocated as follows: 62½ percent to flood control ($25,000,000) repayment and 18¾ percent to Arizona and 18¾ percent to Nevada. After repayment to the United States of all money advanced, with interest, revenues will be kept in a separate Colorado River Basin fund.

Q. Where will the power plant be located?

A. Just below the dam, one-half on the Nevada side of the river and one-half on the Arizona side, forming a U-shaped structure, built of steel and reinforced concrete and about 1,260 feet long, and 125 feet high above the normal tailrace water surface.

Q. How will the water reach the turbines?

A. Through four pressure tunnels, two on each side of the river, each provided with shut-off gates and trash racks.

Q. What will be the principal machinery installations?

A. Plans call for fifteen 115,000 horsepower and two 55,000 horsepower vertical hydraulic turbines; fifteen 50-cycle main generating units of 82,500 kv.a. capacity each, and two 60-cycle main generating units of 40,000 kv.a. capacity each. The larger units exceed in size the largest yet manufactured, namely, the 83,000 horsepower turbines and 76,500 kilovolt-ampere generators in the Dnieprostroy plant in Russia.

Q. What facilities are provided for transporting power plant machinery from the canyon rim to the power plant?

A. A 150-ton capacity permanent cableway, electrically operated, with a span of 1,200 feet across the canyon, will be used to lower not only power plant machinery, but also outlet pipes and other machinery, materials, and equipment.

Q. Under what heads will the turbines operate?

A. Maximum head, 590 feet; minimum head, 420 feet; average head, 530 feet.

Q. What is the estimated cost of the power development?

A. $38,200,000, not including interest.

Q. What will be the charge for primary or firm power?

A. One and sixty-three one hundredths mills per kilowatt-hour for falling water in terms of energy measured at transmission voltage.

Q. How much secondary or dump power will be available yearly?

A. One billion five hundred and fifty million kilowatt-hours on completion of the dam (1937) and this amount decreasing each year by 8,600,000 kilowatt-hours.

Q. What will be the charge for secondary or dump power?

A. One-half mill per kilowatt-hour for falling water in terms of energy measured at transmission voltage.

Q. Are these rates subject to adjustment?

A. Yes, at the end of 15 years from date of execution of lease and every 10 years thereafter the rates may be readjusted.

Q. How much revenue will be derived from the sale of power?

A. For the first year of operation, the income would be $7,057,900 from the sale of 4,330,000,000 kilowatt-hours of primary energy at $0.00163 and $775,000 from the sale of 1,550,000,000 kilowatt-hours of secondary energy at $0.0005. The amount of income will decrease each year thereafter. The estimated annual income from firm energy will average about $6,550,000 and, from secondary energy, $650,000, over the 50-year repayment period.

Q. What is the estimated total gross power revenue for the 50-year period?

A. $361,000,000.

Q. How much of this is surplus, after allowing for operation and maintenance, interest, depreciation, and payments for retirement of investment?

A. $166,500,000.

Q. How will this surplus be divided?

A. United States, $104,000,000 (62½%); Arizona, $31,200,000 (18¾%); Nevada, $31,200,000 (18¾%). This will give an average yearly payment of $620,000 to each State.

Q. What disposition will be made of the Government's share?

A. $37,500,000 will be used for payments for retirement of $25,000,000 allocated to flood control with interest at 4 percent. $66,500,000 will go into a fund to be expended within the Colorado River Basin as prescribed by Congress.

Q. Who will operate and maintain the power plant?

A. The City of Los Angeles and the Southern California Edison Company, under the general supervision of a director appointed by the Secretary of the Interior. The City will generate power for the States, municipalities and the Metropolitan Water District. The Southern California Edison Company will generate power for company purchasers.

Q. When will the first units go into operation?

A. In September, 1935.

Q. What is the allocation of firm power?

A. State of Arizona, 18 percent; State of Nevada, 18 percent; Metropolitan Water District, 36 percent; smaller municipalities, 6 percent; City of Los Angeles, 13 percent; Southern California Edison Company, 9 percent. All secondary energy is allocated to the District; also so much of the firm energy allocated to the States, the City and the Company as may not be in use by them.

Q. How is the machinery in the plant to be paid for?

A. Machinery and equipment for the generation of power costing about $17,700,000 will be furnished, installed and owned by the Government. This will consist of generating, transforming and high-voltage switching equipment. The contractors will pay in 10 equal annual installments an amount sufficient to amortize this total cost.

Q. Who will pay the cost of transmission of power?

A. The contractors who purchase the power.

WATER ALLOCATION:

Q. What is the allocation of water under the Colorado River compact?

A. Based on a mean annual run-off of 16,000,000 acre-feet, the compact allocated 7,500,000 acre-feet to the upper basin States and 7,500,000 acre-feet to the lower basin States, with the right of the latter to increase their beneficial consumptive use of such water by 1,000,000 acre-feet per annum.

Q. How much of the water allocated to the lower basin States does California get?

A. California has agreed that the aggregate annual consumptive use of the river water shall not exceed 4,400,000 acre-feet of the 7,500,000 allocated to the lower basin by Article III (a) of the compact. In addition, California can use one-half of the surplus waters available above the 7,500,000 acre-feet allocated.

Q. How much water is allocated to Nevada and Arizona?

A. The Boulder Canyon Project Act authorizes Arizona, California, and Nevada to enter into an agreement which shall provide that Nevada gets 300,000 acre-feet and Arizona 2,800,000 acre-feet for exclusive beneficial consumptive use; also, that Arizona may annually use one-half of the surplus water unapportioned by the compact and, in addition, shall have the exclusive beneficial consumptive use of the Gila River and its tributaries within the State. Such an agreement has not yet been made.

Q. What agreement as to division of water has been made by the various California interests?

A. (1) 3,850,000 acre-feet of water per annum for beneficial consumptive use to agricultural interests, as follows: First, to Palo Verde Irrigation District, 104,500 acres; Second, to Yuma (Federal) irrigation projects, 25,000 acres in California; remainder to lands in the Imperial and Coachella Valleys served from the All-American Canal and to 16,000 acres on the Lower Palo Verde Mesa; (2) the next 550,000 acre-feet to the Metropolitan Water District; (3) the next 662,000 acre-feet to the Metropolitan Water District (550,000) and San Diego (112,000); (4) the next 300,000 acre-feet to the Imperial and Coachella Valleys and to 16,000 acres on the Lower Palo Verde Mesa; (5) remainder for agricultural use in the Colorado River Basin in California.

RIVER FLOW:

Q. What has been the greatest measured discharge of the Colorado River?

A. Two hundred and forty thousand cubic feet per second measured at Yuma, Arizona.

Q. Have there been any larger floods?

A. A maximum flood of 300,000 cubic feet per second, it is believed, might have been the flow for a short period in 1884.

Q. What has been the smallest measured discharge?

A. Sixty-six cubic feet per second, measured at Yuma, Arizona.

Q. What is the discharge at the dam site?

A. The average is 22,000 cubic feet per second, with an average annual run-off of 15,700,000 acre-feet.

Q. What will be the maximum flood discharge after completion of the project?

A. The largest flood since 1900 would be held to 48,000 cubic feet per second below the dam and 35,000 cubic feet per second in the delta region. An 1884 flood would be reduced to an outflow of 75,000 cubic feet per second.

IRRIGABLE AREAS:

Q. How much irrigable land is there below the Boulder Canyon reservoir, in the United States?

A. About 2,100,000 acres, according to preliminary estimates.

Q. How is this area divided between the States?

A. Arizona 900,000 acres, California 1,200,000 acres, and Nevada 15,000 acres. These are gross areas and may be materially changed when irrigable area surveys are made.

Q. What is the present area under irrigation from the Colorado River below the dam site?

A. About 660,000 acres divided as follows: California 600,000, Arizona 60,000.

Q. What are some of the possible projects in Arizona?

A. The Gila River Valley with a gross area of about 900,000 acres in the southwestern part of the State. The Parker project of about 116,000 acres near Parker, Mohave Valley, with an irrigable area of 33,000 acres near Needles, California, and the Cibola Valley of 16,000 acres in Yuma County. The Yuma project adjacent to the City of Yuma is an active Federal project, with about 55,000 acres irrigated at the present time, and a total ultimate irrigable area of 112,000 acres, including about 45,000 acres of undeveloped mesa lands.

Q. What are the principal California projects which may be benefited?

A. The Imperial Valley has a present irrigable area of 522,000 acres and about 850,000 acres of valley and adjacent mesa lands can be irrigated under the All-American Canal. The Coachella Valley near Indio has an irrigable area of 150,000 acres, which can be served by a branch of the All-American Canal. There are 79,000 acres in the Palo Verde Valley project near Blythe.

Q. Where is the irrigable acreage in Nevada?

A. Cottonwood Island, on the Colorado River, located due west of Chloride, Arizona, has an area of 3,000 acres. The State Engineer plans to develop additional areas by pumping.

Q. What is the approximate classification of the irrigable lands?

A. Public, 44 percent; private, 40 percent; State, 1 percent; railroad, 2 percent; Indian, 8 percent; and entered, 5 percent.

BOULDER CITY:

Q. Where is the new town on the Boulder Canyon project located?

A. The location is about 6 miles west of the dam site, at the summit and near the terminus of the Union Pacific section of the branch railroad.

Q. Has the town been named?

A. Yes, it has been given the name of Boulder City.

Q. What about a domestic water supply?

A. Water is pumped from the Colorado River to the town, a distance of nearly 7 miles, with a total lift of about 2,000 feet. The intake is about 3,500 feet downstream from the dam site on the Nevada side. The water first goes to a presedimentation basin 100 feet above river level, then to a 100,000-gallon receiving tank at Boulder City, from there to a filtration and purification plant, and finally to a 2,000,000-gallon storage tank.

Q. What other improvements were necessary?

A. A sewerage system and electrical distribution system have been installed. Sidewalks and curbs have been provided and streets surfaced and paved.

Q. What was the building program?

A. Government employees, principally engineers, inspectors, and clerks required two dormitories, and 100 houses for living quarters. The Government

has also erected an office building, municipal building, school, warehouse, and garage.

Q. Do employees of the contractors on the dam and power plant live in the town?

A. Yes. A portion of the town has been set aside for the contractors' use. The contractors arrange for the housing of their workmen, with construction subject to Government approval. They have built mess halls, dormitories, hospital, clubhouse, commissary, machine shop, storehouses, garage, laundry, and 700 employees' cottages. The nine great dormitories are heated in winter and artificially cooled in summer, and are equipped with electric lights, running water and shower baths.

Q. Who owns the lands in the town site?

A. The Government owns the land, all of which is under first form withdrawal. It is also included in a Federal reservation.

Q. How can one obtain a town lot for business purposes?

A. The land is leased for a 10-year term to those awarded business permits, the Government to retain ownership and supervisory control. Continuation of the leases is contingent upon compliance with the terms of the contract.

Q. What is the population?

A. About 5,000, which will hold during the construction period, making it the third largest city in the State of Nevada.

Q. Will this town be permanent?

A. It will no doubt be permanent, because the 730-foot dam and 115-mile lake will be a great attraction for tourists. There are also many scenic wonders close by to attract visitors, including three national parks--Grand Canyon, Zion and Bryce Canyon. A sizable force will also be required for operation of the reservoir and power plant.

Q. What construction has been accomplished by the Government?

A. Buildings for employees, waterworks, sewerage system, electric distribution system, street surfacing, sidewalks and curbs have been completed. A highway and railroad from the town to the dam site have also been constructed.

Q. How much money has been expended at Boulder City?

A. It has cost the Government about $1,700,000 to build the town.

Q. What provisions were made for erecting buildings suited to the climatic conditions in that section?

A. A city planner, well acquainted with the type of building construction required, was employed. Government buildings are largely of the Spanish type of architecture, and the main buildings are air-conditioned. The Bureau of Reclamation encountered somewhat similar climatic conditions during construction of the Yuma and Salt River projects in Arizona.

Q. What is the form of town government?

A. The city manager plan is followed and this official is responsible to the construction engineer. An advisory commission of three supplements the city manager. One chief and eight assistant rangers constitute the police force.

Q. What is the range of temperatures in that locality?

A. They vary from 20° to 120°.

Q. How near is Boulder City to Las Vegas, Nevada, and Kingman, Arizona?

A. About 21 miles southeast in an air line, 24 miles by highway, and 32 miles by railroad from Las Vegas, and 95 miles by highway from Kingman.

Q. What is the elevation of the town?

A. About 2,500 feet above sea level.

Q. What is the area of the town site?
A. About 200 acres.

ALL-AMERICAN CANAL:

Q. Is the All-American Canal a part of the Boulder Canyon project?
A. Yes. There are three features included in the project--the Boulder Dam, power plant, and the All-American Canal.
Q. What is the purpose of the canal?
A. To carry water from the Colorado River to the Imperial and Coachella Valleys in the southeastern part of California.
Q. Why the name, "All-American"?
A. Because the canal will be built entirely in the United States. The present Imperial main canal is largely in Mexico.
Q. What part of the $165,000,000 cost of the Boulder Canyon project is allotted to the canal?
A. $38,500,000, not including interest during construction. The Boulder Canyon Project Act of December 21, 1928, authorized the building of a main canal from the Colorado River to the Imperial and Coachella Valleys.
Q. Is this expenditure reimbursable?
A. Yes. Under a repayment contract now being negotiated with the irrigation district, the cost of the canals and appurtenant structures will be returned to the Government as provided in the reclamation law.
Q. Will the district have to pay for the water?
A. There will be no charge for the use, storage or delivery of water for irrigation or water for potable purposes.
Q. Where is the proposed location of the intake?
A. A new diversion dam will be built about 15 miles northeast of Yuma, Arizona, and 5 miles north of Laguna Dam, the diversion point for the main canal of the Yuma (Federal) irrigation project.
Q. What type of structure will be built?
A. The (Imperial) dam will be of the floating or Indian weir type, with a crest about 1,700 feet long, and will raise the water surface of the river 22 feet.
Q. How much water will the canal carry?
A. An initial diversion of 15,000 cubic feet per second is planned, which includes 2,000 cubic feet per second diverted at the Siphon Drop, for the Yuma project, and 3,000 cubic feet per second diverted at Pilot Knob for power development. The largest canal so far built by the Bureau of Reclamation has a capacity of 2,500 second-feet.
Q. What will be the dimensions of the canal?
A. The maximum section will be about 200 feet wide at the water surface, 134 feet bottom width, and 22 feet deep. There are only two larger canals in the United States, both ship canals.
Q. What will be the length?
A. The All-American Canal to Imperial Valley will be 80 miles long, and the main canal to the Coachella Valley will be 130 miles long.
Q. Are the sand hills to be crossed by the canal?
A. Yes. The canal for 10 miles will pass through a ridge of shifting sands. Here the deepest cutting is over 100 feet.
Q. What means are being considered to prevent blow sand from drifting into the canal?
A. (1) Growing vegetation in a zone each side of the canal. (2) Covering the

dune sand with the coarser excavated material. Spraying the sand with crude oil. (3) Maintaining a 15-foot berm on each side of the canal at mesa floor level.

Q. Will any portion of the canal be lined with concrete?

A. The lining of 4 miles of the All-American and 47 miles of the Coachella Canal may be found necessary.

Q. What structures are proposed?

A. Siphons or culverts will be required to carry the canal under numerous washes, 10 on the All-American and 79 on the Coachella. The All-American Canal will also have to be carried under the Alamo and New Rivers by siphons.

Q. What is the estimated total of excavation?

A. 60,000,000 to 65,000,000 cubic yards, of which but 4 percent is rock.

Q. Are there opportunities for power development?

A. Yes. At Pilot Knob, about 7 miles west of Yuma, and also at four drops on the canal.

Q. How much power can be developed?

A. About 60,000 kilowatts.

Q. Is additional water supply for the City of San Diego tied in to All-American Canal plans?

A. San Diego is considering the feasibility of having water carried through the projected All-American Canal and the Imperial Irrigation District system, to be taken from some point on the west side of the Imperial Valley to San Diego.

Q. How much water is San Diego asking for?

A. 155 cubic feet of water per second, together with the necessary energy from the Boulder Dam power plant to lift this water and deliver it to the coastal plain in San Diego County. The pumping lift is over 4,000 feet.

IMPERIAL AND COACHELLA VALLEYS:

Q. What is the irrigable area of the Imperial Irrigation District?

A. 522,000 acres, to water which requires 1,700 miles of canals and laterals.

Q. How much land is now irrigated?

A. From 400,000 to 450,000 acres.

Q. What is the present irrigable area in Mexico (Lower California) from the Imperial Main Canal?

A. About 200,000 acres.

Q. What are the principal crops?

A. Alfalfa, cantaloupes, lettuce, barley, corn, milo maize and small fruits. About 30,000 carloads of cantaloupes and lettuce are shipped out of the Imperial Valley each season.

Q. What are the average crop yields?

A. Alfalfa 7 to 10 tons per acre, a ton to a cutting; cantaloupes, 96 crates per acre.

Q. What is the growing season?

A. 365 days.

Q. What is the elevation of the Valley?

A. From 250 feet below sea level at the Salton Sea to 0 or sea level. The adjoining mesas or high lands vary in elevation from 50 to 150 feet.

Q. What is the Salton Sea?

A. An inland sea in a depression in the northern part of Imperial Valley. Prior to 1905, it was only a small lake, but the Colorado River break of 1905-1907 increased the water surface area of the sea to 515 square miles, or $2\frac{1}{2}$ times the area of the Boulder Canyon reservoir. It then had a length of 42

miles and maximum depth of 80 feet. The present area is 287 square miles and the elevation of the water surface is about stable at 250 feet below sea level.

Q. What is the water surface of the Colorado River which flows to the east and south of the valley?

A. About 100 feet above sea level, or from 100 to 350 feet above the valley floor.

Q. Is the valley protected by levees?

A. Yes. There are 74 miles of protection levees, all in Mexico.

Q. What is the rainfall in this section?

A. About 3 inches a year.

Q. How large is the Coachella Valley?

A. The gross acreage is 187,000 acres. The estimated irrigable area under the proposed canal system is 150,000 acres. There are now about 16,000 acres under cultivation.

Q. What will be the total irrigable area in the Imperial and Coachella Valleys and adjacent East Mesa, West Mesa, Pilot Knob Mesa and Dos Palmas unit, under the proposed canals?

A. The estimated area is 1,000,000 acres.

Q. What is the status of these lands as to ownership?

A. Approximately 20 percent public, 70 percent private and 10 percent State, railroad and Indian.

COLORADO RIVER AQUEDUCT:

Q. Is the aqueduct a part of the Boulder Canyon project?

A. No, but one of the purposes of the project is to provide a supplemental domestic water supply for Los Angeles and neighboring cities and towns. The aqueduct will transport water which is stored in the reservoir behind the Boulder Dam.

Q. What is the Metropolitan Water District?

A. A district comprising several cities and towns in southern California that will use this water supply. The district offices are at 306 West Third Street, Los Angeles, California.

Q. What portion of the Colorado River water will the district receive?

A. The district has contracted with the Secretary of the Interior for delivery each year from the reservoir up to but not exceeding 1,050,000 acre-feet. This corresponds to a flow of about 1,500 cubic feet per second, or about a billion gallons daily from the river. The district will pay to the United States 25 cents per acre-foot for the actual amount used, or an average annual payment of about $250,000.

Q. Will the district obtain power from the plant at Boulder Dam?

A. Yes. Its allocation is 36 percent.

Q. What will be the cost of the aqueduct?

A. A bond issue of $220,000,000 was authorized by the district at a special election held on September 29, 1931. The Reconstruction Finance Corporation, in September, 1932, agreed to bid upon $40,000,000 of 5 percent bonds.

Q. Where on the Colorado River will the intake for the aqueduct be located?

A. At the Parker dam site in Upper Parker Canyon, about 155 miles below Boulder Dam, and 12 miles above Parker, Arizona.

Q. What will be the height of the diversion dam?

A. The proposed Parker Dam will be 72 feet in height.

Q. What is the maximum pumping lift to cross the mountains?

A. About 1,340 feet, from where the water enters the aqueduct. Five

pumping stations will be required.

Q. What is the total length of the proposed aqueduct?

A. About 239 miles of main aqueduct and 155 miles of feeder lines.

Q. How many tunnels will be required?

A. There will be 46 tunnels totaling 85 miles in length. The longest is the San Jacinto, 13 miles. The maximum diameter of the tunnels is 16 feet.

Q. How many miles of conduit and open canal will be constructed?

A. There will be 55 miles of buried concrete conduit and 75 miles of concrete-lined open canal.

Q. What amount of siphon construction is involved?

A. About 24 miles.

Q. How many storage and regulating reservoirs must be constructed?

A. There will be nine reservoirs along the route of the aqueduct.

Q. What are the estimated quantities of the major items of construction?

A. There will be 38,000,000 cubic yards of excavation; 6,800,000 cubic yards of embankment; 4,900,000 cubic yards of concrete, involving the use of 6,400,000 barrels of cement; 129,000,000 pounds of reinforcing steel; 34,000,000 board feet of tunnel timbers; 30,000,000 pounds of structural steel for transmission lines; 20,000,000 pounds of steel for penstocks.

Q. How long will the construction take?

A. The work is scheduled for completion along with the Boulder Canyon project, or about five to six years from the start of the work.

SETTLEMENT:

Q. Are there any public lands susceptible of irrigation which are now open to homestead entry in the areas below Boulder Dam?

A. No. All of these lands have been withdrawn from entry.

Q. When will these lands be opened to settlement?

A. Not until after Boulder Dam and the All-American Canal are completed and water can be furnished for irrigation, which will probably not be before 1937.

Q. How will the lands be opened?

A. Under the provisions of the reclamation law and similar to openings on the Federal irrigation projects.

Q. Will preference right of entry be given to ex-service men?

A. Yes, for a period of three months after date of opening.

Q. What Federal projects have climatic and crop conditions similar to those prevailing on the Boulder Canyon project?

A. The Salt River in Arizona, Yuma in Arizona-California, and Orland in California.

Q. What will be the principal crops grown?

A. Alfalfa, cotton, grain, melons, vegetables, citrus and other fruits.

Q. Have surveys been made to determine the irrigable areas?

A. No. Surveys are in progress in California, and also in Arizona and Nevada.

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Note: The figures used in the above "Questions and Answers" are in some cases taken from preliminary plans, studies and estimates and may be materially changed when final plans are approved and irrigable area surveys are made.

ELWOOD MEAD,
Commissioner.

BEST SCHEME OF

DEVELOPMENT OF

COLORADO RIVER BELOW

ITS JUNCTION WITH THE GREEN.

by Col. W. Kelly,
Chief Engineer,
Federal Power Commission.

Resumé:

The best scheme of development of Colorado River below the junction of the Green is,-

1. A power and storage dam at Black (or Boulder) Canyon with crest from 310 to 360 feet above present low water. Such a dam will provide the lower Basin with immediate and effective flood relief, and will meet its irrigation needs for at least 15 years to come. It will also furnish 225,000 kw. or more primary power which can be sold at a price to carry the entire project.

2. A power dam at Diamond Creek, with crest about 250 feet above low water, to develop 187,500 kw. primary power.

3. A storage dam at Glenn Canyon (Lees Ferry), with crest about 400 feet above low water, to give about 8,000,000 acre-feet storage. This dam will give additional flood protection, additional flow for irrigation when needed, and will increase the primary power of the Black Canyon and Diamond Creek dams by about 375,000 kw. It will also increase the power and reduce the cost of any other dams that may be built below it.

The power dam at Diamond Creek probably should be constructed as the second or third step in the scheme of development but the loss due to carrying charges if it be built at once will not be great, and there will be no loss at all if the completion of the Black Canyon dam is not accomplished till after 1930. Moreover, should the foundations at Black Canyon prove to be as deep as at Boulder Canyon it may be economical to change the order and build Diamond Creek and Glenn Canyon dams first.

E

July 20, 1922.

Investigations, Ariz. & Cal.
Colorado River

MEMORANDUM for the Federal Power Commission:

The Federal Power Commission has before it eleven applications for preliminary permits for power development on Colorado River and tributaries at 21 different points. It has issued one preliminary permit on which an application for license has been filed by Mr. James B. Girand for power development at Diamond Creek. The Commission has suspended action on all applications except Mr. Girand's until report is made by Mr. Hoover's Commission. Mr. Girand's permit has been extended to October 19, 1922, in order to give time to determine whether it is in accord with the best scheme of development. Exhibit No. 1 herewith is a general plan showing the Colorado and its tributaries and the location of projects applied for. Exhibit No. 2 is a profile showing the same.

Girand License.

The application of J. B. Girand for license makes urgent the consideration by the Federal Power Commission of the Colorado development at this time. Mr. Girand certainly has strong equities, if not rights, to have his license granted. He was granted a permit by the Interior Department, which was recognized by the Federal Power Commission as giving him priority, and he was accordingly issued a preliminary permit by the Federal Power Commission to maintain that priority. He has carried out all the terms of his preliminary permit and has expended over $100,000 in securing the data necessary for his application for license. He is being aided financially by the Arizona Copper interests who are planning to use the power in their mining operations. His plans are satisfactory, and his project, while it contributes little to other interests on the river, will fit the best scheme of development (as will be shown later) and will interfere physically with no other interest on the river. The Secretary of the Interior has announced his opposition to granting a license to Girand. His views, as publicly expressed, are embodied in the Swing Bill, H. R. 11449. The Swing bill reserves the Colorado, from the junction of the Green down, for development by the Federal Government and shuts out all development by private interests. Practically, its effect is to take this section of the river out of the jurisdiction of the Federal Power Commission and to place it under the jurisdiction of the Secretary of the Interior with powers very similar to those conferred upon the Federal Power Commission. The Swing Bill also contains an item appropriating $70,000,000 for carrying out a flood protection project at or near Boulder Canyon and for constructing

the "All American" high line canal to extend irrigation in Imperial Valley. The specific objection advanced by the Interior Department to granting the Girand license is that Girand's project, if built before the Interior Department Boulder (or Black) Canyon Project, may absorb the power market to the detriment of the latter project.

Boulder (or Black) Canyon Project - Interior Department.

The Interior Department project is described in a recent publication by the Reclamation Service, entitled "Problems of the Imperial Valley and Vicinity," Senate Doc. 142, 67th Congress, 2nd Session. Since its report was published it is understood that the Reclamation Service has changed the location of the proposed dam from Boulder Canyon to Black Canyon and that it is contemplating building the dam to a reduced height as a first step, with provision for raising it later to the full height.

Two projects are discussed in the original report; one providing complete regulation of the flow of the river and one nearly complete regulation. The former contemplates a dam with crest 600 feet above present low-water level, a storage capacity of 31,400,000 acre-feet, and a power development of 700,000 primary horsepower.

The latter contemplates a dam with crest 550 feet above present low-water level, a storage capacity of 26,500,000 acre-feet, and a power development of 600,000 primary horsepower.

It is proposed to operate the storage so as to limit the maximum flow in the Colorado River below the dam to 50,000 c.f.s. for flood protection of the lower basin. This is the primary purpose of the project. It will increase the flow available for irrigation in the low-water season and will develop a large amount of power. The project is to be built and operated at the expense of the United States, but reimbursement is looked for from the lease or sale of the power. None of the expense of the storage reservoir is to be borne by the irrigation interests for whose benefit the project is designed. "Problems of the Imperial Valley and Vicinity" contains a great deal of valuable data but does not discuss either the flood problem of the lower basin, the best scheme of developing power on the river, or the prospects of marketing power, except in very general terms.

From the power point of view there are two outstanding objections to the project.

1st. It contemplates large expenditures to provide complete regulation of flow of the river at the bottom of the canyon section where no other power development can benefit from it.

2nd. Operation of a power plant under the variation of head proposed is difficult and not efficient. Building such a plant in steps means that the water wheels installed for the first step must be scrapped when the dam is raised or must be operated with loss of efficiency.

The Federal Water Power Act charges the Commission with satisfying itself that projects licensed are in accordance with the scheme of development best adapted to conserve and utilize in the public interest the navigation and water resources of the region. An investigation has therefore been made as to what is the best scheme of development of the lower Colorado considering all uses of the water.

Description of Colorado River.

The Colorado rises in the State of Colorado a few miles west of Denver and flows generally southwest across Colorado and into Utah where it is joined successively by the Green and the San Juan, its principal tributaries. It continues in the same general direction across the northwest corner of Arizona to the Nevada line, from which point it forms the boundary of Arizona, Nevada, and California down to the Mexican boundary. It crosses the Mexican boundary and finally discharges into the Gulf of California.

The Green River rises in Wyoming and flows generally south to its junction with the Colorado.

The San Juan rises in New Mexico and flows slightly north of west into the Colorado.

On account of its characteristics the Colorado naturally divides into three sections:

1. The upper basin, the section above the junction of the Green and including the drainage area of the Green. The upper basin contains considerable areas that may be irrigated, it has a number of good power sites and several reservoir sites of large capacity. It may be developed for both irrigation and power.

2. The middle, or canyon section, from the junction of the Green to the lower end of Black Canyon.

The river in this section lies at the bottom of a deep and narrow canyon; it offers excellent power possibilities and no opportunities for irrigation diversion. In this section there are two reservoir sites with large storage capacity; one at the upper end of the section at Glenn Canyon or Lees Ferry, and the other at the lower end of the section from Black Canyon to above Boulder Canyon.

3. The lower basin, the section below Black Canyon. The lower basin is important principally for its irrigation possibilities and is the only section that is as yet developed to any considerable extent.

The flow of the Colorado River at Yuma, Ariz., varies from about 3,000 c.f.s. to 200,000 c.f.s.

The most urgent demands for immediate improvement of the Colorado in order of their importance are:

1. Protection of the irrigation developments in the lower basin from flood damage.

2. Supply of power for the copper mines in Arizona.

3. Increase of low-water flow for irrigation needs in the lower basin.

Flood Protection for Lower Colorado Basin Irrigation Projects.

Ever since their development the irrigation projects in the lower Colorado River Basin have been seriously menaced by floods in the Colorado and Gila rivers, and amelioration of this condition is the most pressing need for construction on the river at this time. The river in this section carries great quantities of silt and has built up its bed above the adjoining country. It is prevented from entering the irrigated areas by levees, built and maintained, at large expense, by the irrigation projects. The floods from the Gila are due to winter rains, while those in the Colorado are due to melting snows in the summer when the Gila is practically dry. The Gila floods have reached a flow as high as 240,000 c.f.s., which is probably above the maximum reached by the Colorado. The Gila floods are of short duration, however, while the Colorado floods last about three months. The Gila floods are as apt to overtop the levees as the Colorado floods; but the cost of maintaining a flood channel for them is very much less, and the damage in case of a break is also very much less. So long as the Gila remains uncontrolled the levees will have to be maintained to their present dimensions. The Colorado River floods, aside from the threat of tremendous damage in case of breaking into the irrigated areas, cause very heavy yearly expenditures for the maintenance of the levee system. During the period of high water, with varying flow, the Colorado shifts its channel between the levees, and each shift is apt to produce attacks upon the levees at several new points. If the channel could be stabilized between the levees the maintenance cost would be much reduced. The stability of the channel is much more affected by the great range of seasonal variations in the flow than it is by the size of the maximum flow. If the flow were uniform, the channel would adjust itself to a velocity that would not move much material, and the cost of maintenance would be small. The instability of the present channel is undoubtedly considerably aggravated by the diversions for irrigation during the low-water period and by the practice of taking from the water diverted all the sediment possible and returning it to the river channel to be handled by the reduced flow. The ideal condition, so far as flood protection is concerned, would be to regulate the flow so that it could always be uniform below the irrigation diversions. On account of cost and interference with other uses of the water such an ideal will never be realized

but the nearer it is approached the less will be the cost of protecting the lower basin. The problem is so complicated that it will not be possible to determine the exact limit of flood flow that will guarantee relief from flood danger. The Reclamation Service has concluded that if the flood flow be limited to a maximum of 50,000 c.f.s. sufficient relief will be afforded. The lower the maximum flow, the nearer the annual flow will be equated and the greater will be the flood benefit; but no outstanding reason is given for adopting 50,000 c.f.s. as a maximum, and in view of the fact that the channel will have to carry from time to time as much as 250,000 c.f.s. so long as the Gila remains uncontrolled, it is believed that an initial reduction of the maximum flood flow of the Colorado to 75,000 c.f.s. and a building up of the minimum flow to 10,000 c.f.s. can be considered as giving material relief for a first step, if additional relief can be looked forward to in the not too distant future as other projects on the river provide more storage.

The records of flow in the Colorado are not entirely satisfactory. The most complete are those of the Yuma gaging station. Doubt has been cast upon these records due to the wide variations that occur in the area of cross section of the river channel at the gaging stations. The Yuma records extend over a period of more than 20 years. Discharge measurements, accompanied by careful soundings to determine the cross section of the channel, are taken at all stages at least three times a week. It is believed that, in spite of the unfavorable conditions, the Yuma records are reasonably accurate and safe to use for flood studies, especially as the probable net error seems to be on the side of safety. In any case they are the best available.

The flow at Black Canyon during floods exceeds that at Yuma due to losses between the two, from irrigation diversions, from evaporation, and from the reservoir capacity of the river channel between the two points. The Reclamation Service estimates that the flood flow at Black Canyon may exceed that at Yuma by 1,500 c.f.s., and this figure seems reasonable when applied to the flood season. Exhibit No. 3 has been compiled, from the Yuma records by adding to them 1,500 c.f.s., to show the amount of storage required at Black Canyon to reduce the maximum flow to 50,000 c.f.s. and 75,000 c.f.s., respectively. The table includes all years of high flow over the 22 years' period, 1899 to 1920, inclusive.

This Exhibit shows that 4,000,000 acre-feet storage would have kept the flow below 50,000 c.f.s. in all but 5 years out of the 22 and that in those 5 years it would have kept the flow below 75,000 c.f.s. with considerable margin of safety. It further shows that 6,000,000 acre-feet storage would have kept the flow below 50,000 c.f.s. in all years.

It is probable that there will be an occasional flood that will exceed any in the period of record. A study has been made to determine what the probabilities of such a flood are. The figures are based upon the assumption of coincidence of the maximum recorded from all tributaries.

The results indicate that a flood exceeding the maximums recorded by 25 per cent may occur once in 100 years. With 4,000,000 acre-feet storage available, such a flood probably would not have raised the maximum flow above 75,000 c.f.s.

The floods on the Colorado River can be predicted and controlled to a degree that is not possible on any other large river of the country.

The total runoff of the floods can be roughly estimated from Weather Bureau records of the snow precipitation on the drainage area during the previous winter. The water practically all comes from the higher parts of the drainage area and flows many miles through a perfectly arid region before reaching the lower basin. Information on the progress of the runoff can be had several days in advance from gaging stations above. In view of the above, it is believed that if 4,000,000 acre-feet storage is provided for flood control 3,000,000 acre-feet of it can safely be held full at the end of the flood season to build up the low-water flow and if 6,000,000 acre-feet storage were provided 5,000,000 acre-feet could be similarly used.

Irrigation Requirement.

On page 40 of the "Problems of the Imperial Valley and Vicinity" will be found tables giving the amount of storage required to supply the demand of the "most feasible acreage" in the lower basin when the "most feasible acreage" in the upper basin is irrigated. These tables are reproduced herewith for convenience as Exhibit No. 4. On this basis the maximum storage required for irrigation for the 22 years, 1899 to 1920, inclusive, would have been 2,340,000 acre-feet and in all but 6 years out of 22 the storage required would have been less than 1,000,000 acre-feet.

If 4,000,000 acre-feet or more be provided for flood protection, sufficient of it can safely be used to meet all irrigation demands for the next 15 years.

Storage Reservoirs.

On page 42 of "Problems of the Imperial Valley" is a list of reservoirs in the upper section of the river. Some of these reservoirs will certainly be developed in the future and will do their share toward equating the flow of the river. They should be considered in any scheme of ultimate development of the river but are at present so far from a power market that they can not well be considered for an initial development which is to be paid for by the lease or sale of power.

As stated above, there are two possible reservoir sites below the junction of the Green with the Colorado; one at Glenn Canyon, and one at Black (or Boulder) Canyon. Topographic surveys of both areas have been made, and Exhibit No. 5 shows capacity and area curves of both. The Black Canyon site has several advantages over the Glenn Canyon site for an initial development.

It has slightly greater capacity for a reasonable height of dam, it is more accessible, it is more centrally located with respect to a probable power market, and being nearer to the lower basin will give somewhat better control for flood protection and irrigation. It has the disadvantage however of being at the bottom of the power section of the river and for that reason should be developed to no greater extent than necessary to furnish a reasonable amount of flood protection and an amount of power that can be marketed without excessive carrying charges.

A dam at the upper end of Black Canyon, with crest 310 feet above present low-water level and a drawdown of 110 feet, will give 4,000,000 acre-feet of storage for flood protection, 3,000,000 acre-feet of storage for improving the low-water flow, and will develop about 225,000 kw. of primary power at 75 per cent load factor.

The investigation of foundations at this site is not complete, but borings taken by the Reclamation Service indicate that suitable foundations will probably be found at less than 50 feet below the present low-water surface. No investigation of foundations has yet been made at Glenn Canyon, but the conditions strongly indicate that suitable foundations will be found at a reasonable depth. The river at Lees Ferry just below Glenn Canyon undergoes an abrupt change of slope. This change of slope is evidently caused by a stratum of hard limestone which has offered much more resistance to erosion than the red sandstone which both underlies and overlies it. There is apparently a suitable dam site about two miles above Lees Ferry, and it seems unlikely that the river channel at this point has eroded much deeper than at Lees Ferry.

Evaporation and Silting.

If 4,000,000 acre-feet of storage is provided, the supply of water will be sufficient so that losses from evaporation will not have to be considered for 15 or 20 years, and by that time additional storage will probably be available.

Silting of reservoirs on the Colorado will undoubtedly have to be given serious consideration. The Reclamation Service estimates the silt discharge of the river at Boulder Canyon as 88,000 acre-feet per annum. The silt will deposit at the upper end of the reservoir and will begin to encroach on the available storage capacity as soon as the reservoir is put into operation. There will be only one solution for the silt problem for many, many years to come and that is to increase the storage capacity to compensate for the silting. Experience with the first reservoir built will give positive data as to rate of encroachment and will serve as a basis for determining when additional storage should be undertaken.

Power Market for Colorado River Projects.

A market for power from the lower Colorado River must be sought in Arizona, Nevada, and California. A study has therefore been made of the power conditions in these States.

Exhibit No. 6 gives the figures compiled by the Census Bureau, showing power used in electric industries and power used in manufactories in each of these States.

Exhibit No. 7 is a summary of the data collected by the United States Geological Survey, giving the amount of electric power consumed in the three States. Consideration of these tables indicates that California is by far the largest user of electric power and that Nevada uses so little power, and that little is distributed over such great distances, that no general market for Colorado River power can be looked for from Nevada. Perhaps a mining and pumping load of as much as 5,000 kw. may be found in Nevada, but this is so small a part of the load for a development of the size necessary on the lower Colorado and is so uncertain that it can not be given much weight.

Exhibit No. 8, compiled from the records of the California State Railroad Commission, gives the total output of all California public utilities, including Los Angeles and other municipal plants for the years 1911 to 1921, inclusive. It shows the annual increase in the use of power and the percentage of the power that was generated by steam. These figures cover a longer period and are considered more reliable than others available and will be used as a basis for this study.

Exhibit No. 9 shows the increase in population for the State of California from the years 1850 to 1920. It also shows the installed capacity of all hydro plants in California on September 1, 1921, as compiled by Mr. F. H. Fowler, District Engineer of the Forest Service.

Exhibit No. 10 shows the new power developments that are under construction or proposed for the State of California. In this table only projects which are feasible of development are included, and the dates when they may go into operation have been retarded, in many cases as much as 15 years beyond the dates proposed by the parties interested in the development, in order to make them conform more closely to the probable demand. It is believed that these developments will eventually be carried out, either by the present proponents or by other parties. There may be a few feasible developments in California which have not been included in this list, but the list is fairly complete. California has suffered the past 5 years from a shortage or a threatened shortage of power, with the result that at present power development is greatly stimulated; and it is not unlikely that the market will be over-developed before this stimulation dies out. There is much wild talk about the capacity of California to absorb power which should be properly discounted by those considering investment in new development.

Exhibit No. 11 shows what is believed to be a fair estimate of the probable growth of load in California up to 1945. This estimate is based on a consideration of the past total growth of use of electric power, the growth of use of power for manufacturing, and the growth of population. The last column of this table shows the capacity that will be installed, if the program shown on Exhibit 10 is carried out.

Exhibit No. 11 assumes that 90 per cent of the average load will be carried by hydro, whereas in the past not much over 80 per cent has ever been carried. It also assumes that the installed hydro capacity will operate at a capacity load factor of 50 per cent. In the year 1921 the hydro plants in California operated at a capacity load factor over 51 per cent, and it is probable that this load factor will be considerably improved, as many of the new projects include storage capacity which will convert much of the present secondary power into primary power. Both of the above assumptions tend to make the probable growth of load as given in the table higher than it will actually be. A comparison of the last two columns of Exhibit 6 shows that the installed capacity will just about meet the probable load up to include 1927, but that thereafter it will materially exceed the probable market demand up to include 1945.

Exhibit No. 12 is similar to No. 11 except that it represents what may be stated as the greatest possible growth of load in California for the period 1921 to 1945. An inspection of the last two columns of this exhibit indicates that the market demand may catch up to the installed capacity about 1940.

There will be differences of opinion as to the future rate of growth of power consumption in California; but it is safe to conclude that there are developments feasible in California which will supply the California market, whatever its growth, until 1940, and probably longer, and that no market for Colorado River power can be found in California before that date, unless arrangements can be made with the distributing companies to take it instead of developing some of their own projects.

Exhibit No. 13 gives a list of all the projects in California which might be replaced by Colorado power. On account of the great transmission distance, power from the Colorado River will cost as much or more to deliver in California as power from the California projects. Consequently Colorado River power can not expect to enter California through competition and will be dependent upon ability to make agreements with the California companies to postpone their California developments.

Exhibit No. 14 gives a statement of the probable growth of power market in the State of Arizona from 1926 to 1945, inclusive. The last column gives the probable load that will be available for Colorado River projects.

Exhibit No. 15 is a combination of exhibits 13 and 14 and shows the possible load that may be obtained for Colorado River projects in Arizona and California, for the years 1926 to 1945, inclusive. As stated before, the possibilities of obtaining a market in California prior to 1940 will be dependent upon agreements with the California distributing companies.

The only other markets that have been suggested to use Colorado River power are electrification of railroads, new electrochemical or electrometallurgical industries, and pumping for irrigation. Electrification of the railroads entails a capital investment of at least $25,000 per mile of road. None of the railroads in the vicinity of Colorado River is likely to be in a position to undertake such an investment for several years to come. Moreover, if all the railroads within reach of power from the lower Colorado were electrified, they would not use more than 40,000 h.p. The cost of Colorado River power will not be sufficiently low to overcome the high cost of transportation to such an inaccessible region, and there is little prospect of electrochemical industries locating there. The only electrometallurgical industries in sight at present are the copper mines, power for which is included in the prospective load for Arizona. Power for irrigation pumping, except as it may be obtained from plants built in conjunction with the irrigation developments themselves, is included in the probably available load, per Exhibit No. 15. It is concluded that none of these uses of power offers sufficient promise to justify investment at the present time.

Exhibit No. 16 is an estimate of the gross income that may be expected from the sale of Colorado River power for the years 1926 to 1940, inclusive.

There are three sites on the river which must be considered in arriving at the best scheme of development: Black Canyon, Diamond Creek, and Glenn Canyon. There may be others; but nobody is seriously considering spending money on them at present, and so far as information is available the three above mentioned are the most favorable for initial development.

Exhibit No. 17 is a study of four different schemes:

Scheme 1. A dam 310 feet high at Black Canyon which will give 4,000,000 acre-feet storage for flood control, limit the maximum flow to less than 75,000 c.f.s., build up the 90 per cent of the time flow to 10,000 c.f.s., and furnish 225,000 kw. primary power.

Scheme 2. The same dam at Black Canyon with Girand's Diamond Creek project as planned by him with a 250-foot dam. This combination will give practically the same flood protection and low-water flow but will increase the power available to 412,500 kw. primary power.

Scheme 3. The same as Scheme 2 with addition of a 400-foot dam at Glenn Canyon, which will add 8,000,000 acre-feet storage. This will reduce maximum flow to between 40,000 and 50,000 c.f.s. and raise the 90 per cent of the time flow to 15,500 c.f.s. and make possible the development of 787,000 kw. primary power.

Scheme 4. Black Canyon Dam, as per first plan but designed to be raised later to 550 feet height. This will ultimately give 26,500,000 acre-feet of storage and practically equate the flow below, and will make possible the development of 675,000 kw. primary power after taking care of maximum irrigation demands.

In preparing Exhibit No. 17, the gross income that might be earned was taken from Exhibit No. 16. Costs of construction were estimated by Messrs. Bebb and Oakes. For water wheels, electrical machinery, transmission equipment, etc., etc., unit costs were obtained from manufacturers and operating companies. For dams and hydraulic control equipment, the unit costs adopted by the Reclamation Service were used to facilitate comparison. For the Glenn Canyon dam 30 per cent was added to cost of a similar dam at Black Canyon to cover extra cost due to inaccessibility.

Exhibit No. 18 shows the schedule of installation of equipment for each scheme, used to determine the amount and cost of construction each year. Interest during construction was assumed as 6 per cent per annum and is included in cost of construction and cost per kw. installed as given in Exhibit No. 17.

The Depreciation Reserve was computed on the following assumption of the life of equipment:

Dams	100 years
Penstocks	50 "
Buildings	50 "
Transformers	50 "
Transmission lines	50 "
Rotating Apparatus	33 1/3 years.

Taxes were assumed at the rate of 15 mills per $1.00 of the investment (not including interest during construction) at the beginning of each year.

In the computation of the table of earnings and surplus, it was assumed that the projects were to be financed by an issue of 70 per cent of the investment in 6 per cent bonds and the remainder in stock. The amounts in the table are the accumulated net earnings and surplus, including the year under which the amount is entered. Net earnings have been taken as the amount remaining after 6 per cent interest on the bonds, as represented by 70 per cent of the investment on January 1 of any given year, and operating expenses have been paid and the depreciation reserve for the year set up.

Interest at 6 per cent on the depreciation reserve has been included in earnings and surplus each year as well as the interest at 6 per cent on the sum remaining in surplus, if any, after 6 per cent dividends on the stock and $1,000,000 working capital had been deducted.

Exhibit No. 19 shows the estimated cost of the dams, power houses, and transmission lines without interest during construction.

Conclusions.

A study and analysis of the data hereinbefore set forth lead to the following conclusions:

1. The best way to obtain early benefits in flood protection is to construct a dam at Black Canyon to give at least 4,000,000 acre-feet storage and not more than 6,000,000 acre-feet storage. Such a dam will produce about 20 per cent more power than Girand's Diamond Creek project, at a price per kw. slightly less, provided foundations are found as expected. It will also fit into the best scheme of development, and there are several advantages to be gained by constructing it before any other project on the river.

2. The Diamond Creek development of Girand will give no flood protection but will fit into the best scheme of development and will not seriously interfere with any other development on the river, either physically or financially.

3. Schemes 3 and 4 carry the development as far as it is useful to go at present, as they will both meet all needs for lower river development for the next 20 to 30 years.

4. A careful comparison of schemes 3 and 4 shows that scheme 3 is somewhat more favorable in both cost and amount of power developed. It has a great advantage in flexibility, it can be speeded up or retarded to meet the demands of the market, and the carrying charges will probably be much less than for scheme 4. The advantages of scheme 3 over 4 will be very great when more than 675,000 kw. of power is needed from the Colorado, due to having the regulation of flow at the head of the power section of the river. Scheme 3 gives about the same flood protection as 4 and will furnish sufficient water to meet all irrigation demands for the next 20 years. It does not provide hold-over storage, but hold-over storage will not be needed for many years and when needed can be obtained by raising the Glenn Canyon dam. Scheme 4 presents disadvantages from the power point of view, due to the operating difficulties and loss of efficiency caused by the wide variation in head and to the fact that to keep down the cost it is proposed to locate the dam in the narrowest part of the canyon where a suitable place for the power house is almost impossible to find.

5. It is believed that scheme 3 can safely be used as a guide for the development of the lower river. Briefly stated, it consists of the following structures,-

1. A power and storage dam 310 to 360 feet high at Black Canyon.

2. A power dam about 250 feet high at Diamond Creek.

3. A storage dam about 400 feet high at Glenn Canyon. This dam can later be raised as additional storage is needed and when the final height has been reached power can be installed.

If bed rock for foundations at Black Canyon, instead of being 40 to 50 feet below water as expected, is found to be over 100 feet below water, as it is at Boulder Canyon, it may prove economical to change the order or procedure and build Diamond Creek and Glenn Canyon first, so as to have the benefit of the regulated flow from Glenn Canyon during the construction of the deep and difficult foundations at Black Canyon.

6. Regardless of the merits of the Swing Bill, it must be recognized that it raises questions that kept The Federal Water Power Act under discussion in Congress for 12 years, and it has already stirred up sufficient opposition to make its early passage improbable. The Federal Water Power Act with the applications made under it offers a means of immediate action, without the expenditure of any money by the United States. Under it the United States can retain full control of the storage for flood protection, irrigation, and any other necessary activity. The international character of the river is mentioned as a reason for the United States building and operating all projects on the river. There may be international difficulties over diversions in the lower basin, but there is less chance for difficulties over the power developments than there is on the Niagara and St. Lawrence rivers.

7. There seems to be no sufficient reason to justify further delay in granting Girand's license for Diamond Creek, unless the Commission considers the need for immediate flood relief so great that it will be justified in requiring Girand to change his project to Black Canyon instead of Diamond Creek.

8. Operating power projects on the Colorado with the great transmission distances will be unusually difficult and hazardous. It is not a business the Federal Government will find attractive to enter. If the Government is going to invest in the Colorado River for flood protection or irrigation, it would seem advisable for it to undertake the construction of the Glenn Canyon storage dam and obtain reimbursement under the headwater improvement clause of the Federal Water Power Act.

9. The conclusions in this report are believed to be sound, impartial, and conservative; but they are at variance in some respects with those of the Reclamation Service; and if the Commission is not ready to adopt them, it is recommended a Board similar to that on the Columbia be appointed to develop the best scheme of development.

Col. W. Kelly,
Chief Engineer.
Federal Power Commission.

Flood Control of Colorado River (exclusive of Gila)

All years of large runoff 1899 - 1920 incl. - Flow at Black Canyon taken as 1500 c.f.s. greater than Yuma.

Year	Period flow exceeded 50,000 c.f.s.	No. Days	Period flow exceeded 75,000 c.f.s	No. Days	Total discharge per period in which flow exceeded		Storage required to reduce flow to	
					50,000 c.f.s	75,000 c.f.s	50,000 c.f.s.	75,000 c.f.s.
1907	May 27 - Aug. 10	76	June 2 - July 24	53	13,433,000	10,504,000	5,836,000	2,554,000
1909	May 15 - July 21	67	June 2 - July 16	45	12,564,000	9,593,000	5,864,000	2,743,000
1912	May 24 - July 14	52	May 31 - June 26	27	8,981,000	6,108,000	3,781,000	2,058,000
1914	May 18 - July 13	57	May 24 - July 4	42	10,237,000	8,430,000	4,537,000	2,130,000
1917	May 25 - July 24	61	May 30 - July 19	51	11,775,000	10,524,000	5,675,000	2,874,000
1920	May 17 - July 12	57	May 29 - June 30	31	11,413,000	8,018,000	5,713,000	3,368,000

4,000,000 acre-feet storage would have kept flow down to 65,000 c.f.s. in worst year, 1920.

Exhibit 3

PLAN 1. MINIMUM STORAGE DEVELOPMENT.

		Acres.
Upper basin—additional acreage		1,008,000
Lower basin:[1]		
Present acreage	698,000	
Additional acreage	710,000	
		1,408,000
Total		2,416,000

TABLE NO. 13.—*Estimated demand for most feasible acreage.*

[Acre-feet. Based on 5 feet duty for lower basin because of no necessity for economy.]

	Lower basin, 1,408,000 acres.	Upper basin, 1,008,000 acres total.[2]	Total.		Lower basin, 1,408,000 acres.	Upper basin, 1,008,000 acres total.[2]	Total.
January	260,000	.....	260,000	August	800,000	160,000	960,000
February	200,000	.....	200,000	September	730,000	160,000	890,000
March	610,000	.....	610,000	October	450,000	80,000	530,000
April	670,000	80,000	750,000	November	380,000	.....	380,000
May	680,000	380,000	1,060,000	December	110,000	.....	110,000
June	870,000	400,000	1,270,000				
July	870,000	320,000	1,190,000	Total	6,630,000	1,580,000	8,210,000

TABLE NO. 14.—*Storage required for most feasible acreage neglecting evaporation from reservoir.*

	Acre-feet.		Acre-feet.
1899	460,000	1910	410,000
1900	1,660,000	1911	380,000
1901	1,410,000	1912	330,000
1902	2,340,000	1913	810,000
1903	1,010,000	1914	320,000
1904	440,000	1915	1,000,000
1905	980,000	1916	200,000
1906	250,000	1917	370,000
1907	.....	1918	770,000
1908	290,000	1919	1,030,000
1909	.....	1920	460,000

[1] Consists of those items shown as "feasible now" in Table 3, p. 32.
[2] Assumed that withdrawals for storage balance return flow out of irrigation season.

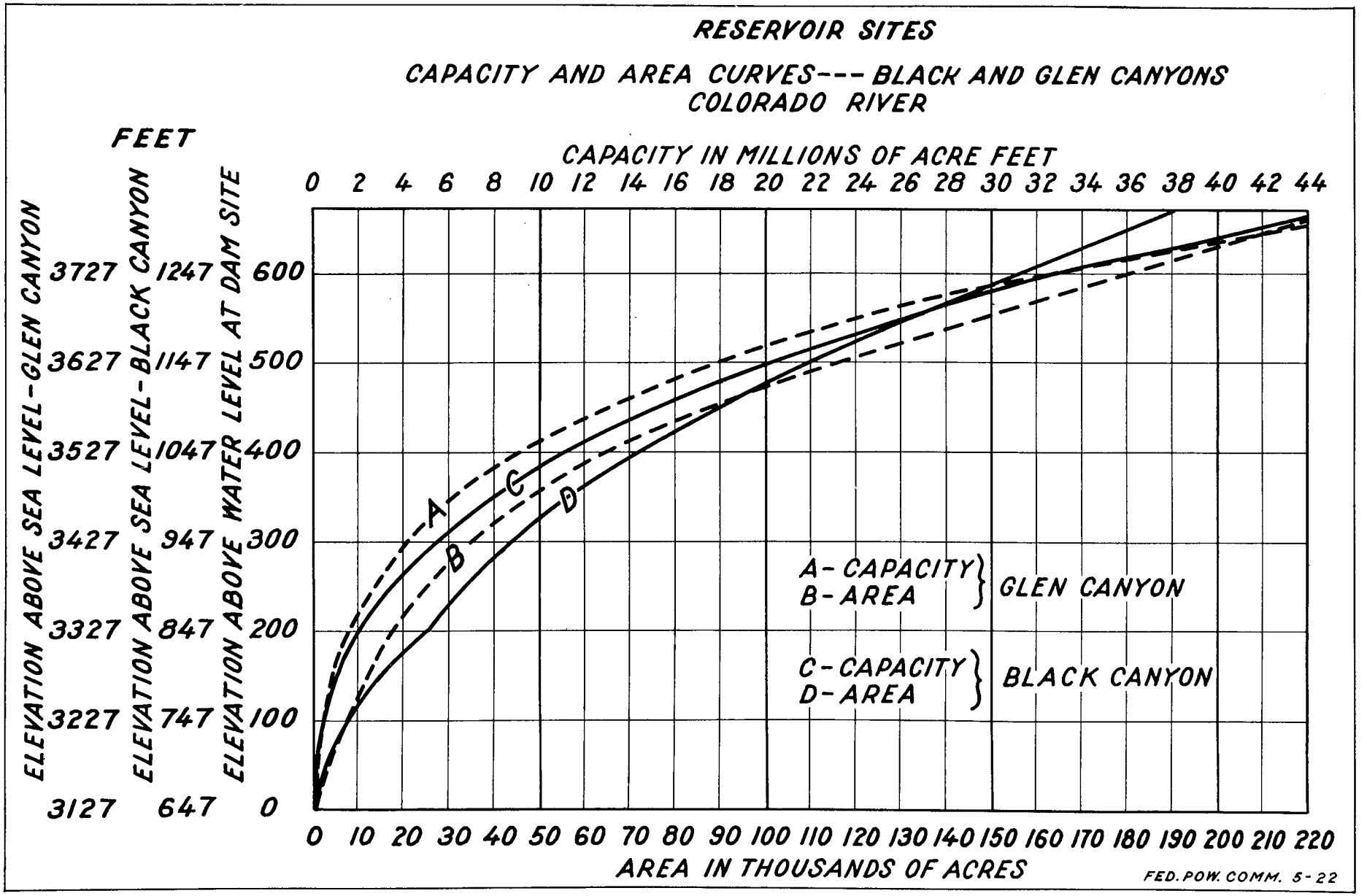
RESERVOIR SITES
CAPACITY AND AREA CURVES--- BLACK AND GLEN CANYONS
COLORADO RIVER
FEET
CAPACITY IN MILLIONS OF ACRE FEET
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44
ELEVATION ABOVE SEA LEVEL-GLEN CANYON
ELEVATION ABOVE SEA LEVEL-BLACK CANYON
ELEVATION ABOVE WATER LEVEL AT DAM SITE
3727 1247 600
3627 1147 500
3527 1047 400
3427 947 300
3327 847 200
3227 747 100
3127 647 0
A
B
C
D
A- CAPACITY
B- AREA
GLEN CANYON
C- CAPACITY
D- AREA
BLACK CANYON
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
AREA IN THOUSANDS OF ACRES
FED. POW. COMM. 5-22

Exhibit 5

CENSUS STATEMENT OF POWER USED IN ELECTRIC INDUSTRIES.						CENSUS STATEMENT OF POWER USED IN MANUFACTURES.	
ARIZONA.							
YEAR		PRIMARY POWER.		OUTPUT.		YEAR	PRIMARY
	NO. OF STATIONS.	STEAM & OIL H. P.	HYDRO. H.P.	THOUSANDS KW. HRS.	AVERAGE KW. YR.		H. P.
1907	15	6,976	750	9,392	1,070	1899	8,537
1912	16	12,775	9,300	32,960	3,760	1904	21,412
1917	29	27,462	11,200	65,732	7,500	1909	39,140
						1914	54,697
NEVADA.							
1907	9	720	6,260	29,622	3,380	1899	1,561
1912	8	2,880	12,540	44,970	5,130	1904	2,834
1917	14	1,717	15,115	53,846	6,140	1909	7,765
						1914	18,748
CALIFORNIA.							
1907	129	176,229	208,444	661,606	75,500	1899	126,953
1912	112	416,186	432,062	1,747,459	199,500	1904	210,359
1917	98	454,992	738,977	2,746,567	313,500	1909	329,100
						1914	491,025

Exhibit 6

ELECTRIC POWER CONSUMED PER REPORT OF UNITED STATES GEOLOGICAL SURVEY.

ARIZONA.

YEAR	THOUSANDS OF KW. HOURS BY HYDROS.	THOUSANDS OF KW. HOURS BY STEAM.	TOTAL THOUSANDS OF KW. HOURS.	AVERAGE KW. HOURS.
1919	85,842	136,530	222,372	25,400
1920	106,527	52,701	159,228	18,200
1921	93,115	41,436	134,551	15,400

Installed capacity of hydros in Arizona in 1921 was about 38,760 K.W.

NEVADA.

1919	32,492	5,222	37,714	4,300
1920	32,690	859	33,549	3,800
1921	36,089	361	36,450	4,100

CALIFORNIA.

1919	2,302,766	942,054	3,244,814	370,400
1920	2,568,541	1,152,152	3,720,693	424,700
1921	3,223,432	755,697	3,979,129	454,200

Exhibit 7

STATE OF CALIFORNIA

KW. HRS. OUTPUT - HYDRO AND STEAM 1911 - 1921, INCLUSIVE

RAILROAD COMMISSION RECORDS OF ALL PUBLIC UTILITIES INCLUDING LOS ANGELES AND OTHER MUNICIPAL PLANTS

Year	Millions of Kw. Hrs.	Average Kw. Yr.	Annual Increase Kw. Yr.	Percent Steam
1911	1,402.0	160,250	..	23.8
1912	1,598.0	182,400	22,150	28.5
1913	1,979.1	225,000	42,600	36.2
1914	2,102.3	239,800	14,800	18.9
1915	2,211.3	252,400	12,600	17.8
1916	2,349.3	267,400	15,000	15.2
1917	2,638.0	301,100	33,700	18.8
1918	2,965.0	338,500	37,400	24.0
1919	3,234.9	369,200	30,700	30.7
1920	3,617.6	412,800	43,600	31.0
1921	3,908.9	446,100	33,300	18.0

The average yearly increase for the 11 years has been 26,000 kw. per year
" " " " " " last 5 years has been 35,700 kw. per year
Over the 11 years demand has been compounding at rate of 10.9 percent.

Exhibit 8

STATE OF CALIFORNIA
(Population Census)

Year	Population
1850	92,597
1860	379,994
1870	560,247
1880	864,694
1890	1,213,398
1900	1,485,053
1910	2,377,549
1920	3,426,861

INSTALLED CAPACITY HYDRO PLANTS IN CALIFORNIA SEPT. 1. 1921
(Per Fowler's Report)

a r k e t	Hydro Electric		Steam		Total	
	H. P.	K.W.	H. P.	K. W.	H. P.	K. W.
Northern California	513,185	384,888	218,164	163,623	731,349	548,511
Southern California	533,602	400,200	218,296	163,722	751,898	563,922
Total	1,046,787	785,088	436,460	327,345	1,483,247	1,112,433

In 1921 704,100,000 Kw. hrs. was generated by steam = 80,300 kw. yrs.
3,204,800,000 " " " " " hydro.= 365,800 kw.yrs.

Hydro in 1921 operated @ 51.1% load Factor

Exhibit 9

CALIFORNIA HYDRO-POWER PROJECT

INSTALLED CAPACITIES AND PROBABLE YEAR OF INSTALLATION OF ADDITIONAL CAPACITY.

COMPANIES.	STREAMS. (Project)	SEPT.1921 INSTALLED CAPACITIES KVA.	PROGRAM OF DEVELOPMENT IN KVA. 1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1935	1940	1945	ULTIMATE CAPACITY Any Project
Calif. Oregon Power Co.	Klamath River, (215)	23,760		25,000						64,000		64,000				153,000
Pacific Gas & Elec. Co.				9,000												9,000
Mt. Shasta Pwr.Corp.	Pit River, (233)	229,200		63,000		15,700			61,000	72,000	171,000					352,700
Pitt R																
Pitt River Power Co.	Pit River, (9)											52,500	52,500			105,000
Great Western Power Co.	Feather River (146)	109,000							39,000							39,000
Jorgensen, Lars.	" " (249)								21,000		43,000		65,000	40,000		169,000
G. W. Pwr. Co.	" " (291)											22,500	22,500			45,000
Forest Service Permits,						20,000				40,000		40,000				100,000
Snow Mountain W. & Pr. Co.	So. Eel River, (77)	8,500				11,000										11,000
San Joaquin L. & P. Corp.	Kings River, (102)	82,450												91,500		91,500
	" " (175)							31,000				31,000	23,000	15,500	126,000	227,500
	" " (226)														150,000	150,000
	Merced River, (260)								30,000		52,500					82,400
So. Calif. Edison Co.	Big Creek, (67)	201,350					50,000		50,000	90,000		195,000				385,000
	San Joaquin River, (105)												212,000			212,000
	" " " (120)				49,000		49,000		49,000							147,000
	Salmon and Horse Ck(85)				2,200											2,200
Western States G.& E. Co.	Trinity River, (99)	7,025				1,440										1,440
El Dorado Power Co.	American River, (184)				15,000		15,000		15,000	35,600						80,600
City of Los Angeles,	Owens River, (123)	72,460										22,500	37,500	48,000	25,000	133,000
	" " (208)							17,500			37,500					55,000
	Big Pine Creek, (193)											1,570	4,000	2,300		7,870
	Rock Creek, (194)													7,100		7,100
	Division Creek, (195)												1,580	1,120		2,700
	Cottonwood Creek, (196)											2,150	3,000	2,700		7,850
	Kings River, (98)														350,000	350,000
	Kern River, (128)											7,200			19,000	26,200
	" " (152)													65,000		65,000
Nevada Calif. Power Co.	Leavining Creek, (97)	40,100				7,500		5,600				750	3,000			16,850
So. Sierras Pr. Co.	Whitewater River, (124)							2,250		2,250	1,500					6,000
	Snow Creek, (155)				2,000	1,500										3,500
	Vivian & other Cks(185)				3,000											3,000
Seepe Light & Pr. Co.	Piru Creek, (64)					1,500	6,000	1,500	7,000	5,200	2,250					23,450
Miscellanea,																
Hawley, R.W.	Silver Creek, (32)											2,500	11,200	52,500		66,200
Seybold, A.P.	Klamath River, (62)												37,500	18,750		56,250
Van Zandt, J.G.	Bear Ck.& S. Ana R.(73)							19,500								19,500
Electro Metals Co.	Klamath River, (74)												95,000	107,000		202,000
McDonald, R.G.	Convict Creek, (75)								4,700							4,700
Merced Irr. Dist.	Merced River, (88)						30,000									30,000
Utica Mining Co.	Stanislaus River, (95)	1,500										22,500				22,500
Pattee,et al.,	" " (103)									7,900						7,900
Trent, C.M.	Carson River, (127)											36,000				36,000
Crooker & Preston,	Mokelumne River, (137)								12,000		13,500	27,700				53,200
Yuba Development Co.	Yuba River, (187)											22,500	15,000	22,500		60,000
Provident Irr.Co.	Deer Creek, (189)											14,000				14,000
Yosemite Power Co.	Tuolumne River, (210)									16,000						16,000
Fletcher, Ed.	Boulder Creek, (217)											980				980
Excelsior Wt. & M. Co.	Yuba River, (237)									6,000	9,750	45,000	14,250	15,000		90,000
Loose, C.E.	Walker River, (139)										5,500					5,500
Samson, W.H.	Trinity River, (247)									7,500		11,250				18,750
Hughes, J.H.	Feather River, (251)							3,000								3,000
Thebo,Starr & Anderton,	McCloud River, (300)											48,000	48,000	76,500		172,500
" " "	American River, (307)										22,500					22,500
City of San Francisco,	Moccasin Creek,				75,000						112,500					225,000
Turlock,Modesto Irr.Dis.	Don Pedro Dam,			30,000		22,500		37,500								52,500
TOTAL	NOTE: This table includes only projects that are feasible and likely to be installed. In many cases the possible date of installation has been setforward (in some cases as much as 15 years) to a more distant future than projected by the applicants.			127,000	146,200	81,140	150,000	117,850	288,700	348,450	471,500	669,630	645,030	566,470	670,000	4,281,970
ACCUMULATIVE TOTAL					273,200	354,340	504,340	622,190	910,890	1,259,340	1,730,840	2,400,470	3,045,500	3,611,970	4,281,970	

Exhibit 10

STATE OF CALIFORNIA

Probable Growth of Load. 1921 to 1945 Inc.
10.9% till 1925, 9% till 1930, 7.5% till 1935, 6% till 1940 & 4% till 1945.

YEAR	PROBABLE AVERAGE LOAD.KW. YR.	ASSUME 90% OF AV.LOAD CARRIED BY HYDRO KW YR.	ASSUME 50% L.F. INSTALLED HYDRO CAPACITY REQUIRED WILL BE K. W.	INSTALLED CAPACITY EXISTING AND PROPOSED K.W.
1921	446,100.	401,490.	802,900.	785,088
1922	494,700.	445,200.	890,400.	912,000
1923	548,600.	493,700.	987,400.	1,058,200
1924	608,400.	547,600.	1,097,200.	1,139,300
1925	674,700.	607,200.	1,214,400.	1,289,000
1926	735,400.	661,900.	1,325,000.	1,307,000
1927	801,600.	721,400.	1,443,000.	1,695,000
1928	873,700.	786,300.	1,573,000.	2,044,000
1929	952,300.	857,100.	1,714,000.	2,516,000
1930	1,038,000.	934,200.	1,868,000.	3,185,000
1935	1,499,000.	1,349,100.	2,698,000.	3,830,000
1940	1,995,000.	1,795,500.	3,591,000.	4,396,000
1945	2,427,000.	2,184,300.	4,369,000.	5,067,000

Electric power consumption has increased at rate of 10.9% from 1911 to 1921 inc. Power used in manufacturing per Census Report increased at rate of 11% from 1899 to 1909, and at rate of 8.3% for five years 1909 to 1914.

Population of California per Census Report increased at rate of 4.8% from 1900 to 1910 and at rate of 4.0% from 1910 to 1920.

Exhibit 11

STATE OF CALIFORNIA.

Possible Growth of Load 1921 to 1945, inc.
Assume rate of 10.9% till 1930, 8% till 1940 and 4% thereafter.

YEAR	AVERAGE LOAD KW. YR.	ASSUME 90% OF AV. LOAD CARRIED BY HYDRO. KW.	INSTALLED HYDRO CAPACITY REQUIRED @ 50% L. F.	INSTALLED CAPACITY EXISTING AND PROPOSED, K.W.
1921	446.100.	401,490.	802,900.	785,088
1922	494,700.	445,200.	890,400,	912,000
1923	548,600.	493,700.	987,400.	1,058,200
1924	608,400.	547,600.	1, 097,200.	1,139,300
1925	674,700.	607,200.	1, 214,400.	1,289,000
1926	748,200.	673,400.	1, 347,000.	1,307,000
1927	829,800.	746,800.	1, 493,000.	1,695,000
1928	919,200.	827,300.	1, 654,600.	2,044,000
1929	1,019,400.	917,500.	1, 835,000.	2,516,000
1930	1,130,500.	1,017,500.	2, 035,000.	3,185,000
1935	1,661,000.	1,494,900.	2, 989,800.	3,830,000
1940	2,440,000.	2,196,000.	4, 392,000.	4,396,000
1945	2,969,000.	2,672,100.	5, 344,000.	5,067,000

Exhibit 12

LIST OF ALL CALIFORNIA PROJECTS WHICH MAY BE REPLACED BY COLORADO POWER

Companies	Streams	Project No.	Year			
			1930	1935	1940	1945
San Joaquin Light & Power Corporation	Kings River	226				150,000
Southern California Edison Co.	Big Creek	67	195,000			
	San Joaquin	105		212,000		
City of Los Angeles	Big Pine Creek	193	1,570	4,000	2,300	
	Rock Creek	194			7,100	
	Diversion Creek	195		1,580	1,120	
	Cottonwood Creek	196		2,180	3,000	2,700
	Kings River	98				350,000
	Kern River	128	7,200			19,000
	" "	152			65,000	
			203,770	219,760	78,520	571,700

Colorado River will cost nearly as much to deliver in California as power from above projects. Consequently it cannot enter through competition. Its entry will be dependent upon agreement with the California Companies to postpone their California developments.

Exhibit 13

STATE OF ARIZONA

Probable Growth of Load 1921 to 1945, inclusive

Assume Pub. Utility load will increase at 9% until 1925, 8% until 1930, 7% until 1935, 6% until 1940 and 5% until 1945
Assume Mining Load will be 83,300 kw. at 75% L.F. and 90% Diversity Factor in 1926 and will increase at 5.2% until 1935 and 4% thereafter.

Year	Public Utility Load					Mining Load		
	Average load kw. yrs.	90% of Av. Load Hydro. kw. yrs.	Installed Hydro.cap. required @ 60% L.F.	Assume Hydro Installations other than Colo. River will increase @ 2%, installed Cap.will.be kw.	Installed capacity in Colo. River Projects kw.	Average Load kw. yrs.	Installed capacity @ 75% L.F. kw.	Probable load available for Colo. River Proj. @ about 70% L.F. kw.
1926	30,000	27,000	45,000	41,900	3,100	56,000	75,000	78,100
1927	32,400	29,200	48,700	42,800	5,900	58,900	78,500	84,400
1928	35,000	31,500	52,500	43,600	8,900	61,900	82,500	91,400
1929	37,880	34,000	56,700	44,500	12,200	65,100	86,800	99,000
1930	40,800	36,700	61,200	45,400	15,800	68,500	91,300	107,100
1935	57,200	51,500	86,000	50,200	35,800	88,200	117,600	153,400
1940	76,600	68,900	115,000	55,300	59,700	107,200	143,000	202,700
1945	97,700	87,900	146,500	61,100	85,400	130,500	174,000	259,400

Figures on probable mining load deduced from statements of mining companies filed with application of Girand, Proj. No. 121, Arizona.

Exhibit 14

Table No. 15.

Possible Load for Colorado River Power in

ARIZONA & CALIFORNIA

Year	Arizona KW 70% L.F.	California KW 60% L. F.	Combined KW	Capacity Load Factor
1926	78,100		78,100	70%
1927	84,400		84,400	70%
1928	91,400		91,400	70%
1929	99,000		99,000	70%
1930	107,100	203,770	310,870	63%
1935	153,400	423,530	576,930	62%
1940	202,700	502,050	704,750	62%
1945	259,400	1,073,750	1,333,150	61%

Exhibit 15

Exhibit No. 16

Estimate of Gross Income that may be Expected from Sale of Colorado River Power.

Year	Arizona kw yrs. that may be sold at point of delivery	Income @ $60.00 per kw yr.	California kw yrs. that can be sold at point of delivery	Income @ $55.00 per kw yr.	Total Gross Income
1926	55,000	$ 3,300,000		$	$ 3,300,000
1927	60,000	3,600,000			3,600,000
1928	64,000	3,840,000			3,840,000
1929	69,000	4,140,000			4,140,000
1930	75,000	4,500,000	18,200	1,000,000	5,500,000
1931	81,000	4,860,000	36,400	2,000,000	6,860,000
1932	88,000	5,280,000	54,600	3,000,000	8,280,000
1933	94,000	5,640,000	72,800	4,000,000	9,640,000
1934	100,000	6,000,000	91,000	5,000,000	11,000,000
1935	107,000	6,420,000	111,000	6,100,000	12,520,000
1936	114,000	6,840,000	135,000	7,400,000	14,240,000
1937	121,000	7,260,000	158,000	8,700,000	15,960,000
1938	128,000	7,680,000	182,000	10,000,000	17,680,000
1939	135,000	8,100,000	206,000	11,300,000	19,400,000
1940	142,000	8,520,000	230,000	12,700,000	21,220,000

Exhibit No. 16

Exhibit No. 17

Summary of Estimates of Cost of Construction
and Predicted Earning Capacity of
Four Hydroelectric Projects on the
Colorado River.

	Project							
	Black Canyon Project 310 ft. Dam: Includes generating station, transmission lines & substations.		Black Canyon-Diamond Creek without storage above Diamond Creek: Includes generating station, transmission lines and substations.		Black Canyon - Diamond Creek - Glen Canyon Includes generating station, transmission lines & substations.		Black Canyon - 310 ft. dam raised to 550 ft. above water level. Includes generating station, transmission lines & substations.	
	12th year of operation	Ultimate	12th year of operation	Ultimate	12th year of operation	Ultimate	12th year of operation	Ultimate
Installed power capacity k.w.	225,000	225,000	412,500	412,000	512,500	787,000	525,000	675,000
Cost of construction	$64,061,000	$64,061,000	$98,606,600	$98,606,600	$143,395,000	172,829,000	$133,395,000	150,044,000
Cost entire project per k.w.	$284.70	$284.70	$239.50	$239.50	$280.00	$219.50	$254.00	$222.00
Cost of separable parts. generating station, dam and step-up transformer.	$140.00	$140.00	$145.50	$145.50	$180.00	$130.00	$155.50	$129.00
Transmission lines and substations	$144.70	$144.70	94.00	94.00	100.00	89.50	98.50	93.00
Years till power becomes available	3		3		3		3	

Year of operation.	Depreciation Reserve Accumulated to end of Year.			
1	683,800	683,800	683,800	683,800
2	1,367,600	1,367,600	1,367,600	1,367,600
3	2,092,400	2,092,400	2,092,400	2,092,400
4	2,735,200	2,735,200	2,735,200	2,735,200
5	3,468,600	3,468,600	3,468,600	3,468,600
6	4,466,700	4,466,700	4,466,700	4,466,700
7	5,540,000	5,706,700	5,706,700	5,909,600
8	6,615,300	7,020,100	7,020,100	7,415,800
9	7,686,600	8,414,400	8,414,400	8,997,300
10	8,761,900	9,906,700	9,906,700	10,661,900
11	9,835,200	11,494,200	11,494,200	12,435,200
12	10,908,500	13,061,700	13,391,200	14,257,400

Year of operation.	Estimated Earnings and Surplus or Deficit (After Interest on Bonds and Depreciation) (Accumulated to End of Year)			
1	-640,000	-640,000	-640,000	-640,000
2	-911,000	-911,000	-911,000	-911,000
3	-977,500	-977,500	-977,500	-977,500
4	-705,700	-767,100	-767,100	-705,700
5	471,900	295,600	295,600	471,700
6	1,844,300	1,518,400	1,518,400	1,853,900
7	3,029,200	2,712,100	2,712,100	1,560,900
8	4,228,500	4,864,200	4,786,000	2,454,600
9	5,492,200	8,059,700	7,857,200	4,368,200
10	6,770,300	15,371,700	11,895,000	7,360,800
11	8,112,900	17,613,600	17,252,400	11,679,900
12	9,459,900	22,120,800	22,479,300	17,458,200

Exhibit 17

SCHEDULE OF INSTALLATION OF EQUIPMENT, SUBSTATIONS AND TRANSMISSION LINES - (EXHIBIT NUMBER 16)

YEAR	Load Factor on Substation Assumed as %	Power Factor Correction at Substations Assumed as %	SUBSTATIONS					
			Ajo	Canyon Junction	Kelvin	Safford	Inspiration	Los Angeles
1925	63	98	Transformers 220/60 kv. 25,950 kva. Spare " 220/60 kv. 8,650 Total - 34,600 kva. Synchronous Condensers 9,250 kva. 1 double-circuit 226,800 cm. A.C.S.R. Transmission line - 110 kv.	Transformers 220/150-110 kv. 25,050 kva. Spare " 220/150-110 kv. 8,350 Total - 33,400 kva. 2-single circuit, 500,000 cm. A.C.S.R. 220 kv. transmission line	Transformers 220/110 kv. 50,400 kva. Spare " 16,800 Total - 67,200 kva. Transformers 220/150 kv. 41,550 kva. Spare " 220/150 kv. 13,850 Total - 55,400 kva. Synchronous Condensers 36,000 kva. 2-single circuit, 500,000 cm. A.C.S.R. 220 kv. transmission line	Transformers 150/60 kv. 39,300 kva. Spare " 150/60 kv. 13,000 Total - 52,300 kva. 1-double circuit, 336,400 cm 150 kv transmission line	Transformers 110/60 kv. 47,300 kva. Spare " 15,900 kva. Total - 63,200 kva. 1-single circuit, 336,400 cm. A.C.S.R. - 110 kv.	No Installation
1926	63	98	No Installation	No Installation	No Installation	No Installation	No Installation	No Installation
1927	63	98	No Installation	No Installation	No Installation	No Installation	No Installation	No Installation
1928	63	98	No Installation	No Installation	No Installation	No Installation	No Installation	No Installation
1929	63	98	Transformers 220/60 kv. 3,750 kva.	Transformers 220/150-110 kv. 3,650 kva.	Transformers 220/150 kv. 6,000 kva. " 220/110 kv. 7,200 kva. Synchronous Condensers 5,000 kva.	Transformers 150/60kv. 5,700 kva.	Transformers 110/60 kv. 7,000 kva.	No Installation
1930	63	98	No Installation	No Installation	No Installation	No Installation	No Installation	Transformers 220/60 kv. 34,100 kva. Spare " 220/60 kv. 11,400 kva. Total - 45,500 kva. Synchronous Condensers 11,800 kva. 2-single circuit, 750,000 cm. A.C.S.R. transmission lines
1931	63	98	Transformers 150/110/60 kv. 5,000 kva. Synchronous Condensers 3,150 kva.	Transformer 220/150/110 kv. 5,000 kva.	Transformers 220/110 10,000 kva. " 220/150 8,250 kva. Synchronous Condensers 6,500 kva.	Transformers 150/60 kv. 7,600 kva.	Transformers 110/60 kv. 9,000 kva.	Transformers 220/60 kv. 34,100 kva. Synchronous Condensers 11,400 kva.
1932	63	98	No Installation	No Installation	No Installation	No Installation	No Installation	Transformers 220/60 kv. 34,100 kva. " formers 220/60 kv. 11,400 kva. Synchronous Condensers 11,400 kva.
1933	63	98	Synchronous Condenser 5,000 kva.	Transformers 220/150-110 kv. 5,300 kva.	Transformers 220/110 kv. 11,000 kva. " 220/150 9,100 kva.	Transformers 150/60 kv. 8,400 kva.	Transformers 110/60 kv. 10,500 kva.	Transformers 220/60 kv. 34,100 kva. Synchronous Condensers 13,200 kva.
1934	63	100	Transformers 150/110/60 kv. 8,300 kva.	No Installation	Synchronous Condensers 9,000 kva.	No Installation	1-single circuit, 336,400 cm. A.C.S.R. - 110 kv. line	Transformers 220/60 kv. 34,100 kva. Synchronous Condensers 41,300 kva.
1935	63	100	Transformers 150/60 kv. 36,000 kva. Spare " 150/60 kv. 10,000 kva. Transfer 38,350 kva. - 110/60 kv. transformers to Inspiration Substation. Raise voltage of transmission line to 150 kv.	Transformers 220/150-110 kv. 5,400 kva.	Transformers 220/110 kv. 11,000 kva. " 220/150 kv. 9,100 kva.	Transformers 150/60 kv. 8,700kva.	Transformers from Ajo Substation 38,350 kva.	Transformers 220/60 kv. 34,500 kva. Synchronous Condensers 30,000 kva.
1936	70	100	No Installation	No Installation	No Installation	No Installation	No Installation	No Installation
1937	70	100	Synchroncus Condenser 7,500 kva.	Transmission line 1-single circuit 500,000 cm. A.C.S.R. 220 kv.	Synchronous Condensers 33,500 kva	No Installation	No Installation	Transformers 45,000 kva. Synchronous Condensers 36,000 kva. 1-single circuit 750,000 cm. A.C.S.R. 220 kv. line.

Exhibit 16

Exhibit No. 18

Schedule of Installation of Equipment. Generating Stations

Year	Step-up Transformers	Station Equipment
1925	Transformers 13/220 kv. - 118,500 kva.	3 - 60-cycle, 3 phase, 13,000 AC generators, 37,500kva each at unity power factor. 112,500 kva. 3 - Hydraulic turbines 53,300 HP 160,000 HP 3 - Hydraulic valves 3 - Relief valves 3 - Penstocks
1926	No Installation	No Installation
1927	"	"
1928	"	"
1929	Transformers 13/220 kv. - 17.300 kva.	1 - 37,500 kva. Generator unit as above 1 - 53,300 HP Hydraulic trubine with valves and penstock as above.
1930	Transformers 13/220 kv. - 44,800 kva.	1 - 37,500 kva. Generator unit as above 1 - 53,300 HP Hydraulic turbine with valves and penstock as above.
1931	Transformers 13/220 kv. - 56,100 kva.	1 - 37,500 kva. Generator unit as above 1 - 53,300 HP Hydraulic turbine with valves and penstock as above.
1932	Transformers 13/220 kv. - 62,700 kva.	1 - 37,500 kva. Generator unit as above 1 - 53,300 HP Hydraulic turbine with valves and penstock as above.
1933	Transformers 13/220 kv. - 46,100 kva.	1 - 50,000 kva. Generator unit as above 1 - 66,600 HP Hydraulic turbine with penstock and valves as above.
1934	Transformers 13/220 kv. - 46,100 kva.	1 - 50,000 kva. Generator unit as above 1 - 66,000 HP Hydraulic turbine with penstock and valves as above.
1935	Transformers 13/220 kv/ - 58,400 kva.	1 - 50,000 kva. Generator unit as above 1 - 66,600 HP Hydraulic turbine with penstock and valves as above.
1936	Transformers 13/220 kv. - 36,100 kva.	1 - 50,000 kva. Generator unit as above. 1 - 66,600 HP Hydraulic turbine with penstock and valves as above.
1937	No Installation	1 - 50,000 kva. Generator unit as above 1 - 66,600 HP Hydraulic turbine with valves and penstock as above.

ESTIMATED INVESTMENT IN COMPONENT PARTS OF PROJECTS
(Not including interest during construction)

COMPONENT PART	BLACK CANYON PROJECT 310 ft. Dam		BLACK CANYON - Diamond Creek Project - Without storage above Diamond Creek		BLACK CANYON - Diamond Creek - Glen Canyon Project		BLACK CANYON PROJECT - 310 ft. Dam raised to 550 ft. above water level.	
	12th yr.of Opr.	Ultim.Devel.	12th yr.Oper.	Ultim.Dev.	12th yr.Oper.	Ultim.Devel	12th yr.Opr.	Ultim.Devel.
Dam, gates, penstocks tunnels, etc.	$	$	$	$	$	$	$	$
Black Canyon	18,860,000	18,860,000	18,860,000	18,860,000	18,860,000	18,860,000	54,860,000	54,860,000
Diamond Creek			17,431,400	17,431,400	18,271,400	18,271,400		
Glen Canyon					26,000,000	26,000,000		
TOTAL	18,860,000	18,860,000	36,291,400	36,291,400	63,131,400	63,131,400	54,860,000	54,860,000
Power House, Generating Equipment and Step-up Transformers and accessories.								
Black Canyon	9,948,400	9,948,400	9,948,400	9,948,400	9,948,400	14,694,400	22,454,600	27,638,600
Diamond Creek			6,143,000	6,143,000	11,680,400	16,426,400		
TOTAL	9,948,400	9,948,400	16,091,400	16,091,400	21,628,800	31,120,800	22,454,600	27,638,600
Six Substations	5,355,700	5,355,700	7,817,400	7,817,400	11,355,400	15,729,400	11,356,100	13,891,100
Transmission Lines	24,493,000	24,493,000	25,840,000	25,840,000	32,941,400	46,799,800	33,413,900	41,543,900
TOTAL	58,657,100	58,657,100	101,640,200	101,640,200	129,057,000	156,781,400	122,084,600	137,933,600

Exhibit 19

UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF RECLAMATION
ELWOOD MEAD, COMMISSIONER
WASHINGTON

JULY 1, 1933.

GENERAL INFORMATION CONCERNING THE BOULDER CANYON PROJECT

APPROVAL OF BOULDER CANYON PROJECT ACT

1. On December 21, 1928, the President approved the Boulder Canyon Project Act, which authorizes the construction by the Secretary of the Interior of the Boulder Dam and incidental works on the Colorado River at a cost not to exceed $165,000,000. The project includes:

BOULDER DAM AND RESERVOIR

(*a*) The construction of the Boulder Dam in Black Canyon where the Colorado River forms the boundary between the States of Arizona and Nevada. This structure will raise the present water surface of the river 582 feet. The dam site is about 25 miles southeast of Las Vegas, Nev., a town with a present population of about 6,000, located on the Los Angeles and Salt Lake line of the Union Pacific System. The dam will be about 700 feet in height, the highest ever constructed, and will create a reservoir with a capacity of 30,500,000 acre-feet. It will serve to impound the surplus flood waters of the Colorado River for use in irrigation and will also regulate the flow of the river so as to improve navigation and protect the lands in the valleys adjacent to the river below the dam and in the Imperial Valley in southern California from overflow, water shortage, and silt accumulation, which are at present a great menace to successful agriculture. The lake formed by the dam will be about 115 miles in length and have an area of 145,000 acres—the largest artificial reservoir in the world.

POWER DEVELOPMENT

(*b*) The development of hydroelectric energy at the dam will make 663,000 firm or constant horsepower available at all times. The installed capacity of the plant will be 1,835,000 horsepower. The United States will construct the dam, power plant, and appurtenant works by contract; and will furnish generating, transforming, and high-voltage switching equipment for the generation of energy allotted to the lessees and to the various purchasers. Rates of payment for falling water in terms of energy have been fixed at 1.63 mills per kilowatt-hour for firm energy and one half mill per kilowatt-hour for secondary energy. In addition, the contractors must pay for the power machinery and its installation and construct the necessary transmission lines.

ALL-AMERICAN CANAL

(*c*) The construction of an All-American canal from a diversion dam to be built about 5 miles above Laguna Dam near Yuma, Ariz., to connect with the present irrigation distribution system in the Imperial Valley in southern California, a distance of about 80 miles, and also a 130-mile branch canal to the adjacent Coachella Valley. Preliminary surveys and studies have been made, under a cooperative agreement with the Imperial and Coachella Valley irrigation districts, and a report was submitted in May 1931. Present plans contemplate a maximum canal capacity of 15,000 second-feet. A repayment contract has been negotiated with the irrigation district. No appropriation has yet been made for this feature of the project.

TIME REQUIRED FOR CONSTRUCTION

2. It is expected that it will take about six years to complete the dam and appurtenant works from the time construction began in 1931. It is proposed to install units of the power plant progressively as rapidly as demand for power develops. The first units will go into operation in September 1935. Construction of the All-American canal will probably require four or five years.

TEMPERATURE RECORDS

3. The temperatures at Boulder City during the year vary from 20° to 120° above zero with a mean temperature of 52° in December and 94° in July, the average temperatures being 7° cooler than at the dam site and 2° cooler than at Las Vegas. The summers are hot and dry, but the winter climate is mild and agreeable.

LAND WITHDRAWALS

4. All public lands in the immediate vicinity of the dam and reservoir sites have been withdrawn from entry for construction purposes.

RESTORATION AND OPENING LANDS TO ENTRY

5. All public lands which can be irrigated under the Boulder Canyon project have been withdrawn from entry and will not be available for settlement until the dam is completed and water can be furnished for irrigation purposes. The lands, when restored, are to be subject to entry under the reclamation law, and preference right of entry is to be given to ex-service men. As before mentioned, the construction of the dam will require approximately six years, so that it will be a number of years before irrigation water will be available and the land to be irrigated opened to settlement and development. There are no irrigable lands in the immediate vicinity of the reservoir, such lands as are susceptible of irrigation under this project being mainly in the vicinity of Parker, Ariz., in the areas tributary to the Yuma project in Arizona, the Palo Verde or Blythe project, California, and lands in and adjacent to the Imperial and Coachella Valleys of California.

APPROPRIATIONS MADE

6. Preliminary requirements having been met, Congress made an initial appropriation of $10,660,000 to provide for the first year's operations. This amount was spent on the following features: Railroad for construction purposes from near Las Vegas, Nev., to dam site; highway from Boulder City to dam site; buildings, streets, water, and sewer systems for Boulder City; purchase of power for construction purposes; starting work on the four diversion tunnels. An appropriation of $15,000,000 was made by Congress for the fiscal year 1931–32; the principal work comprised the completion of Boulder City and excavation of the four 50-foot diameter diversion tunnels. The sum of $23,000,000 was available for the fiscal year, 1932–33, and was used principally for completing the diversion tunnels and cofferdams, excavating for spillways, tunnels, and adits, and excavating for the foundation of the dam. For the current fiscal year, 1933–34, an appropriation of $8,000,000 has been made. Work in progress includes excavating pen-stock tunnels and construction adits, placing mass concrete in the dam and construction of spillways and outlet works.

CONTRACT POLICY OF DEPARTMENT

7. Following the present policy of the Department of the Interior, all construction is being done by contract.

PRINCIPAL CONTRACTS AWARDED

8. Bids were opened on March 4, 1931, at Denver, Colo., for construction of the Boulder Dam power plant and appurtenant works. The low bid of $48,890,995 was submitted by the Six Companies Incorporated, 510 Financial Center Building, San Francisco, Calif., made up of the Utah Construction Company of Ogden, Utah; Henry J. Kaiser and W. A. Bechtel Company of Oakland, Calif., and 206 Sansome Street, San Francisco, Calif., respectively; MacDonald & Kahn, Ltd., of Los Angeles, Calif.; Morrison-Knudson Company of Boise, Idaho; J. F. Shea Company of Portland, Oreg., and Pacific Bridge Company of Portland, Oreg. On March 11, 1931, the Secretary of the Interior awarded the contract to the Six Companies Incorporated. These contractors have a field office at Boulder City, Nev., with F. T. Crowe as general superintendent. This is the largest contract on the Boulder Canyon project, and includes the 700-foot dam, the four 50-foot diameter diversion tunnels, cofferdams, spillways, outlet works, and the power plant (but not including installation of machinery).

The Babcock & Wilcox Company of New York City has the contract for furnishing, erecting, and painting 14,500 feet of plate-steel outlet pipes, varying from 8½ feet to 30 feet in diameter, for $10,908,000. The time allowed for completion of this contract is 1,975 days, and the weight of the pipe materials is about 110,000,000 pounds. A fabricating plant has been built by the contractor at Bechtel, Nev., about one mile from the dam site. The Allis-Chalmers Manufacturing Company of Milwaukee, Wis., has the contract for furnishing four 115,000-horsepower, vertical hydraulic turbines for the power plant at a price of $1,087,200. The Newport News Shipbuilding and Dry Dock Company of New York City has the contract for furnishing one 55,000-horsepower turbine for $124,684.

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The Southern Sierras Power Company, of Riverside, Calif., has the contract for furnishing power for construction purposes. A transmission line was constructed for a distance of 235 miles from Victorville, Calif., to the dam site. The company also built a substation near the dam site. Power was available on the project June 25, 1931. Both transmission line and substation are operated and maintained by the power company.

PROGRESS UNDER CONTRACTS

9. Excellent progress has been made on all contracts, and under the Six Companies Incorporated contract the work is now about 15 months ahead of schedule.

PURCHASE OF CONSTRUCTION EQUIPMENT

10. The contractors, and not the United States, purchase and furnish all construction equipment required on the work.

PURCHASE OF MATERIALS

11. Materials entering into the permanent works, such as cement, lumber (not including lumber for forms), reinforcing steel, pipe, gates and valves, structural steel, machinery, etc., are being purchased by the Government after appropriate advertising and competitive bidding. All major purchases are made through the Chief Engineer's Office, United States Custom House, Denver, Colo., where the main purchasing office of the Bureau of Reclamation is located. Equipment, materials, and supplies required in the construction plant and camp and in the incidental operations of the contractors are purchased by the contractors.

GOVERNMENT ORGANIZATION

12. With the work done by contract, a certain organization is required by the United States to handle the inspection, engineering, and supervision. All employments on the Government rolls are made in strict accordance with the rules and regulations of the United States Civil Service Commission. To be eligible for appointment in the classified civil service, applicants must first qualify through appropriate competitive examinations.

LOCATION OF RECLAMATION FIELD OFFICE

13. On March 1, 1932, all offices of the project were moved from Las Vegas to Boulder City, Nev. Walker R. Young is construction engineer in charge. The administration building is occupied by the construction engineer and the field and office engineering and clerical forces employed in supervision of building of the project. The city manager and his staff of assistants are located in the municipal building. Communications regarding this project should be addressed to the Commissioner, Bureau of Reclamation, Washington, D.C., the Chief Engineer, Bureau of Reclamation, United States Customhouse, Denver, Colo., or the Construction Engineer, Bureau of Reclamation, Boulder City, Nev.

LOCATION OF UNITED STATES EMPLOYMENT SERVICE

14. The United States Employment Service, under the Department of Labor, in cooperation with the State of Nevada, has established a Public Employment Service at Las Vegas, Nev., with Mr. Leonard T. Blood as superintendent in charge. The major contractors, Six Companies Incorporated, and Babcock and Wilcox Company have announced that all employments will be made through that office. Interviews, listings, and selections are made by the United States Employment Service, and it also assists in supplying the country, through the newspapers and otherwise, with accurate information concerning the progress of work on the Boulder Canyon Project, and the demand for workmen.

GOVERNMENT TOWN SITE

15. The Government town site of Boulder City is about 6 miles from the dam site on the Nevada side of the river, and 23 miles southeast of Las Vegas, Nev. It is situated on a branch line of the Los Angeles & Salt Lake Railroad (Union Pacific System) extending from Boulder Junction on the main line 6 miles south of Las Vegas to the town site. The elevation is 2,500 feet above sea level, 1,000 feet higher than the top of the canyon wall at the dam site and 500 feet higher than Las Vegas. The development of Boulder City by the Government was completed in the summer of 1932, at a cost of approximately $2,000,000. Located on the divide between the river area and the plain sloping toward Las Vegas, it is a modern town in every respect, and includes complete water and sewerage systems, street improvements of paving, sidewalks, curbs, gutters,

and an electrical distribution system. During the six-year construction period for the dam, power plant and appurtenant works, the residents of Boulder City will include the engineering and clerical employees of the Government organization, most of the employees of Six Companies Incorporated, the contractor building the dam, the employees of Babcock and Wilcox, contractor for steel pipe for outlet tunnels, and business and professional people engaged in their enterprises in this town. After completion of construction, the contractors' forces will vacate, and the population of Boulder City will be composed of the operating personnel and such business and professional inhabitants as are justified in staying by the business then obtainable, augmented by tourists traveling over the transcontinental highway which will cross the Colorado River on Boulder Dam. The present population of Boulder City is approximately 5,000.

The town site is located on Government reserved land, and it has been planned as a permanent community. Ownership is retained by the Government, which grants leases for terms not to exceed 10 years to those who reside in the town or use the land for commercial purposes. One of the features of these leases is that they will continue only during the period of good behavior of the tenant. It is the intention of the Government that the bootlegger, the gambler, or other law violator shall not interfere with the well-being of the workmen assigned to this huge task. The power to terminate leases, and therefore residence, in this town will be used as one of the means of enforcing proper conduct.

LEASE AND PERMIT POLICY

16. A definite policy to govern in the matter of leasing land and granting permits for business or residential purposes in the Government town site of Boulder City, was adopted and on May 18, 1931, public announcement was made, through the newspapers and otherwise, that applications would be received and considered. In certain types of business it was indicated that the number of permits to be granted was limited. Permits in the designated number have been granted, and the types of business operating thereunder cover those generally found in a small town. It is therefore improbable that any additional competitive permits will be granted in the near future.

BUILDINGS

17. Approximately 900 buildings have been erected in Boulder City. Of these, the Six Companies Incorporated, has constructed 681 buildings, which include 10 dormitories of 1,600 persons total capacity; 661 residences of 2-, 3-, 5-, and 6-room size; a mess hall seating 1,300 persons; a laundry, clubroom, and large commissary. Persons holding permits for business enterprises in Boulder City have erected nearly 100 commercial buildings or residences, and the Government has completed a group of 100 residences, an administration building, two dormitories, municipal building, and other structures of various types. The town is adequately protected from fire by two volunteer fire-engine companies.

SCHOOLS

18. A census recently completed in Boulder City lists 839 children, 563 of whom are of school age. The Government has constructed and equipped a modern school building for 12 grades. Excellent school facilities are available in Las Vegas, where a high school building was erected in 1930 at a cost, with equipment, of $250,000.

CHURCHES

19. The Catholic, Episcopal, and Latter Day Saints denominations have erected church buildings in Boulder City. A community church has been established, and meetings are held at present in the American Legion Hall.

MISCELLANEOUS

20. Efficient mail service is provided in Boulder City by a post office force of eight persons. The office has recently been moved into the new municipal building.

The Government operates the water supply and distribution system and furnishes water to consumers through individual meters. The Nevada-California Power Company supplies electricity to the Government which resells it to consumers.

The Six Companies Incorporated, has built and equipped a modern hospital, and employs the physicians, surgeons, nurses, and attendants on the staff. The capacity of the hospital is 60 beds. The hospital is adequately equipped in all details to provide its patients with scientific and modern medical attention.

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BUSINESS ESTABLISHMENTS

21. The principal contractor, following the usual practice in large construction operations, is operating a general store and a laundry, as well as all operations connected with the housing and feeding of its men, and the requisite shops and warehouses used in construction activities. The commissary, operated by a subsidiary organization, the Boulder City Company, is a combined department, grocery, and drug store carrying rather complete lines of many standard articles.

Buildings constructed under Government permits for concessions in Boulder City include two wholesale gasoline and oil stations, two restaurants, two tourist camps, two men's clothing stores, dry cleaning shop, building supplies yard, garage and filling station, lodging house, moving picture theater, bus terminal station, Western Union telegraph office, meat, bakery, barber shop, lunch rooms, music store, general store, furniture stores, drug stores, beauty shops, laundry, mortuary, electrical appliances store, and several other businesses.

BUILDING REQUIREMENTS

22. To comply with the architectural and landscaping plans for Boulder City and for purposes of fire protection, all plans for buildings must be approved by the Government in regard to construction, height, architectural design, and location on lots.

In the central business district, buildings must conform in general to the following regulations:

All buildings must be of Spanish design, and arcades shall be provided to cover the sidewalks as a protection against severe sunlight.

Construction must be "semifireproof" for hospitals, theaters, and all public buildings involving the public safety, and "ordinary construction" for all other buildings within the central business district.

Walls shall be of brick, stone, adobe, or of concrete of the massive, hollow block, solid block, or reinforced type.

The terms "semifireproof" and "ordinary construction", used above, correspond in general with the requirements for these types given in the "Building Code Recommended by the National Board of Fire Underwriters", Fifth Edition, 1931.

In the industrial district, located in the outskirts of the town and along the highway leading into the business district, the building requirements are more lenient. Here enterprises such as bottling works, filling stations, welding and battery shops, and tourist camps are allowed to be located. Those industries which spread dust, create noise, or carry unusual fire hazard, or are otherwise objectionable will not be permitted in the central business district or in residential districts.

A lease for residence use will be granted to any responsible person of good character. A pleasing appearance is practically the only requirement for buildings of this type, but plans must be submitted for the approval of the Bureau before construction.

ADMINISTRATION OF BOULDER CITY

23. Boulder City is located on Government reserved land and is entirely controlled and regulated by the United States Government through the Bureau of Reclamation and directly by the construction engineer, Walker R. Young.

A city manager, Mr. Sims Ely, has been appointed for administration of Boulder City, including matters concerning business concessions and all transactions usually performed by a city government. Police powers are vested in Federal rangers operating under the city manager.

A committee has been appointed to act in an advisory capacity to the construction engineer and the city manager on all matters relating to the administration of Boulder City. The members of this committee are Office Engineer John C. Page and District Counsel J. R. Alexander of the Bureau of Reclamation, and Mr. J. F. Reiss, an official of the Six Companies Incorporated.

WARNING TO ALL INTERESTED PERSONS

24. All persons interested in establishing business enterprises in Boulder City should take notice of the following facts:

(*a*) The population of the town is approximately 5,000 persons.

(*b*) The surrounding country is undeveloped desert, and there is no outside population from which patronage may be expected.

(c) The amount of business to be derived from tourists and other visitors to the town is uncertain.

(d) The climatic conditions may not be suitable to every one.

(e) The principal contractor will, through his commissary and other facilities, furnish goods and service in competition with permittees.

(f) The future of the town, after the completion of the construction period, is uncertain.

The Government does not represent to anyone that a profit can be made under any business permit it may grant in Boulder City. The number of permits have been limited in order to guard against the wholesale bankruptcy which might result from extravagant overdevelopment of the business district because of nation-wide interest in the project and plans based in many cases upon hopes rather than information.

After an application is approved, the applicant is advised to go to Boulder City and investigate conditions there before finally committing himself.

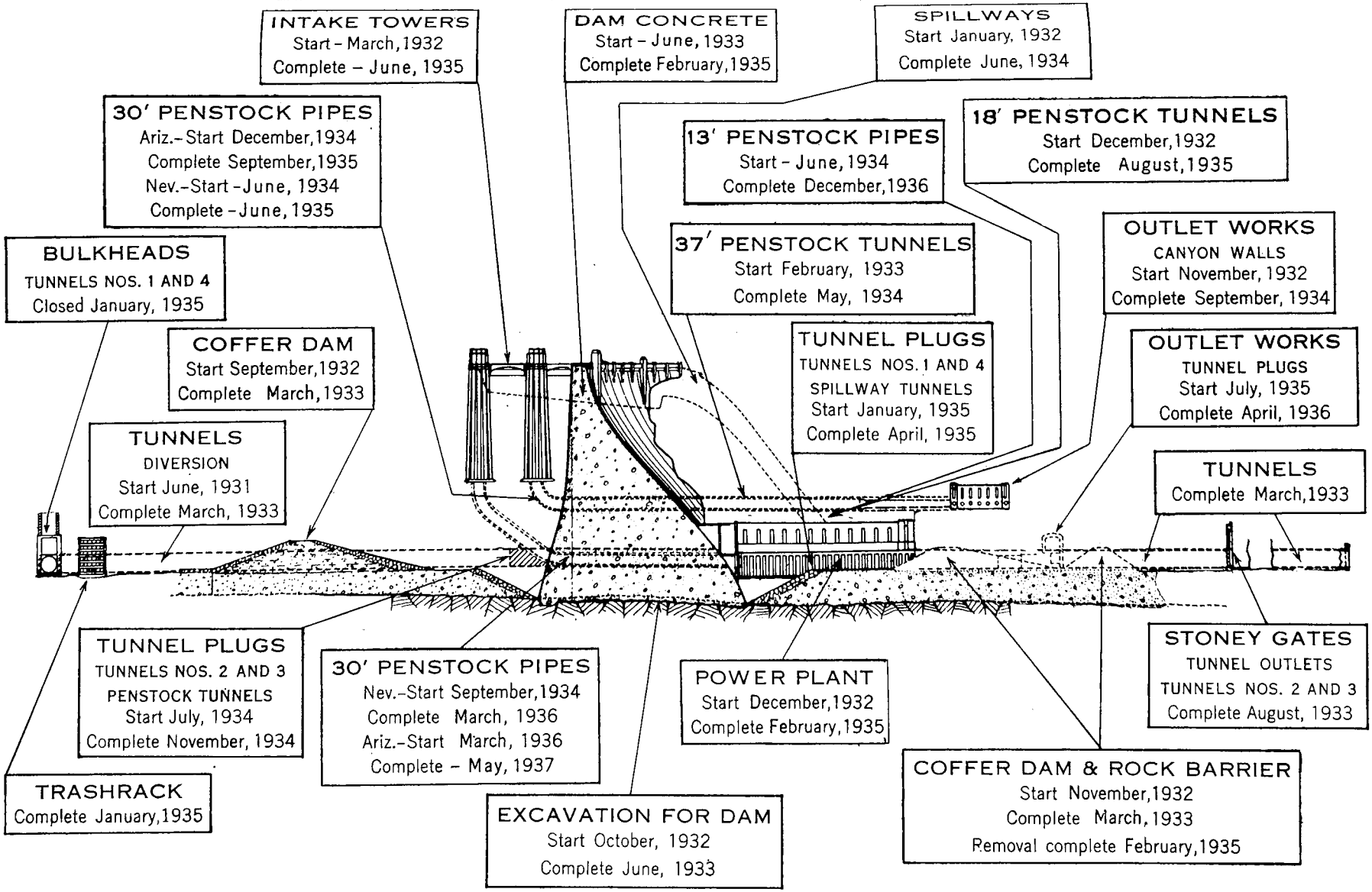
Leases and all applications for permits must be submitted directly by persons desiring such leases and permits, and all are warned to beware of all persons pretending to possess special influence in securing such leases or permits and seeking to obtain money, directly or indirectly, for such pretended influence. Any applicant known to have paid anyone for use of supposed influence in this connection will not be favorably considered.

REQUESTS FOR FURTHER INFORMATION

25. All requests for further information and correspondence with reference to leases and permits in Boulder City should be addressed to the City Manager, Boulder City, Nev.

ELWOOD MEAD,
Commissioner.

U. S. GOVERNMENT PRINTING OFFICE: 1933 6—8105

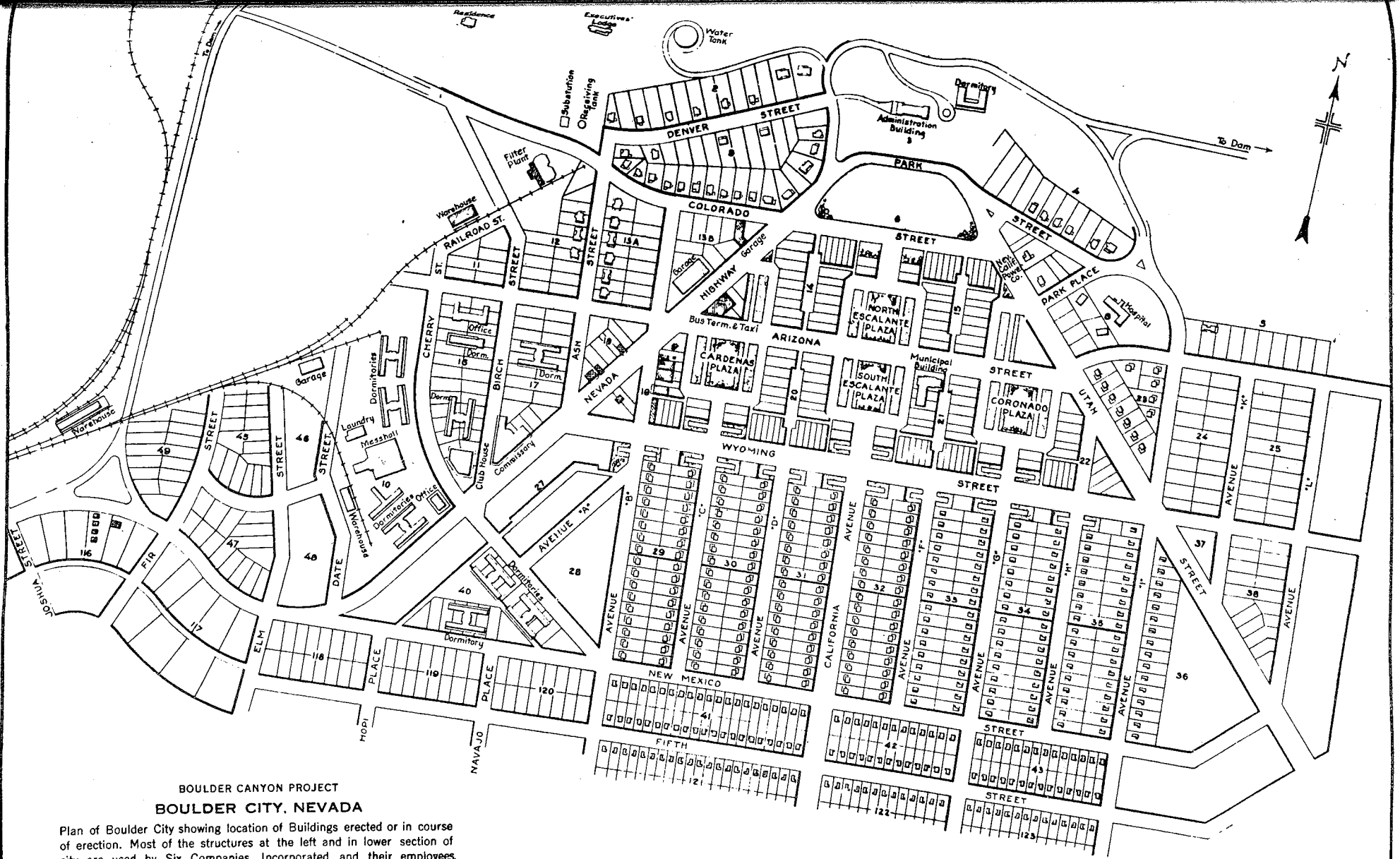


BOULDER DAM

CONSTRUCTION PROGRESS PICTORIAL DIAGRAM

U. S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

24879



BOULDER CANYON PROJECT

BOULDER CITY, NEVADA

Plan of Boulder City showing location of Buildings erected or in course of erection. Most of the structures at the left and in lower section of city are used by Six Companies, Incorporated, and their employees.

MAP NO. 24500

1932

100 0 100 200 300 400 500
Scale of Feet

U. S. Bureau of Reclamation

BOULDER CANYON PROJECT ACT

PUBLIC No. 642, 70th CONGRESS
APPROVED DECEMBER 21, 1928

PURPOSES

1. CONTROL OF FLOODS
2. IMPROVEMENT OF NAVIGATION
3. REGULATION OF FLOW
4. IRRIGATION DEVELOPMENT
5. DOMESTIC WATER SUPPLY
6. GENERATION OF POWER

CONDITIONS

1.- Not effective until the Colorado River Compact has been ratified by the 7 basin States or after 6 months by California and 5 others. *Sec. 4 (a)*
2.- Not effective until California agrees to limit her annual consumptive use of Colorado River water to 4,400,000 acre feet plus one-half of any surplus waters unapportioned by the Colorado River Compact. *Sec. 4 (a)*
3.- No appropriation is to be made for construction until the Secretary of the Interior shall provide by contract for revenues adequate to pay operation and maintenance expenses and meet repayment requirements. *Sec. 4(b)*
4.- All operations are to be subject to the Colorado River Compact. *Sec. 8*
5.- The Act shall be deemed a supplement to the Reclamation Law. *Sec. 14*

BOULDER CANYON PROJECT

Authorizes the Secretary of the Interior to construct the Boulder Canyon Project. *Section 1*

BOULDER DAM

PURPOSES
1. River regulation, improvement of navigation and flood control.
2. Irrigation and domestic water supply.
3. Power. *Section 6*

Location:
Boulder or Black Canyon.
Capacity:
Not less than 20,000,000 acre feet. *Section 1*

Irrigable public lands shall be withdrawn to be opened to entry under Reclamation Law, with preference to ex-soldiers, sailors and marines. *Section 9*

Title to works shall forever remain in the United States. *Section 6*

ALL-AMERICAN CANAL

To connect Laguna or another suitable diversion dam with Imperial and Coachella Valleys. *Sec. 1*

Cost to be reimbursable in accordance with terms of the Reclamation Law. *Section 4 (b)*

Title with certain exceptions may be transferred to districts or other agencies after all repayments are made. *Section 7*

No charge shall be made for water for irrigation or potable purposes in Imperial and Coachella Valleys. *Section 1*

Districts may utilize power possibilities on the canal and be credited with net proceeds. *Section 7*

POWER DEVELOPMENT

ALTERNATIVES
The Secretary of the Interior
(a) may build a plant *Sec 1* and deliver energy at the switchboard *Section 5*
(b) lease one or more units of the Gov't built plant *Sec 6*
(c) lease water for generation of power in plants to be built by lessees. *Sec 6*

Rules and regulations shall conform to requirements and policies of the Federal Water Power Act. *Section 6*

Rates shall assure reasonable returns and may be readjusted periodically as justified by competitive conditions. *Section 5 (a)*

COLORADO RIVER DAM FUND

Establishes the Colorado River Dam Fund for carrying out the provisions of the Act. *Section 2*

REVENUES

All revenues shall be paid into the Colorado River Dam Fund. *Section 2 (a)*

Balance available for repayment shall be determined at close of each fiscal year and covered into the U. S. Treasury. *Section 2 (e)*

EXCESS REVENUES

Revenues in excess of amortization requirements to be allotted —
62½ % to flood control repayment. *Section 2 (b)*
18¾ % to State of Arizona *Section 4 (b)*
18¾ % to State of Nevada *Section 4 (b)*

After repayment to U. S. of all money advanced, with interest, revenues shall be kept in separate fund and expended within the Colorado River Basin as prescribed by Congress. *Sec 5*

APPROPRIATIONS

Appropriations not to exceed $165,000,000 in the aggregate are authorized. *Section 2 (b)*

Amounts deemed necessary by Secretary of the Interior shall be advanced to the Fund by Secretary of the Treasury, within appropriation limits. Interest to be charged annually at 4% on amounts advanced. *Section 2 (b)*

Operation and maintenance expenses to be paid only from appropriations therefor *Section 2 (c)*

REPAYMENTS

All amounts advanced for operation and maintenance and for construction of the dam and power plant to be repaid with interest within 50 years. *Section 4 (b)*

Expenditures on All-American Canal, including O. and M. to be repaid in manner provided in the Reclamation Law *Sec. 4*

FLOOD CONTROL

$25,000,000 is allocated to flood control and is to be repaid from revenues in excess of amortization requirements *Section 2 (b)*

CONTRACTS

No contract shall be for longer duration than 50 years, with right of renewal at expiration under then existing laws and regulations. *Section 5 (a) and (b)*

Conflicting applications for contracts to be resolved in conformity with policy of Federal Water Power Act, except that preference shall be given to a State for energy for use in the State. *Section 5 (c)*

Any contractor for 100,000 h. p. or more may be required to permit any contractor for less than 25,000 h. p. to share his transmission lines. *Section 5 (d)*

COLORADO RIVER COMPACT

Ratifies the Colorado River Compact and makes other provisions. *Section 13*

INVESTIGATIONS

Authorizes the appropriation of $250,000 for investigations to formulate a comprehensive plan for the utilization of Colorado River *Section 15*

Authorizes investigations of the Parker-Gila Valley reclamation project. *Sec. 11*

WATER RIGHTS

All rights of the U. S. and its grantees to waters of the Colorado River shall be subject to the Colorado River Compact. *Section 13 (b)*

Nothing in the Act shall be construed as a denial or recognition of any rights in Mexico to the use of waters of the Colorado River *Section 20*

INTERSTATE COMPACTS

Ratifies Colorado River Compact on behalf of the U. S., 6 or 7 State basis. *Section 13 (a)*

Authorizes negotiation of interstate compacts supplemental to the Colorado River Compact. *Section 19*

Authorizes tri-state compact between Arizona, California and Nevada. *Section 4 (a)*

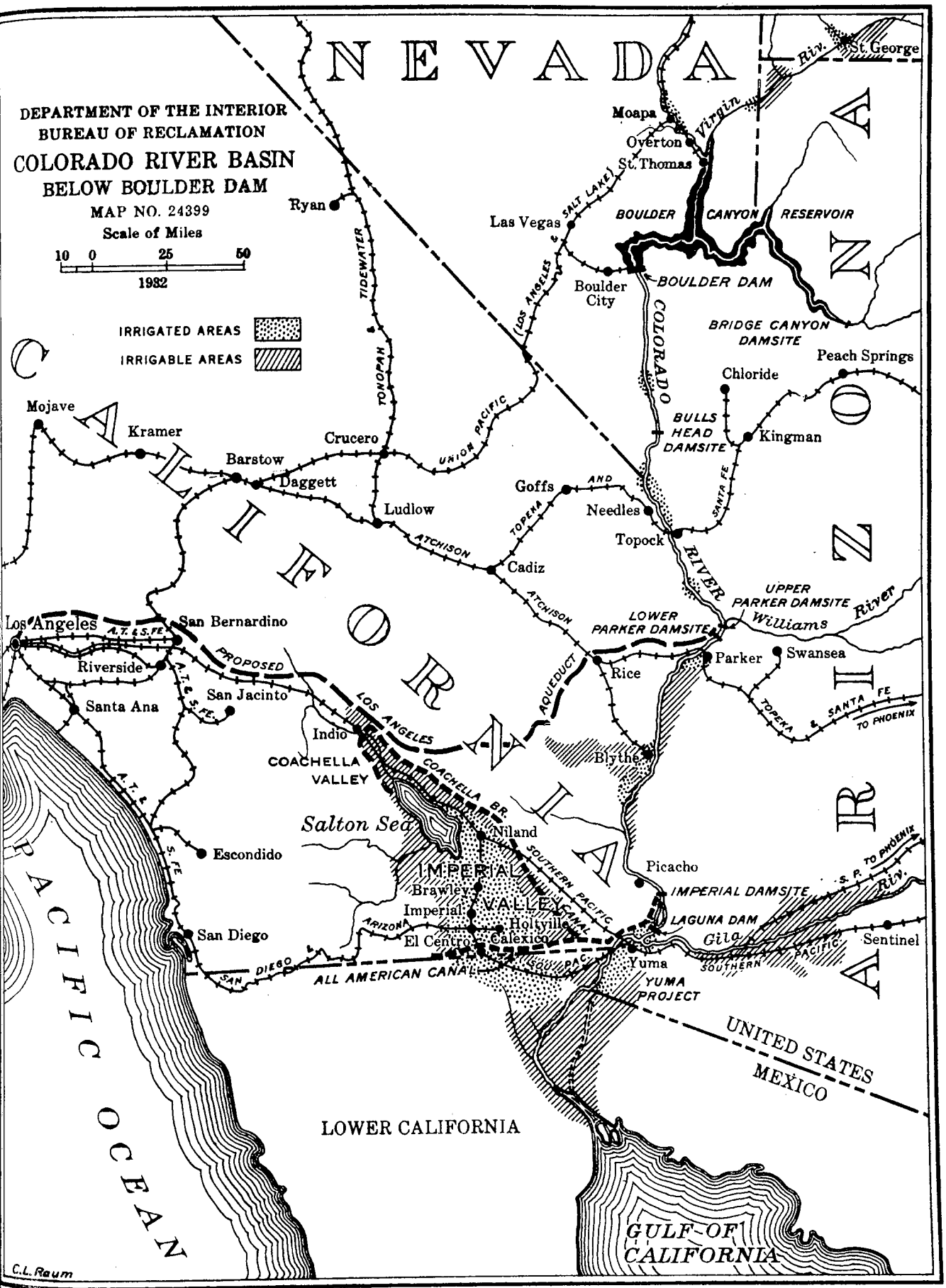
POWER LICENSES

Federal Power Commission is not to issue licenses except on Gila River until the Act becomes effective *Sec. 6*

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
APRIL 1929

SYNOPSIS OF
BOULDER CANYON PROJECT ACT
CHART NO. 23640

U. S. GOVERNMENT PRINTING OFFICE: 1934 64160


DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN
BELOW BOULDER DAM
MAP NO. 24399
Scale of Miles
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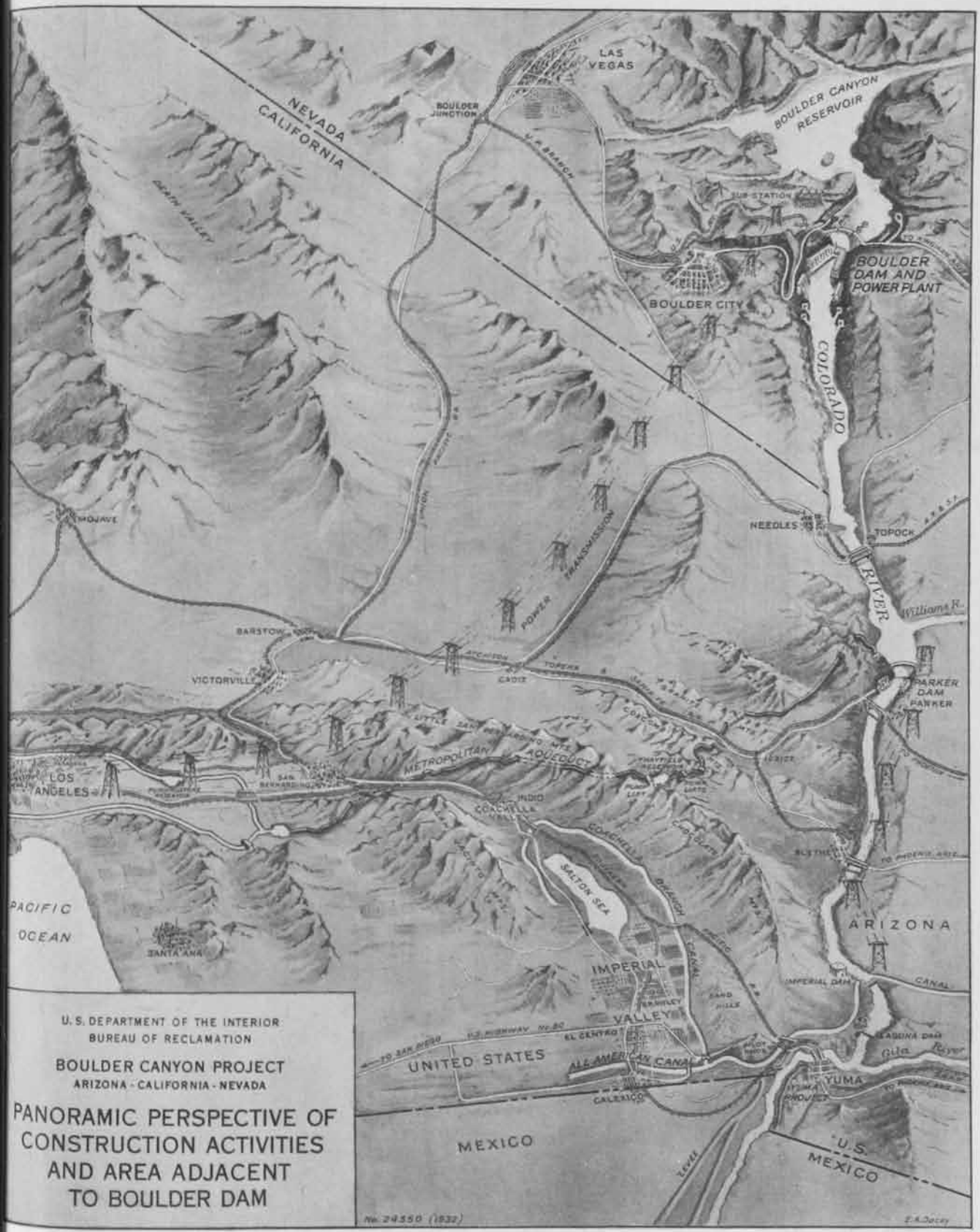
1932
IRRIGATED AREAS
IRRIGABLE AREAS
NEVADA
ARIZONA
CALIFORNIA
Riv.
St. George
Moapa
Overton
Virgin
St. Thomas
Ryan
Las Vegas
SALT LAKE &
BOULDER CANYON RESERVOIR
Boulder City
BOULDER DAM
LOS ANGELES
COLORADO
BRIDGE CANYON DAMSITE
Peach Springs
Chloride
BULLS HEAD DAMSITE
Kingman
TIDEWATER & TONOPAH
Mojave
Kramer
Crucero
UNION PACIFIC
Barstow
Daggett
Goffs
AND
Needles
SANTA FE
Ludlow
TOPEKA
ATCHISON
Topock
Cadiz
RIVER
UPPER PARKER DAMSITE
Williams
River
Los Angeles
A.T. & S.F.
San Bernardino
LOWER PARKER DAMSITE
Parker
Swansea
Riverside
PROPOSED
AQUEDUCT
Rice
TOPEKA & SANTA FE
TO PHOENIX
San Jacinto
Santa Ana
LOS ANGELES
Indio
COACHELLA VALLEY
COACHELLA BR.
Blythe
Salton Sea
Niland
SOUTHERN PACIFIC
Escondito
IMPERIAL VALLEY
Picacho
IMPERIAL DAMSITE
S.P.
TO PHOENIX
Riv.
Brawley
Imperial
Holtville
LAGUNA DAM
Gila
Sentinel
San Diego
ARIZONA
El Centro
Calexico
SOUTHERN PACIFIC
Yuma
SAN DIEGO &
ALL AMERICAN CANAL
SOU. PAC.
YUMA PROJECT
UNITED STATES
MEXICO
PACIFIC OCEAN
LOWER CALIFORNIA
GULF OF CALIFORNIA
C.L. Raum

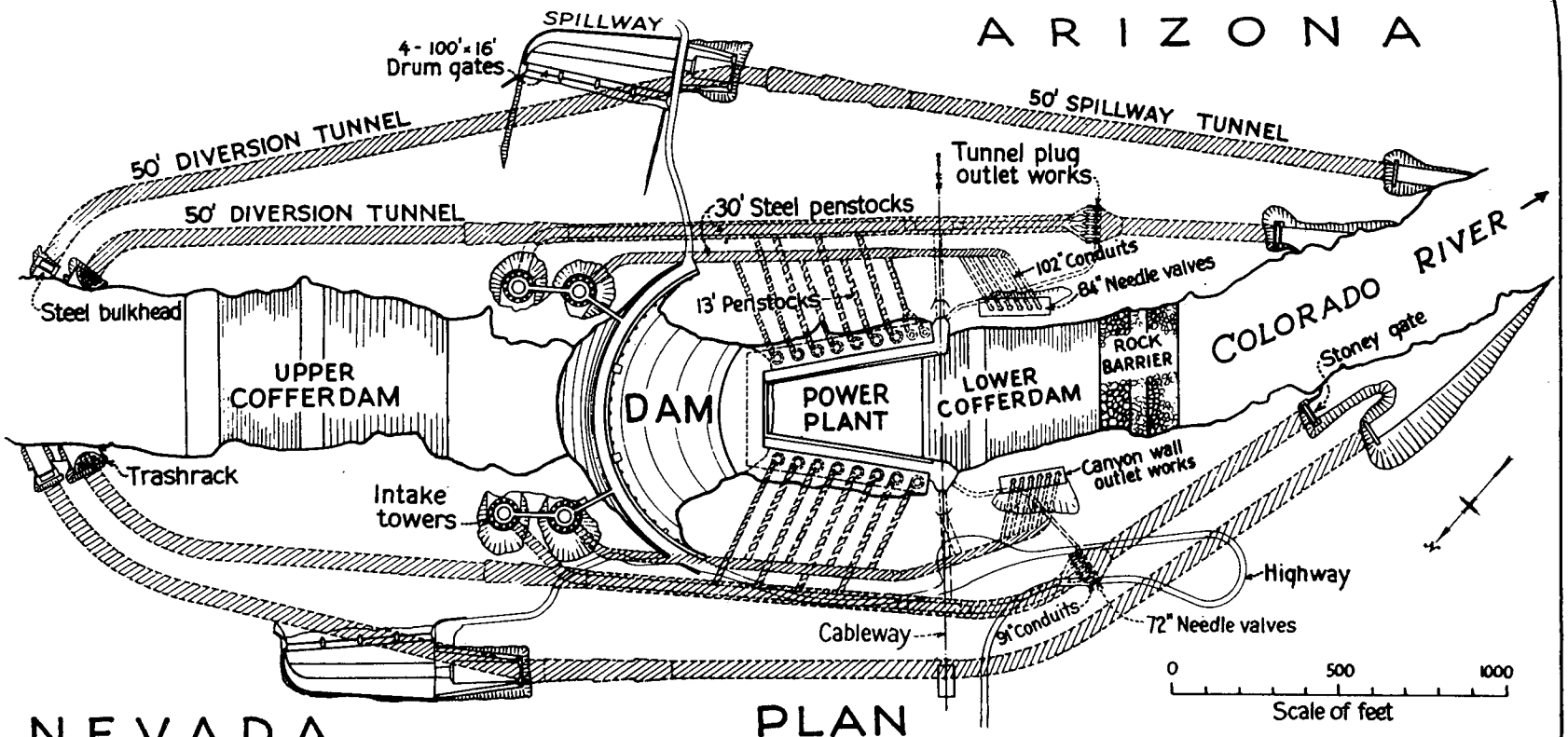


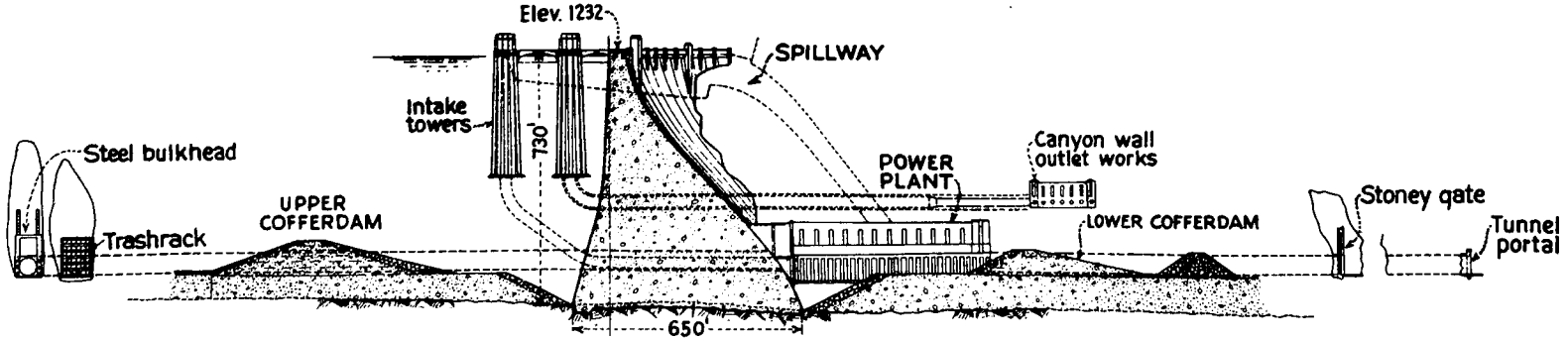
U. S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

BOULDER CANYON PROJECT
ARIZONA - CALIFORNIA - NEVADA

PANORAMIC PERSPECTIVE OF CONSTRUCTION ACTIVITIES AND AREA ADJACENT TO BOULDER DAM

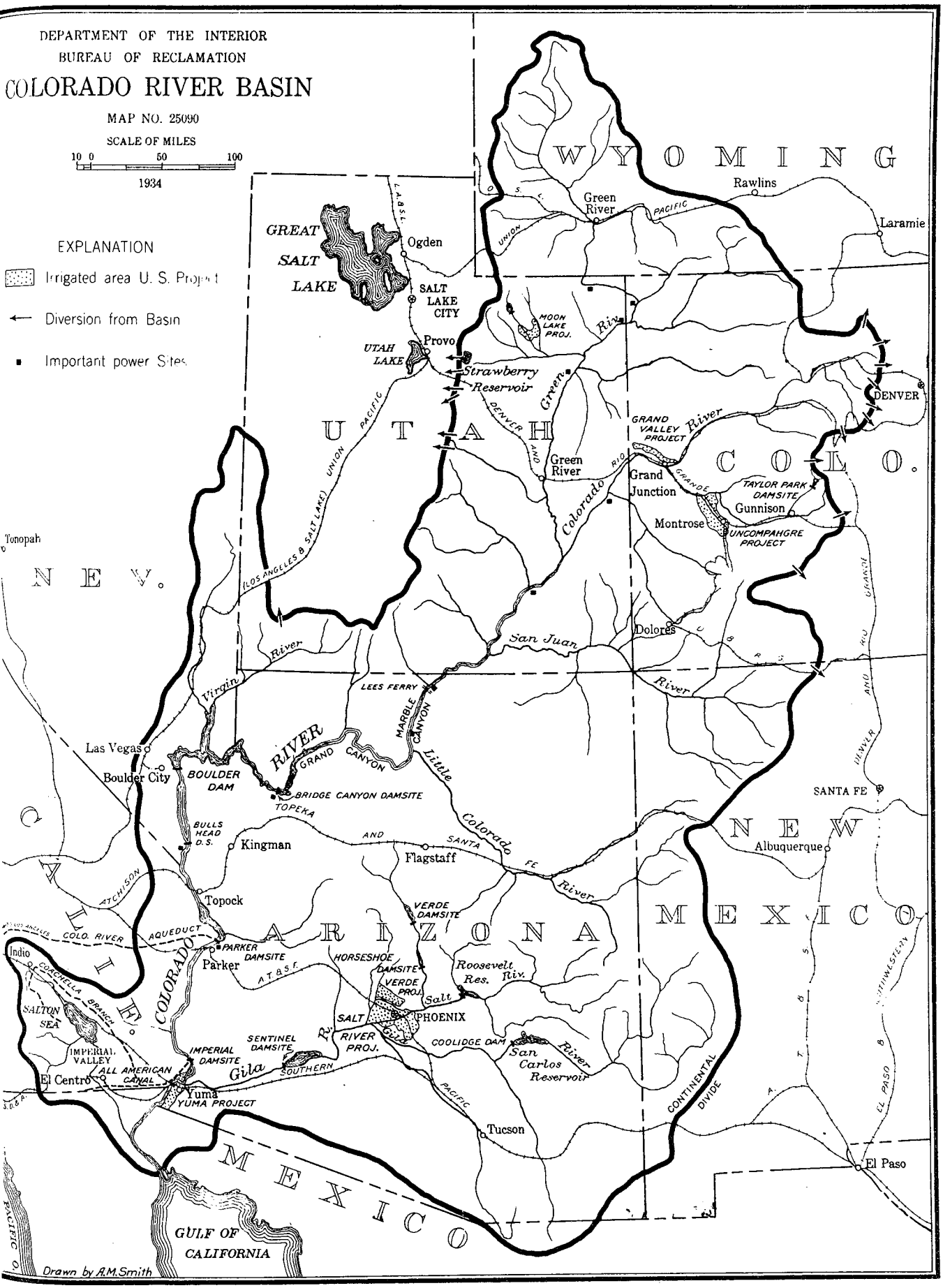
No. 24550 (1932)





LONGIT. SECTION

BOULDER DAM AND APPURTENANT WORKS


DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN
MAP NO. 25090
SCALE OF MILES
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1934
EXPLANATION
Irrigated area U. S. Project
Diversion from Basin
Important power Sites
WYOMING
Rawlins
Green River
Laramie
GREAT SALT LAKE
Ogden
SALT LAKE CITY
MOON LAKE PROJ.
Provo
UTAH LAKE
Strawberry Reservoir
DENVER
UTAH
GRAND VALLEY PROJECT
Green River
Grand Junction
COLO.
TAYLOR PARK DAMSITE
Gunnison
Montrose
UNCOMPAHGRE PROJECT
Tonopah
NEV.
Dolores
San Juan River
Virgin River
LEES FERRY
MARBLE CANYON
Las Vegas
Boulder City
BOULDER DAM
GRAND CANYON
BRIDGE CANYON DAMSITE
TOPEKA
Little Colorado River
SANTA FE
BULLS HEAD D.S.
Kingman
Flagstaff
Albuquerque
NEW MEXICO
Topock
VERDE DAMSITE
ARIZONA
Indio
PARKER DAMSITE
Parker
HORSESHOE DAMSITE
VERDE PROJ.
Roosevelt Res.
SALTON SEA
SALT RIVER PROJ.
PHOENIX
COOLIDGE DAM
San Carlos Reservoir
IMPERIAL VALLEY
IMPERIAL DAMSITE
SENTINEL DAMSITE
El Centro
Yuma
YUMA PROJECT
Tucson
El Paso
CONTINENTAL DIVIDE
MEXICO
GULF OF CALIFORNIA
Drawn by A.M.Smith

CHAMBER OF COMMERCE
OF THE
UNITED STATES OF AMERICA
WASHINGTON

OF THE SECRETARY

January 9, 1928.

TO OFFICERS AND MEMBERS OF THE BOARD OF DIRECTORS
OF THE CHAMBER OF COMMERCE OF THE UNITED STATES:

With respect to the Boulder Dam Project, the Board of Directors at its meeting October 17, 1927, took the following action:

> "Mr. Defrees, Chairman of the Committee on the Colorado River Project, on behalf of that Committee submitted a report recommending that a special committee be appointed to make an immediate study of the project, such Committee to present to the Board or to the Executive Committee at its next meeting a report covering the questions involved and indicating those which should require the Board's attention, together with the Committee's recommendations thereon, and it was voted that the report be approved."

The following special committee was appointed by President Pierson:

Joseph H. Defrees, Defrees, Buckingham and Eaton, Chicago, Ill., CHAIRMAN
L. Ward Bannister, Attorney, Denver, Colo.
A. S. Bent, President, Bent Bros. Inc., Los Angeles, Calif.
A. J. Brosseau, President, Mack Trucks, Inc., New York, N. Y.
W. L. Clause, Chairman of Board, Pittsburgh Plate Glass Co., Pittsburgh, Pa.
John M. Crawford, President, Parkersburg Rig & Reel Co., Parkersburg, W. Va.
Everett G. Griggs, President, St. Paul & Tacoma Lumber Co., Tacoma, Wash.
Dwight B. Heard, President, Dwight B. Heard Investment Co., Phoenix, Ariz.
John W. O'Leary, Vice President, Chicago Trust Co., Chicago, Ill.
M. S. Sloan, President, Brooklyn Edison Co., Brooklyn, N. Y.
L. B. Stillwell, President, L. B. Stillwell Engineering Corp., New York, N. Y.

After mature consideration of a vast amount of data assembled by members of the Chamber's staff, the Committee on Saturday, January 7, 1928, formulated a report, a copy of which is enclosed. This report was unanimously adopted by all members of the committee present, namely, Messrs. Defrees, Bent, Bannister, Crawford, Heard, Sloan and Stillwell.

In view of the fact that hearings by Committees of Congress with respect to the Boulder Dam Project are now in progress, President Pierson and Chairman Parker have directed that this report be placed by mail before the members of the Board of Directors with the request that each Director give it his immediate consideration and telegraph the Secretary collect whether or not the report has his approval.

Very truly yours,

Secretary.

2/47
Enclosure .

Chamber of Commerce of the United States

WASHINGTON

January 7, 1928.

To the Board of Directors of the
Chamber of Commerce of the United States:

You have asked this committee to consider proposals which are pending in Congress for a large project on the Colorado River, usually described as the Boulder Dam project, and to submit to you our recommendations as to the course which you should take either in inaugurating the Chamber's procedure for arriving at a position with respect to subjects on which it as yet has not declared policy or in interpreting existing policies which have already been given to the Chamber by the organizations in its membership as these policies may apply to any feature of the project in any of the forms which have recently received prominence.

Examination of the Boulder Dam project discloses its great importance and the purposes of national character which it will serve. These purposes involve questions of preparation for adjustment of international relations with Mexico, flood control, and apportionment of water resources among states, the utilization of such resources, and compensation, if any, to states in respect thereto. Upon some of the questions which arise in connection with these purposes it might be appropriate under other circumstances for you to have the studies made which are preliminary to the Chamber's referendum system. It appears, however, that hearings before Congressional committees are at hand and that the time for legislative decision may arrive before determination of new policies could be completed. For this reason we are not recommending to you that you should begin the procedure leading to referendum as to any of these questions.

One of the features of the project is of such a nature, however, that we believe, and recommend, that the Board should take action with reference to a policy which has already been declared, and which has been considered by the membership to be so important that it has been reiterated. This is the position that the government should scrupulously refrain from entering any phase of business which can be

successfully undertaken and conducted by private enterprise.

This action on the part of the Board should be taken with reference to provisions in any proposed legislation as to the utilization of the water power which will be made available by the project and the distribution of the electricity which is generated. We believe that any legislation which is enacted with respect to the Boulder Dam project should expressly and affirmatively provide that all proper effort shall be made to have private enterprise receive such opportunity to generate and distribute power at Boulder Dam as is provided under the Federal Water Power Act as to the utilization of water powers at government dams elsewhere in the country and will be consistent with the other purposes for which this dam will be constructed. The Federal Power Act not only provides for opportunity to private enterprise but for opportunity to states and their municipalities, as well as to the federal government.

The committee recommends that the Board of Directors authorize presentation to committees of Congress considering the Boulder Dam project the opposition repeatedly declared by the Chamber's membership to the government undertaking any of the phases of business which can be successfully undertaken and conducted by private enterprise. This presentation should include a suggestion that in any legislative authorization for the Boulder Dam project the power provisions will be contrary to the principle to which the Chamber is committed unless they contain clear and distinct recognition that private enterprise is to have the opportunity above described. We also recommend that the Board of Directors authorize the president of the Chamber to take such other action as it deems consistent with this report, and desirable.

Respectfully submitted,

Joseph H. Defrees, Chairman
Arthur S. Bent,
Dwight B. Heard,
L. Ward Bannister,
John M. Crawford,
M. S. Sloan,
Lewis B. Stillwell.

California's Masterly Statement on Its Colorado River Water Needs

HERE is a summary of the statement made by California's Colorado River Commission at Denver on the position of this State on the water question as it relates to diversion from that stream. It is a reply to the proposal of the Governors of the Upper Basin States that California take 4,200,000 acre feet of water. The Commission insists that California shall have a minimum of 4,600,000 acre feet and half of the surplus water not allocated. The points made are:

1 There is no question of States' rights, as advanced by Upper Basin States Governors. Every State may divert for beneficial use water not appropriated.

2 Arizona seeks more water than she can ever put to beneficial use, proposing to deprive California of water she will urgently need.

3 California has established rights to 3,173,000 acre feet of water, Los Angeles has filed on an additional 1,095,000 acre feet for domestic use of Southern California cities, the All-American Canal will require 1,174,000 acre feet; total requirements for projects established and definitely planned are 6,074,900 acre feet.

4 California demands 4,600,000 acre feet and one-half surplus water in Lower River. She will have to take chance on surplus. Less than this she could not take with safety.

5 The allocation by the Upper States Governors of 675,000 acre feet to Indian lands is unjustifiable; the United States is not a party to the Compact and there is no allocation of water to Indian lands, either in California or any Upper Basin State.

FOLLOWING is the full text of the remarkably clear and able statement of the Colorado River Commissioners of California submitted at the Denver Conference in answer to the proposal of water allocation between California and Arizona advanced by the Governors of Colorado, New Mexico, Utah and Wyoming. It is the most complete and masterly summary ever made of California's position with regard to Colorado River water. Undoubtedly it may be regarded as one of the most notable documents treating of the River and its problems:

September 20, 1927.

To the Colorado River Conference,

Denver, Colorado.

Gentlemen:

The position of California as to its allocation from the waters to be provided by the States of the Upper Division at Lee Ferry under the Colorado River Compact is that it should be not less than 4,600,000 acre feet per annum.

With such allocation to California, Arizona will receive approximately 65 per cent and California approximately 35 per cent of the waters of the Colorado River system below Lee Ferry, based upon the Colorado River Compact and Arizona's computations.

STATE RIGHTS

Much has been said in this conference about State rights and yet the whole theory of the Colorado River Compact, as well as the proposed Three State Compact, is in conflict with the State Rights Doctrine. It waives the rights of some States in favor of other States. Under the law of appropriations, as well established in the Western States, the citizens of any State may appropriate and use water for any beneficial purpose, and, regardless of State lines, so long as such use does not interfere with prior appropriations.

For nearly three hundred miles the Colorado River forms the boundary line between Arizona and California and all of the lands in either State which can receive water directly from the River lies adjacent to that portion of the River, thus forming the boundary line between the two States. Either State has the unquestioned right to divert and beneficially use such water as it may, not in conflict with prior appropriations, even to the extent of completely exhausting the supply. This is a beneficent rule designed to bring about the highest and most beneficial and most economic use of water so essential to development in the arid West. Arizona seeks not only to change this rule but to change it in such a way that she will have not only abundance of water for all known requirements but a surplus left over which will forever waste itself in the sea or be available for use in a foreign country and at the same time deprive California of water for its known requirements—even water long since appropriated and required for the completion of projects already well under way and of proven feasibility—in an amount of more than 1,000,000 acre feet per year. The Upper State

Governors have apparently concurred, in part, with Arizona in this view. Such a division of the use of water would be uneconomical even to Arizona. It is definitely discriminatory against California. It is wasteful and in direct conflict with all known rules for distribution of water in Western States, and is decidedly unfair to California. California, of course, cannot accede to so gross a violation of her State rights.

The Colorado River Compact is not for the protection of any rights of any State. The purpose of the Compact is to create rights in certain States which rights do not now exist. California is willing to approve the Compact and create those rights, but it is not obliged to do so. California is likewise willing to make an equitable agreement with Arizona and create rights in that State which do not now exist, but she is not obliged to do so and certainly she is not obliged to enter into or even consider an agreement which on its face is grossly unjust. Those temporarily entrusted with making decisions on her behalf would be untrue to their trust if they permitted her present necessities, great as they are, to influence them in binding future generations to an unjust agreement.

The Lower River cannot be developed for many years to come without California resources.

If California is to surrender rights which she now enjoys or is to assist in creating rights which do not now exist, and if California resources are to be employed in the development of the River which will benefit not only California but all of the Colorado River Basin, and particularly Arizona, then certainly California has some rights and some equities which should not be wholly ignored.

Arizona has developed more rapidly in her use of the Colorado River water than has California, and largely through Government financing. On this basis no Compact should be required by Arizona. But if she fears a slowing up of her development, however, then the most she has a right to demand is protection against the possibility of a more rapid future development in California.

She has no right to demand of California that which she is not willing to accord to California. She has no right to demand an arbitrary division of water; she has no right to demand title to water she cannot use, and which could be used in California. She has no more right to arbitrarily demand 50 per cent of the main stream than has Nevada the right to demand one-third of the main stream.

Under the present law California has the right to take and use the whole stream on her lands if necessary, and not in conflict with earlier appropriations, Arizona has the same right. If this well-established rule is to be changed by agreement, then the only demand which Arizona can, in justice, make is that the uses of the same character should enjoy the same priority in either State.

There is no justice nor equity in abrogating a well-recognized rule and tying up the title to water on the hope that some day it can be used by a pump lift of four hundred and fifty feet or more, when it is now needed and can be used economically in another State. The only theory of the Compact is to do equity between States which may not develop with the same rapidity. It is not upon the theory of the State's rights or the State's ownership of the water, but only in an equitable use of the water. To arrive at this equity, determination must be made of the uses to which the water may be applied on either side of the stream, with the same class of uses on each side standing in the same relationship one to the other.

CALIFORNIA'S REQUIREMENTS

At the present time there is actually being diverted and used by California 2,882,000 acre feet of water per year from the Colorado River. This is based upon service including in Imperial Valley only 462,000 acres of lands, whereas, Imperial Valley, with an appropriation going back to 1898 has long since had its canals in operation with a capacity of more than 7000 cubic feet of water per second and its canal system fully constructed to irrigate 515,000 acres of land, or 53,000 acres more than is actually irrigated at the present time, but which has the right to demand and could receive water at any time. This land would require, under present conditions, 291,500 acre feet additional, or a total for present demands in California of 3,178,500 acre feet, to which rights are fully established and which rights cannot be taken away by Compact or otherwise, but which are fully protected under the law.

In fact, the present California rights go much further. There are valid appropriations in California from the tributaries as well as from the main stream, not in conflict with any other appropriations, for something like 12,000 second feet of water, or enough to assure a supply for nearly all known requirements in that State. The water, in each instance, has been applied to use with diligence, and definite fixed rights have been acquired which cannot be taken away, at least without California's consent.

Imperial Valley is paying $96,000 per year to the United States under the contract of 1918, one purpose of which is to bring about this larger development for which rights have already been acquired.

In addition, all of the water that is now used in the Yuma project in Arizona is being diverted in California and passed through a power house in California for the generation of electric power. While this is for the sole benefit of Arizona and was constructed at Government expense, nevertheless it is a right in California which has actually attached to the beneficial use of this water and a right which cannot be taken away, but for the sake of this statement, claim to this additional water is not made by California.

In order to ascertain the total requirements of California we must add to the 2,882,000 acre feet present use, such water as will be necessary for the completion of present projects, rights to which have already vested; waters for known domestic requirements, with rights also vested, and water which can be served within an economic pump lift for irrigation purposes, considered by California to be one hundred and fifty feet.

The City of Los Angeles has already made a filing on 1500 second feet of water, or a total of 1,095,000 acre feet per year, for domestic purposes only for the benefit of itself and other Southern California cities. Bonds have already been voted by that city in the amount of $2,000,000 for preliminary work, and a large part of the same have been sold. Extensive work in the form of surveys, infiltration plans and otherwise

has been carried on. The City of Pasadena has now passed, or is about to pass, initiating ordinances for the formation of a Metropolitan Water District under the laws of California to take over and complete this great undertaking. Some twenty-eight cities in Southern California have expressed their intentions of becoming members of the District.

With the known water resources of the coastal plain of Southern California, now inadequate and rapidly being exhausted, and in view of the law of self-preservation and the known activities of these cities in that behalf, it may be taken as a settled fact that these coastal cities will actually divert and use 1,095,000 acre feet of water per year from the Colorado River for domestic purposes.

Under the All-American Canal there will be added to the present irrigated area in Imperial and Coachella Valleys 267,000 acres which will be served by gravity, requiring 1,174,800 acre feet of water per year, and 171,700 acres which will be served by a pump lift not exceeding 150 feet and requiring 755,480 acre feet of water per year.

There are projects already under way with water rights already vested and when completed will require, together with present uses, a total of 5,589,800 acre feet of water per year.

Under a pump lift of 150 feet there may be added to the above areas 121,650 acres requiring 485,100 acre feet of water per year, or a total demand in California for the present known projects of 6,074,900 acre feet of water per year.

ARIZONA DEMANDS

The total actually used in Arizona from the main stream at present is 306,000 acre feet per year, and with a pump lift of 150 feet, based upon figures furnished by Arizona, her total future demand, even including Indian land, which is unjustifiable and will be treated later, will amount to 1,739,500 acre feet per year.

COMPARISON OF ARIZONA REQUIREMENTS WITH CALIFORNIA REQUIREMENTS FROM MAIN STREAM

Upon these computations we find that of the present use from the main stream Arizona has 9.6 per cent, California has 90.4 per cent.

The use for projects existing and those under way will be, by Arizona 7.1 per cent, and by California 92.9 per cent.

For all known projects, present and suggested, under 150 foot pump lift, the water demands of Arizona will be 23 per cent and of California 77 per cent.

AVAILABLE WATER

The Colorado River system below Lee Ferry includes not only the main stream but all streams flowing into it below that point. Under the Colorado River Compact the Upper Basin States are required to deliver at Lee Ferry an average of 7,500,000 acre feet per year. The tributaries of the Colorado River in Arizona, upon her figures, produce a minimum of 6,000,000 acre feet per year, making a total in the Lower Basin of 13,500,000 acre feet of water per year, not considering the Nevada tributaries.

Of this total of 13,500,000 acre feet, California demands title to only 4,600,000 acre feet plus one-half of the surplus or unused water of the main stream over and above that allocated by the Colorado River Compact, or consumptively used in the Upper Basin. Upon this basis, without considering surplus or allocated water, upon the California proposal, Arizona would receive more than 65 per cent of the waters of the Colorado River system in the Lower Basin, and California would receive less than 35 per cent.

This is a smaller amount of title water than California, in good conscience, can be asked to take in the division of water among the Lower Basin States.

For California to make an agreement on her own proposal she will be 1,474,900 acre feet of water short of her present known requirements, while on the same basis Arizona will receive all of her tributaries, yielding at least 6,000,000 acre feet per annum, and also receive title to the use of all the water from the main stream which she can use up to and including a 200-foot pump lift, or 50 feet more than any considered by California, and have a surplus of 300,000 acre feet per year left over.

If California is to serve her present known requirements, upon her own proposal, she must receive from surplus or unallocated water—water to which she can have no title—1,474,900 acre feet of water per year. This would provide only for the known requirements, with no water whatever left over or wasted. Under the California proposal, if California shall receive this amount of surplus water for her known requirements, Arizona would receive a like amount which, together with her surplus of 300,000 acre feet of title water, would give her sufficient for all known requirements up to and including a 200-foot pump lift and 1,774,900 acre feet left over for her higher pump lifts, or to waste in the sea, or be applied to Mexican lands.

SUFFICIENT WATER WITH GOOD TITLE ESSENTIAL TO FEASIBILITY OF PROJECTS

The All American Canal, which is conceded by all to be necessary to the future protection of all of the Basin States, must be paid for by California lands. This will be a large undertaking. For it to be practicable it must be constructed to serve all of the lands that can be reached by it. Under the California law any contract for repayment must be submitted to a vote of the people concerned. If there is any question about the title to water sufficient to serve the lands the people will be reluctant to vote the obligation, and properly so. This is for the All-American Canal itself. Before it can be used extensive distribution must also be constructed. The money for the distribution system must be derived from the sale of bonds upon the lands to be served. The first step for such a bond issue, under the California law, is the submission of the whole proposition to a Commission known as the California Bond Certification Commission. This Commission first passes upon the feasibility of the project, and its first and most pertinent inquiry will naturally be whether or not there is a known water supply with good title and sufficient for the full development. The purpose of this Commission is to permit no bond issues that are not sound for investments of savings banks and public funds. To get by this Commission we must naturally show, not mere hope or possible expectancy or confidence that the water needed will be available but actual title to enough water for the purpose.

After the Commission has approved the issue, it is not yet an assured fact. It must be submitted to the people. Nearly all of those voting upon the proposition will be residents of the Imperial Irrigation District. This District already has a canal system, unsatisfactory to be sure, but nevertheless one that does supply them with water through Mexico. This supply may continue. Therefore the people in this District will be slow, and properly so, to vote bonds where there is a serious question about the title to the water supply. Still further, after the bonds are issued, they must be sold, and money is timid where security is weak or questionable.

The Coastal cities will be required to vote bonds to the

amount of perhaps $150,000,000 for their domestic water supply. These bonds require a two-thirds vote if they are to be issued by the cities, or a majority vote if to be issued by a metropolitan district. Such enormous financing cannot be done on a mere hope, and yet if California is allocated the use of only 4,600,000 acre feet of water to which she can actually acquire title, a large amount of this financing must be done upon the hope there will be a large amount of water which California may use even though she does not have title to it. As said before, to serve all of the lands proposed under the All-American Canal and to serve the Coastal cities, California will be more than 1,000,000 acre feet short. This figure makes financing extremely difficult, and to go below that figure will make it impossible and impracticable.

California has tried to bring about the Seven State Compact and to that end has been and is perfectly willing to enter into a fair and equitable agreement with Arizona. It is obvious, however, that neither a Three State Compact nor a Seven State Compact in and of itself is of value to California.

California is willing that the other States be fully protected in their future requirements. To do this, however, by Compact, California is simply waiving present and future rights which she is not willing to waive without the construction of projects on the River that will be absolutely necessary to safeguard her own future. If California cedes away title to so much water that she cannot economically finance or develop her own resources, then she has no interest whatever in the Three State Compact or the Seven State Compact.

When California offered to contract with title to only 4,600,000 acre feet of water she well recognized that her offer was at the danger point below which she could not go, and without the reasonable time limit for putting water to beneficial use which California suggested, she could not consider for a moment accepting title to so small an amount of water. California is willing to stand bound by the Seven State Compact and enter into a Three State Compact with the assurance of development, but if these Compacts are so rigorous in their terms as to tend to defeat this development, then California is not interested in either of them.

Section 2 of the Governors' suggestion, providing for allocation to Arizona of 1,000,000 acre feet of waters of the tributaries in that State, is accepted.

Regarding Section 3, in reference to other tributary waters, it will be understood that the waters of tributaries must be considered as part of the River system, and all taken into account in ascertaining what is "surplus water" for the purpose of supplying Mexican demands under Subdivision (c) of Article III of the Colorado River Compact.

We understand that Section 3 also means that after the water from tributaries reaches the main stream it is no longer to be regarded as tributary water, and the States in which the tributaries are located lose all claim thereto as tributary water.

The proviso attached to Section 3 is unnecessary and perhaps confusing. Other States which may be interested in some of the tributaries will not be parties to the proposed Three State Agreement and their respective rights cannot be protected or impaired by such agreement.

Subject to the foregoing suggestions and interpretations, Section 3 is accepted.

Section 4, subject to readjustment of the water allocations in Section 1 to comply with California requirements, is accepted except as to the part dealing with Indian lands.

Allocations to States for the use of Indian lands have no place in the proposed Three State Compact.

The water is for use of the United States, not a party to the Compact, and the United States would be under no obligation to respect such allocation. California objected to water for Indian lands being classed as a perfected right for Arizona and pointed out that California likewise has Indian lands and that no such provision is made for them. The proposal was then put in its present form, which is no more satisfactory to California.

It is apparent, taking the Governors' suggested allocation in conjunction with previous suggestions, that their proposed allocation to Arizona includes 675,000 acre feet of water for Indian lands. That is, we submit, unjustifiable, first, because it is in large part without basis in the theory of vested rights, and, second, it is an allocation to which Arizona is in no sense entitled. It really amounts to a double allocation to Arizona at the expense of vested rights in California, which, of course, was not intended by the Governors.

Moreover, the Colorado River Compact expressly provides that nothing therein shall be construed as affecting the obligation of the United States of America to Indian tribes, and clearly the proposed Three State Compact should deal with the subject of Indian lands in the same fashion.

Regarding Section 5, relating to "unapportioned waters," if the term "unapportioned waters" means waters not otherwise apportioned by the proposed Three State Compact, such term is satisfactory. If it means unapportioned by the Colorado River Compact, then it is not satisfactory, as the Lower Division State should have the use of all of the waters of the Colorado River below Lee Ferry, subject to the terms of the Colorado River Compact.

Section 5 further provides that the use of the waters so divided shall be "subject to future equitable apportionment between the said States after the year 1963." This is not satisfactory. It will also be even more difficult to ascertain and divide the equitable use of such water as may not then be in actual use than it is now. Hence, the California suggestion is that any water not actually put to beneficial use for agricultural or domestic purposes prior to October 1, 1963, shall thereafter be subject to appropriation and use in either State, pursuant to its laws. California maintained, and still maintains, that twenty years is a reasonable time, after which water not put to beneficial use should be open to appropriation, but at the insistence of the Upper State Governors and others that period was extended to 1963. It is only with some such provision as this that California can accept so small an allocation of title water as 4,600,000 acre feet per year.

The latter part of Section 5, providing that the use of the so-called unappropriated waters between the Lower Basin States shall be without prejudice to the rights of the Upper Basin States to further apportionment of water as provided by the Colorado River Compact, is rejected. That provision, designed to protect the Upper Basin States against equities created by use of water in the Lower Basin, has no place in the proposed Compact to which the three Lower Basin States alone are to be parties, and besides, is unfair to the Lower Basin States.

OTHER POINTS

There are other points, more or less of detail, and yet important, that should not be overlooked in the drafting of a Three State Compact, among which is the provision, like one contained in the Colorado River Compact, that no State shall demand the delivery of water and no State shall withhold water that cannot be reasonably applied to beneficial use. There is also the provision defining the relative proportions of the Mexican demand each State should bear. Other essential provisions for such Compact might be mentioned by us, but we will not attempt to discuss them at this time.

Respectfully submitted,
CALIFORNIA RIVER COMMISSION,
By John L. Bacon, Chairman.

Boulder Dam Progress

THE SECOND construction stage on the Boulder Dam project is fast becoming history. Notable accomplishments have followed one another in rapid sequence. A year ago our issue of December 15 was composed of ten articles commemorating the completion of the first stage of the construction. Such a high tempo of activity had been maintained on that preliminary work, leading up to river diversion, that the project was a year ahead of schedule. Now, after another twelve months of even greater accomplishment, the work appears to be a full two years ahead of the originally scheduled date of completion. How such success has been achieved is told in the following:

Reprinted from Engineering News-Record, December 21, 1933

SECOND STAGE AT BOULDER DAM

This reprint chronicles the operations involved in stage 2 of the Boulder Dam construction. By chance it follows just a year after the special issue of Dec. 15, 1932, which was devoted to stage 1, the work leading up to river diversion. Progress then was one year ahead of schedule; due to remarkable speed of construction during 1933 it is now a full two years ahead. The procedures which have made this record possible are described in the accompanying articles.

Engineering News-Record

New York

December 21, 1933

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A Year of Achievement at Boulder Dam

By Dr. Elwood Mead
Commissioner, U. S. Bureau of Reclamation, Washington, D. C.

I VISITED Boulder Dam on November 15. An interval of one year had elapsed since my preceding visit. In that time the river had been turned from its course, the foundations of the dam excavated, the concrete mixing plant and works for the fabrication of penstock pipes had been erected and put in operation. It had been a year of remarkable achievement, marked by the installation of equipment of greater size and strength than ever before required or used. A number of construction records had been broken.

The construction of Boulder Dam and power plant goes on day by day with the same order and efficiency that has marked these operations from the beginning, but today construction is more varied and complicated. Six Companies, Inc., is not only building the dam, but is driving and lining penstock tunnels and preparing the foundations for the power house. The Babcock & Wilcox Co. is fabricating the great penstock pipes. The gates that regulate the flow of water to the turbines are being installed and in half-a-dozen great factories of the country, power equipment, of which the turbines and the generators are the largest ever made, is being constructed. This requires that different operations shall fit into each other to avoid confusion and delay. It places on the Bureau of Reclamation a greater burden than ever before in preparing for the contractors the details of plans. The tracings of these details turned out of the Denver office each month run into hundreds. The accompanying view is indicative of the operations that are plugging the gorge of the Colorado River for the first time.

Black Canyon as it appears at present. Nearly 1,000,000 yd. of concrete have been placed in Boulder Dam.

The area between Boulder City and the dam site, including the canyon walls on both sides of the river, is more striking than ever before. Thousands of tourists visiting the project each week are carrying back to their homes stories of the impressiveness of these colossal operations. A tourist bureau to pilot visitors and explain what it all means is being run as a private enterprise and is proving a profitable convenience.

The network of highways which traverse the deep gorges and precipitous cliffs between Boulder City and the dam is one of the spectacular features. Buses traveling over these roads carry 150 workmen at a load from Boulder City to the job. Scenic panoramas of the highway are supplemented by those of the bridges and suspended cableways that span the river from canyon wall to canyon wall. Some of these cableways are the largest ever made, and with powerful operating machinery are a vital factor in the employment of thousands of workers, who continue to make new records in speed of construction.

It now appears that water will begin to be stored in 1934

and power generated in 1935, nearly two years in advance of the original schedule.

When I first saw the site of Boulder City it was a hideous desert. Now attractive headquarters of the government and contractors, churches, stores, a motion-picture house, the largest in Nevada, and the new hotel, all set in an expanse of well-kept lawns and thousands of trees and shrubs, present a picture not only of comfort but of beauty, which has helped to develop in more than 5,000 residents a civic pride that is one of the influences which goes to build up the remarkable morale of this organization. To the original desire of the Bureau to do all that was possible to insure health and comfort to the workers, there has been added, through cooperation with those workers, an attractiveness and beauty that is causing many of the business men and workers to desire the town as a permanent home. They are hoping that the completion of the dam may be followed by the establishment of industries which, with the visitors attracted by the scenic beauties of the great lake that is to stretch up the canyon for 100 miles, will make Boulder City a permanent and substantial town.

On my recent visit I first visited the canyon at night. The 20-ton buckets carrying 8 cu.yd. of concrete at a trip were being loaded and handled more quickly and with more accuracy than even seen before. This smoothness of operation permits more than 6,000 cu.yd. of concrete to be placed in the dam each day. This speed has been made possible by the improvements in the details of the cooling system, under which the 2-in. pipes originally contemplated have been displaced by 1-in. tubes with very thin walls, by which the temperature of the concrete is being lowered to 54 deg. before the next layer is placed.

Benefits are nation-wide

An interesting point about all these construction operations is the wide distribution of the money spent for the project. A common error of thinking assumes that this money is expended in Arizona and Nevada alone, but at this time 40 per cent of the monthly payrolls are going to buy steel, pay for fabrication of gates, turbines and generators, all of which comes from east of the Mississippi River. One has to talk with those who operate these great industrial works to know what a contribution the construction of Boulder Dam is proving to be to our industrial recovery.

The personnel that planned this development and that is directing construction has shown itself equal to the task. In the Reclamation Bureau R. F. Walter, as chief engineer, John Savage, as chief designing engineer, and Walker Young as construction engineer have ably met the emergencies and the difficulties as they arose. Six Companies, Inc., is a great organization. Frank Crowe and Charles Shea have shown courage and resource of high order. The fabrication of the penstock pipes, 30 ft. in diameter, is a major engineering problem. I. Harter, vice-president of Babcock & Wilcox Co., who directs this, belongs to the Boulder Canyon group. On the whole, this construction is a research school in engineering. Boulder Dam and power plant not only mean great structures but a distinct advance in engineering science and methods.

Reviewing the Past Year at Boulder Dam

By J. I. Ballard
Pacific Coast Editor, Engineering News-Record

TWELVE MONTHS AGO the preliminary stage of construction on the Boulder Dam project had been completed, marked by the diversion of the river, and work was centered on building the permanent cofferdams, excavating the dam site proper and concreting the dam to an elevation above flood level. Today, this second and intermediate stage of the program is fast becoming history and the operations are settling down to the final stage—manufacturing and placing 3,400,000 cu. yd. of concrete in the dam. A year ago the work was described in terms of "excavation and trucks"; today the feature is "concrete and cableways." Then, it was a deafening roar of machines and explosives in the fierce drive to get the cofferdams finished and the site ready; today, the atmosphere is characterized by a quiet, orderly rhythm of concrete placing with the swing of giant cableways. A year ago, at the completion of the first major stage of the construction program up to the diversion of the river, the history of the project and a review of all operations were presented in a special number of *Engineering News-Record*, Dec. 15, 1932; the present issue brings this reporting to date. This second progress review outlines the work of the past year and describes in detail the concrete, its development and characteristics, and the methods of placing which will constitute one of the main features of the work for the following year. For the proper orientation of the material presented in the following pages and to provide a link between these two special issues it is proper to review briefly the accomplishments of the past twelve months.

When the river was diverted from its channel into the 50-ft. diameter tunnels on Nov. 13, 1932, it was the signal for the start of a phenomenal excavation and earth-moving operation. To insure an uninterrupted construction program in the canyon, it was essential to complete the two permanent cofferdams before the spring and summer flood season of 1933. It was equally important to prosecute the excavation of the dam site at the same time from the standpoint of economy in time and use of equipment. As a result, the two operations were combined, and week after week trains and trucks moved in and out of the canyon at an ever-increasing pace. During the month of December 440,000 cu. yd. of fill was placed in the upstream rolled-earthfill cofferdam, and the total excavation handled for the same month—fill going into the canyon and rock coming out—was 593,000 cu. yd. This work (*ENR*, June 15, 1933, p. 776) involved the use of about 80 trucks and seven trains and continued at high speed through the month of March.

The volume of excavation decreased as the work approached final clean-up late in the spring with the opening up of the narrow gorge in the center of the channel (page 735). Finally, foundation

One of the pleasing vistas in Boulder City, looking from the yard in front of the administration building toward the hospital of the Six Companies. Other sections of the town still retain much of the desert character, with no grass and the sand drifting over sidewalks and streets.

rock was exposed over the entire area and received geological approval. Along the line of the upstream face of the dam the cutoff trench was extended farther into rock, narrowing to a width of about 10 ft. and extending at its lowest point to El. 503, which is about 140 ft. below original low-water surface (El. 645) at the site. This depth for the lowest concrete fixes the total height of the dam as 729 ft. to the crest at El. 1,232. In June, 1933, concrete placing started in the dam. The concrete to form this 3,400,000-cu. yd. mass, its antecedents, the cement, the mix, forms, placing and the important cooling system are described in the following articles.

While this essential work was going forward, other features were kept in step to balance the accelerated construction program. The two side-channel spillways high on the sides of the canyon, with a total capacity of 400,000 sec.-ft., were practically completed and are described by the designer in the article on page 754. In preparation for the fabrication and installation of the steel penstock pipes, a large ultra-modern steel-fabricating plant, including provisions for X-raying welded joints, had been built near the site and was placed in operation, rolling and welding sections of penstock. The plant and the methods of fabrication are described on page 751. Also, the tunneling program to complete the smaller penstock and outlet tunnels has been completed, and lining is under way on these smaller bores (p. 757).

During the year the floodflow of the river did not exceed 80,000 sec.-ft., as compared to about 100,000 sec.-ft. for the preceding year, which is about average. Of course, floodflows up to 200,000 sec.-ft. are provided for by the permanent cofferdams, which were completed months before the 1933 flood season, but the low peak provided a construction advantage in allowing the turning of the river out of one or two of the tunnels by temporary dams, to permit work on final grouting and connection to the spillways to be continued.

With almost one-quarter of the concrete already placed in the dam, the project continues to move forward toward a completion date of Dec. 31, 1936. The dam itself, according to present schedule, will be completed in a nineteen-month period, ending about December, 1934.

Future Progress Recharted on Work Yet to Be Done

By R. F. Walter
Chief Engineer, U. S. Bureau of Reclamation, Denver, Colo.

ON DECEMBER 15, 1933, more than 800,000 cu.yd., or about a fourth of the total of about 3,400,000 cu.yd. of mass concrete in Boulder Dam, was in place. At the time of letting the construction contract in March, 1931, the tentative construction program called for placing the mass concrete during the period from December, 1934, to August, 1937. If present progress of placing continues, this feature of the work will be completed by May 1, 1935, or two years and three months in advance of the date originally contemplated.

One year ago construction had progressed so rapidly that it was then estimated that the river-diversion bulkhead gates could be closed and storage of water commenced on June 15, 1935, or one year ahead of the original program. Now it appears that there is an excellent prospect of performing this operation in the late summer of 1934.

In addition to placing the balance of the mass concrete in the dam, there remains to be completed the construction of the following major features: the intake towers, the plate-steel pipe in the pressure tunnels, the canyon-wall outlet works, the downstream tunnel plug outlet works, the power house and the removal of the downstream cofferdam and rock barrier.

Of the appurtenant works, probably no feature attracts as much attention as the four intake towers of reinforced-concrete constructiton. These towers, tapering from an overall diameter of 82 ft. at their bases to about 64 ft. at their tops, will rest on the canyon walls upstream from the dam, two in Arizona and the other two in Nevada. They are identical in design and will rise from a foundation elevation 388 ft. higher than the lowest point of foundation excavation for the dam. The total height to the top of the gate-operating house will be 380 ft. Each tower will house two 32-ft. diameter cylinder gates, one at the base and the other 150 ft. higher, by which storage water will be released to the outlet and power penstock tunnels.

Geological investigations give no indication of recent seismic disturbances in the vicinity of the dam, but on account of the great height and relative slenderness of these towers it was considered wise to design them to take earthquake shock. Thus, while concrete in each tower will amount to only 21,000 cu.yd., 6,500 tons of steel bars will be used to provide heavy reinforcement, amounting to slightly over 150 lb. of steel per cubic yard of concrete.

Single-span steel girder bridges with framework incased in concrete will connect each downstream tower to the top

Excavation of the deep central notch in the floor of the canyon was well advanced by May 1, 1933 (left), and concrete placing started in this area about the middle of June (right).

A network of cableways swings high over the gorge. This one and its mate, both of the traveling type, serve the two spillways and the upstream portion of the dam.

of the dam, and to the upstream tower on the same side of the canyon. The average span length of each of these four bridges will be 107 ft.

Excavation for the towers has been completed and construction of the two towers nearest the dam is starting, with the expectation that they will be completed by next June. Present construction plans anticipate completion of the two upstream towers by January, 1935, and the construction of the connecting bridges during the spring of that year.

Excellent progress has been made during 1933 by the Babcock & Wilcox Co. on its contract for furnishing and installing the plate-steel outlet and power penstock pipe. The steel plates are shipped to the modern fabricating plant erected by the contractor near the dam site, where they are rolled and welded into circular sections convenient for short-haul railroad and truck transportation to the top of the canyon downstream from the dam on the Nevada side. The fabricated sections are then moved by a permanent 150-ton cableway, provided by the government, to the mouths of construction adits in the canyon walls, whence they are transported to their final position in the concrete-lined tunnels and joined to adjacent sections.

The total weight of installed plate steel involved in the contract is 44,820 tons. The largest fabricated sections will be 30-ft. inside diameter and 24 ft. long, with a maximum plate thickness of $2\frac{3}{4}$ in. Such a section will tax the capacity of the permanent cableway.

It is expected that all pipe in the tunnels leading from the downstream intake towers will be installed and ready for operation by late fall of 1934, and that the balance of the pipe will be installed during 1935 and 1936.

The canyon-wall outlet works, located on each side of the canyon at the ends of the upper penstock tunnels, will regulate the flow of all stored water released through the downstream towers that is not used for the generation of power. A valve house will be constructed on each side inclosing six 84-in. internal differential needle valves and an emergency gate for each. These valve houses, perched on narrow shelves excavated high upon the canyon walls, will be about 65 ft. high, 35 ft. wide and almost 200 ft. long, the last dimension being parallel to the canyon. Excavation for these houses has been completed recently, and their erection should be finished before next summer.

The downstream tunnel plug outlet works, located in each 50-ft. inner diversion tunnel several hundred feet upstream from the outlet end, will regulate the flow of all stored water released through the upstream towers, which is not used for the generation of power. The interior chambers that house these outlet works will have a maximum width of about 115 ft. and a height at the location of the gate-operating gallery of about 65 ft. The chambers require the widening of the diversion tunnels for a length of almost 200 ft. Each chamber will house six 72-in. internal differential needle valves and an emergency gate for each.

A large part of the excavation for the tunnel plug outlet works has been completed, but present plans call for the major construction and the completion of these works during the first six months of 1935.

The power house, located at the downstream toe of the dam, will consist of two wings, one on each side of the river, which will be connected at their upstream ends by a structure accommodating operation, shop and storage rooms. The river face of each wing will have an over-all length of about 575 ft., a depth from this face to the excavated canyon wall of 76 ft. and a height from the generator floor to the top of the roof of 85 ft.

Present plans provide for placing eight 82,500-kva. units in the Nevada wing, and seven 82,500-kva. units and two 40,000-kva. units in the Arizona wing. All power-plant machinery is to be installed by the government as needed. The greater part of the foundation excavation for the power house has been completed. It is planned to complete the power-house substructure by June, 1934, and the superstructure prior to the following September.

After completion of the power house the downstream cofferdam and rock barrier must be removed to clear the tailrace for the generation of power. This will require the excavation and disposal of over 400,000 cu.yd. of earth and rockfill materials, which it is planned to accomplish during the winter of 1934-'35. It is expected that the first power units will be placed in operation in September, 1935.

A number of smaller features, and of somewhat lesser importance than those mentioned, will be in progress of construction during the next three years. It is more than likely, judging from the past rapid progress made, that all features of the work will be completed by the early spring of 1937, or at least a year in advance of the date originally contemplated.

MAJOR ARTICLES ON THE BOULDER DAM PROJECT PUBLISHED IN PREVIOUS ISSUES OF ENGINEERING NEWS-RECORD

Mass Concrete for Boulder Dam—Its Development and Characteristics

Size and construction speed dictate new provisions to control heat and shrinkage cracks—Properties of the aggregate and mix and advantages of the special low-heat cement—Problems of placing and cooling the concrete

By Byram W. Steele
Designing Engineer on Dams, Bureau of Reclamation, Denver, Colo.

CONCRETE PROBLEMS of a magnitude never before encountered in dam construction provide one of the outstanding features of the Boulder Dam project. They result directly from the record-breaking height of the structure and the relation of this dimension to the mass of concrete, for if the dam had been twice as long as any previous dam, rather than twice as high, it would not have attracted such widespread attention or involved the present concrete problems. However, it was the volume of concrete which resulted in expenditures that, in turn, made feasible the research commensurate with the magnitude of the problems.

The preliminary results of these studies, which can now be reviewed in part for the first time, should form the basis for opening a new era in the field of large concrete-dam construction. It is the intent of this article to present a review of developments in mass-concrete work that have resulted from the years of experience of the Bureau of Reclamation in the design and construction of dams, with special reference to the unusual features of the concrete used in constructing Boulder Dam.

Past Experience — The Bureau of Reclamation has been placing concrete in large and small masses since its establishment in 1902. The variety of operating conditions embodied in its experience resulted in various conclusions, including the judgment that it was not economically practicable to introduce larger rock into mass concrete than could be run through the mixer. It was also apparent that the design of mixers to handle cobble-rock concrete warranted further study to the end that the batch would be a uniform mass when dumped. The attainment of uniformity in a mass-concrete mix containing cobbles is much more difficult than in other classes of concrete.

This experience indicated the desirability of a combined field and laboratory study of the maximum size of aggregate permissible in mass concrete and the minimum cement requirement for satisfactory results, together with many other specialized problems. Not until the construction of Boulder Dam was authorized, however, did the expenditure of sufficient funds to carry on such experiments seem warranted.

Recent developments

In recent years it has been noted that the combination of construction speed, rapid-hardening cement with attendant greater evolution of heat, and higher dams has resulted in increasing the volume change in mass concrete and consequently has accentuated the number and width of contraction cracks.

It has always been customary in dam construction to form radial or transverse contraction joints, but not until these modern factors became cumulative did the necessity for longitudinal contraction joints become evident. Cracking is objectionable in any structure, of course, but it is believed that cracks in a hydraulic structure, such as a dam, should be especially avoided, since they may directly or indirectly affect the stability, permeability, appearance and durability of the structure.

The primary cause of cracking is volume change resulting from temperature variations. To control this volume change so as to obtain, by means of contraction joints (designed cracks) and pressure-grouting, a monolithic dam, necessitated research along many lines and resulted in the inauguration by the bureau of an unprecedented program of mass-concrete research. This study has been in progress for the past 2½ years and is now approaching completion.

Stress distribution

In the construction of any large dam the engineering problems may be placed in two groups: (1) a design to secure a satisfactory distribution of stress; and (2) a construction plan that will result in essentially the same distribution of stress in the finished structure as contemplated in the design. To fulfill the latter, the various parts of the structure must be capable of transmitting compression and shear to all adjacent parts, which in turn requires proper shaping of the contact surfaces between adjacent sections with regard to the direction and magnitude of the stresses to be transmitted.

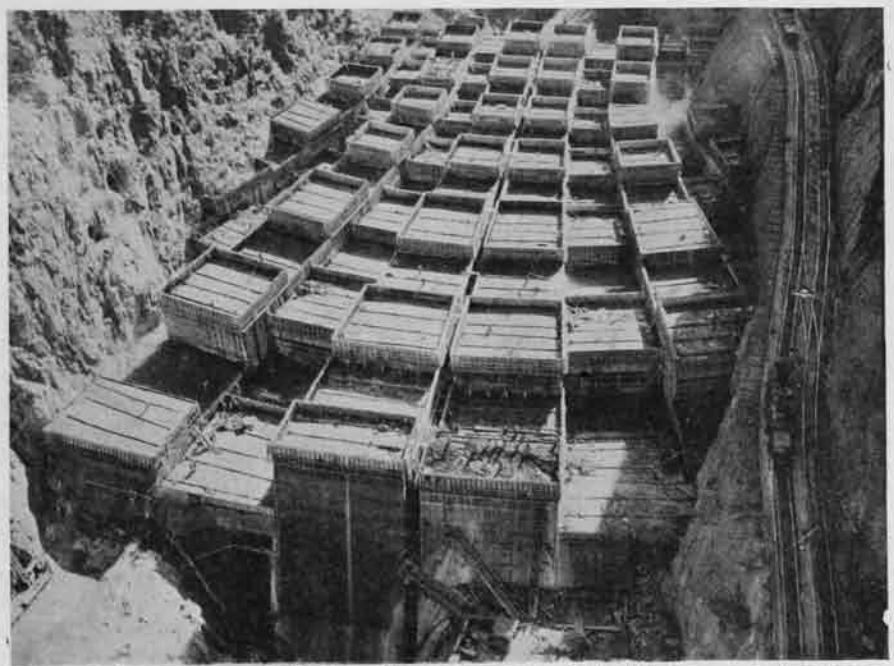


Fig. 1—Early progress on a 3,400,000-cu.yd. mass of concrete, 650 ft. thick from up- to downstream face, that presented a great many problems of unprecedented magnitude. Note the columnar construction, the central 8-ft. slot for the cooler-pipe headers and concrete placing under way on one of the blocks in the foreground.

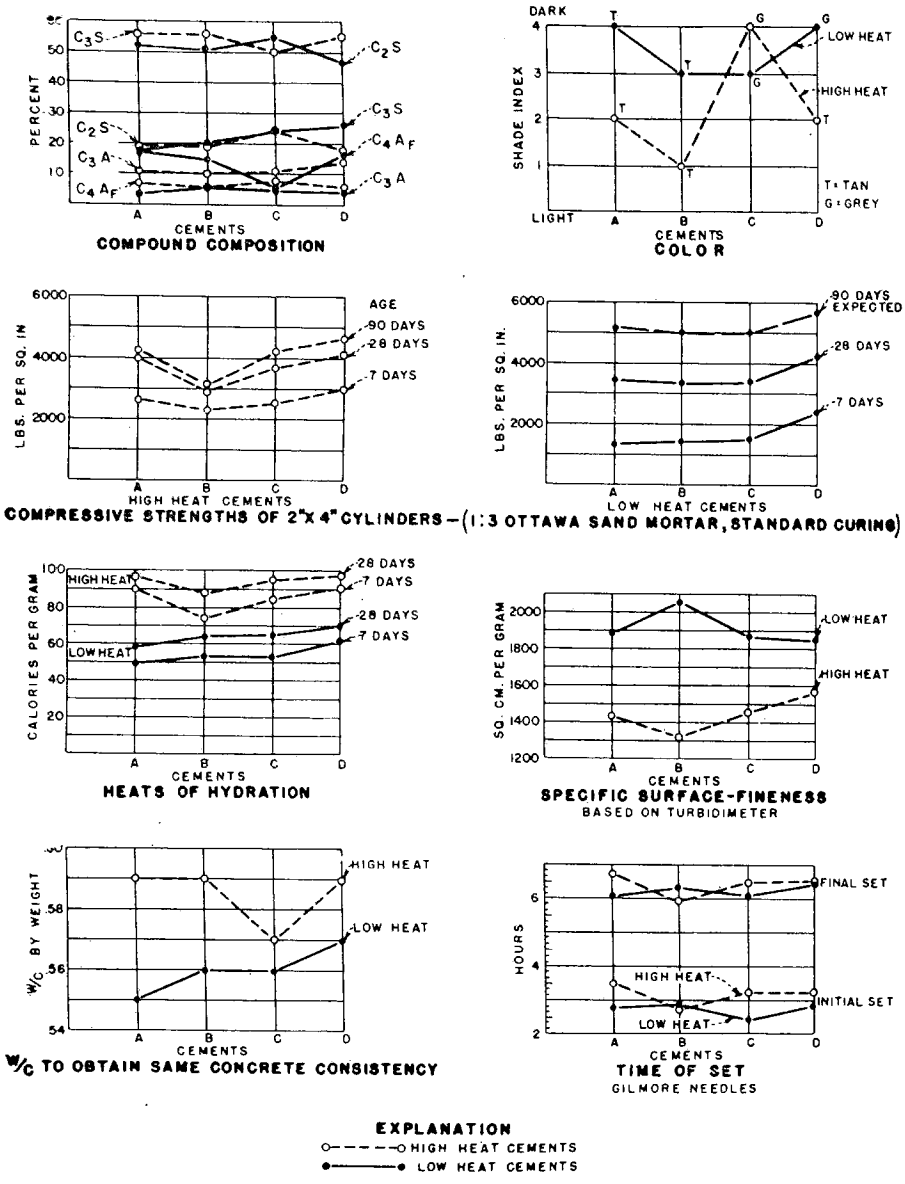


Fig. 2—Characteristics of the low-heat cements compared to the standard cement from the same four mills (A. B, C and D) based on laboratory studies.

All of the above assumptions imply a structure which is in effect monolithic. If it is not monolithic and volumetric changes take place within the structure, the desired stress distribution does not obtain.

The method of providing for volume change within the mass is treated later in the discussions of refrigeration and grouting. If this volume change were not provided for, a sequence of stress distribution would begin at the time of completion, with initial expansion to maximum volume as a result of the chemical heat generated by the hydrating cement, placing all parts of the structure in contact. The resulting structural unit and the stress distribution would be only temporary, however, for, as the heat within the mass was dissipated and the exposed surfaces cooled and contracted, parts of the dam would be called upon to assume additional load. This process of cooling and contraction from the exterior might be conceived to continue until a condition is reached where the entire load on the structure is carried by a central core, still intact, with a unit stress greatly in excess of the allowable, possibly impairing the safety of the structure.

To correct this condition would require successive grouting of joint openings and shrinkage cracks over a long period of time, as is being done in the case of one of the high dams in this country. This type of treatment is not well adapted to a structure of the magnitude of Boulder Dam and would place responsibility for the safety of the structure on a future generation of operators who might not appreciate the gravity of the situation. The adopted plan of cooling and grouting as construction proceeds, however, will result in a monolithic structure, the safety of which will not be impaired by volumetric change.

Specifications

In the concrete specifications for Boulder Dam, special provisions were included to insure a mass-concrete structure superior to any heretofore constructed. In brief, the specifications represent an attempt to secure those qualities which make for the greatest durability of mass concrete at the lowest practicable cost. As evidence of the generally favorable reception accorded these specifications, it has been noted that several specifications for dams published since have provided for similar methods and materials.

Proportioning by weight, which had become generally accepted practice, was incorporated in the specifications and was amplified by providing that "The equipment shall include an accurate automatic recorder, capable of being locked, for visibly and graphically recording the time of weighing and the actual amount of each separate concrete ingredient weighed out." Further, the desire for greater uniformity in concrete consistency from batch to batch led to the provision which required the contractor "to equip each mixer with an efficient recording consistency gage and timer" for indicating and recording the consistency of the mix during its sojourn in the mixer.

Maximum slumps were specified for the various classes of concrete, with the provision that "Only sufficient water shall be used to secure a plastic concrete of suitable workability which, without segregation, will flow or can be worked properly into place with thorough spading or working," and with the further provision that "The government reserves the right to require a lower water-cement ratio in any and all mixes than required to produce these slumps whenever, in the opinion of the contracting officer, such lower water-cement ratios are practicable and will produce concrete of better quality."

The curing of mass concrete in the dam was adequately provided for in the specifications by the provision that "All horizontal construction joints in the dam . . . shall be kept continuously moist, regardless of time, until they are covered with concrete," and that "The upstream and downstream faces of the dam and the surfaces of all contraction joints in the dam shall be kept continuously moist for at least two weeks after the concrete is placed."

Special cement

Desire for the utmost in durability was the primary motive which dictated the features of design and construction. The selection of a special cement was only one of the many developments in connection with the manufacture of mass concrete.

Cement having qualities different from that usually purchased under federal specifications SS-C-191 was first considered to assist in control of maximum temperatures in the concrete and thus decrease the total amount of heat to be extracted. Since it was necessary to control the chemical composition of the cement to obtain lower heat-generating qualities, it was decided to investigate

at the same time the possibility of obtaining other desirable qualities such as: (1) increased workability by closer control of the fineness; and (2) greater durability by modifying the chemical constituents. Cement specifications were reviewed in *Engineering News Record*, Nov. 10, 1932, p. 558. The cement is at present being purchased from four mills in southern California and blended at the dam site.

The reduction in water-cement ratio that resulted when the special cement was substituted for standard cement in August was from 0.642 to 0.597. Fig. 2 indicates the principal properties of four brands of low-heat cement and regular commercial cement from the same mills. The data applying to low-heat cement are representative of about 200,000 bbl. used during September, 1933. In general, the characteristics of the finely ground special low-heat cements (high in dicalcium silicate and low in tricalcium silicate and tricalcium aluminate) as compared with the higher-heat commercial cements are:

(*a*) Heat generation about one-third less.

(*b*) Marked improvement in workability of concrete with lower water-cement ratio, due principally to higher fineness.

(*c*) Greater uniformity of concrete as a result of blending and controlling composition.

(*d*) Less rapid strength development but probably greater ultimate strength in mass concrete.

Results of recent research also indicate that greater durability may be expected with the special cement now being used at Boulder Dam as a result of the decreased tricalcium aluminate content. In this connection it is believed that control of this compound, as adopted for the limiting of generation of heat, is worthy of serious consideration for all cements because of the apparent effect on durability.

Standard cements from different plants, and even from the same plant over a period of time vary considerably in physical and chemical properties due to the variability of raw materials and manufacturing control. As a result of the improvement brought about by blending, it is a certainty that if the project were to be started over again, all cement would be blended to eliminate the trouble experienced from non-uniformity of cement of various brands.

TABLE I—GRADING OF ARIZONA GRAVEL USED IN BOULDER DAM CONCRETE

Sieve Size	Sand		Gravel		Combined	
	Per Cent Retained	Cumulative Per Cent	Per Cent Retained	Cumulative Per Cent	Per Cent Retained	Cumulative Per Cent
9 in.	.....	.....	0	0	0	0
6 in.	.....	.....	9.41	9.41	6.98	6.98
3 in.	.....	.....	21.61	31.02	16.04	23.02
1½ in.	.....	.....	23.48	54.50	17.41	40.43
¾ in.	.....	.....	20.63	75.13	15.31	55.74
⅜ in.	.....	.....	14.63	89.76	10.85	66.59
No. 4	.....	.....	10.24	100.00	7.60	74.19
No. 8	17.01	17.01	.....	.....	4.39	78.58
No. 14	11.63	28.64	.....	.....	3.00	81.58
No. 28	15.03	43.67	.....	.....	3.88	85.46
No. 48	41.54	85.21	.....	.....	10.72	96.18
No. 100	12.34	97.56	.....	.....	3.19	99.37
Pan	2.44	100.00	.....	.....	0.63	100.00
Total	100.00	F.M. = 2.72	100.00	F.M. = 8.60	100.00	F.M. = 7.08

TABLE II—PROPORTIONS OF THE MIX AND CHARACTERISTICS OF THE BOULDER DAM CONCRETE

	Size, (In.)	Proportions	Weight Dry-Rodded, Cu. Ft.	Spec. Grav.	Voids, Per Cent
Cement	.....	1.00	.....	....	..
Sand	.....	2.45	109.6	2.64	33
Fine Gravel	¼-¾	1.75	.....	....	..
Inter. Gravel	¾-1½	1.46	.....	....	..
Coarse Gravel	1½-3	1.66	.....	....	..
Cobbles	3-9	2.18	.....	....	..
All Gravels	.....	....	121.0	2.69	28
All Aggregates	.....	....	137.6	2.67	17
Water	.....	.54	.....	....	..

One part cement to 9.50 parts total aggregate.

Mass Concrete Characteristics:

Weight 156 lb./cu. ft.
W/C 0.54 by weight
Paste content 19.5%
Poisson's ratio 0.18

Slump 3½ in. at forms
Cement yield 1.01 bbl./cu. yd.
Modulus of elasticity 5,200,000
Strength (28 days) in 36x72-in. cylinders 3,100 lb./sq. in.

TABLE III—COMPRESSIVE STRENGTH OF BOULDER DAM MASS CONCRETE
(Pounds per Square Inch)

Test Age in Days	Full-Mass Mix, 9-in. Max. Size				Wet-Screened to 1½-in. Max. Size				
	18x36-In. to 36x72-In. Cyl.				36x72-In. Cyl.	6x12-In. Cyl.			
	Standard Cured		Mass Cured		Std. Cured	Std. Cured		Mass Cured	
	High-Heat cement	Low-Heat cement	High-Heat cement	Low-Heat cement	High-Heat cement	High-Heat cement	Low-Heat cement	High-Heat cement	Low-Heat cement
7	....	....	....	....	2,260	2,990	1,440	3,680	2,240
28	3,100	2,670	3,640	3,120	3,370	4,040	3,210	5,010	4,090
90	3,680	....	....	....	3,920	5,050	4,360	5,180	4,350
365	4,250	....	....	....	....	6,070	....	....	....

The mix

Mass concrete for Boulder Dam contains 1 bbl. of cement per cubic yard. The selection of this minimum cement content is the result of past experience, laboratory studies, design stipulations in regard to strength and a careful digest of available data on durability and permeability.

The Arizona gravel pit, the source of aggregate supply, is a typical water-borne deposit of well-rounded particles of excellent quality. The sand is largely quartz, while the gravel is made up principally of limestone, intermixed with granite, basalt and quartzite. The material is unusually clean and contains no organic impurities.

The average grading or yield of the deposit was determined from test pits. Grading was changed only slightly in the final mix design resulting from large cylinder tests in the Denver laboratories of the bureau. The only changes from the natural grading were: (1) slight reduction of the No. 48 and smaller sizes; and (2) crushing of the material retained on a 9-in screen. Limiting the maximum size to 9 in. was desirable from the standpoint of mixing and placing operations. Grading is shown in Table I.

Comparison of Table I and the characteristics of the proportions of the concrete mix shown in Table II indicates that Boulder Dam is essentially a transposition of the Arizona gravel deposit with the voids filled by a high-quality cement paste, since the paste content in the concrete is only 2 per cent greater than the void space in the dry rodded aggregates.

Properties of the concrete

Compressive strength of the concrete (Denver tests) is shown in Table III. In this table the term "standard curing" refers to storage in fog rooms maintained at 70 deg. F. (±2 deg.), and "mass curing" indicates curing adiabatically in sealed containers on a rising temperature cycle for 28 days and at 70 deg. F. thereafter.

Extensive tests show that identical strengths for the full-mass mix (9-in. maximum aggregate) are obtained in 18x36-in., 24x48-in. and 36x72-in. cylinders. This fact greatly simplifies the testing of mass concrete, since an 18x36-in. specimen requires only one-eighth as much material as a 36x72-in. test cylinder.

Young's modulus for the full-mass mix in large cylinders varies from 5,200,000 to 6,500,000, according to curing, type of cement and age at test; the average value is about 5,700,000. The 1½-in. maximum wet-screened concrete in 6x12-in. cylinders gave values from 4,900,000 at seven days to 6,450,000 at one year. Poisson's ratio varies from 0.18 to 0.23.

TABLE IV—COMPARISON OF DENVER LABORATORY AND FIELD TESTS FOR CONCRETE

Test	Field	Denver Lab.
High-Heat Cement		
Net W/C by weight	0.56	0.53
Slump, in.	4½	3¼
Actual 28-day strength	3760	4040
Adjusted 28-day strength	4250	4040
Low-Heat Cement		
Net W/C by weight	0.53	0.55
Slump, in.	3¾	3⅛
Actual 28-day strength	3210	3210
Adjusted 28-day strength	3310	3210

The relation between full-mix strengths in large cylinders and the 1½-in. maximum wet-screened concrete in 6x12-in. cylinders (usual field-test specimen) is indicated in Table III. Apparently this relation for the Boulder Dam mix varies only with strength, while type of cement, method of curing and test age have no appreciable effect.

Unusually close correlation has been obtained between the field and laboratory. Various mixes have been tried in the field, and at present the field mix and gradation are almost identical to those established by the large cylinder tests in Denver and the test-pit explorations.

It is gratifying that this gradation has been proved by actual gravel-plant operations and that practically the only waste material is a small proportion of the finer sizes of sand which are removed by washing in the sand classifier.

The Denver laboratory and field values for water cement ratio, slump and compressive strength of 1½-in. maximum wet-screened concrete in 6x12-in. cylinders at 28 days are given for comparison in Table IV. High-heat (ordinary) cement was used in the lowest sections of the dam as a result of the advance in the contractor's placing schedule. The field values given for high-heat cement are averages for the period from June, when the dam was started, to August, when the use of low-heat cement was initiated. The values given for low-heat cement are averages for the month of September.

Field slumps are determined at the mixers and correspond to about 3 in. at the forms, the loss results from the appreciable length of time between mixing and deposition under conditions of extremely high temperature and low humidity. Reducing the field slump to 3¼in. would lower the water-cement ratio to 0.53, the same as the laboratory value.

Field strengths must be increased by 8 per cent to be directly comparable with the laboratory results, due to the fact that the uniform method of load application as used in the Denver tests yields higher values than standard loading (0.05-in. head travel at idling speed) employed in the field. The adjusted values (Table IV) for field strengths are reduced to the same water-cement ratio and method of testing basis as the laboratory results, for the purpose of direct comparison. The agreement, within 5 per cent for the high-heat cement and 3 per cent for the low-heat cement, is most remarkable considering the many variable factors involved, which singly or collectively might account for the difference.

The field strength of 3,210 lb. per sq. in., when increased by 8 per cent for uniform loading conditions, becomes 3,470, which, from the test results giving the relation between wet-screened and full-mass concrete, corresponds to a strength of 2,780 lb. for mass concrete in large cylinders at 28 days. It is to be noted that this value is somewhat higher than the 2,500-lb. strength required by the specifications.

The field and laboratory experience in connection with mix design and specifications indicates rather conclusively that the mix design can be more advantageously developed in the laboratory than in the field, provided the laboratory is suitably equipped, sufficient preliminary data regarding field conditions are obtained and representative samples of aggregates are available. The problem is essentially one of engineering design, and the solution is a function of the designing rather than the construction organization.

Placement

From the standpoint of both structural results and contractor's cost, the various phases of placing mass concrete are of vital importance. In Boulder Dam every effort has been extended to secure a high degree of uniformity of placement from batch to batch. The requirement for bottom-dump buckets was an attempt to secure placement without segregation and with a minimum variation in the water content.

If it were economically practicable to deposit mass concrete in units of 1 or possibly 2 yd., so that no movement would be required except to provide consolidation and intimate contact with previous adjacent batches, there is little doubt but that 1- to 1½-in. slump concrete would be desirable. But when concrete is placed by cableway in 8-yd. buckets under remote control, it is virtually impossible to deposit the concrete exactly as desired. Consequently the concrete must be spread out and transported horizontally to some extent, necessitating flow within the mass and resulting in more or less segregation.

Gravity is the principal active force in the production of dense concrete. Spading, working, tamping and vibrating serve mainly to assist gravity in securing a minimum volume by a better arrangement of the component particles of the mass and by the expulsion of entrained air. Extensive tests in the Denver laboratories led to the conclusion that compaction by internal vibration as compared with other methods results in more uniform distribution of aggregate particles, improved quality and texture of the matrix, greater density and greater ease in placing harsh or dry mixtures. Conditions at Boulder Dam during the past summer months

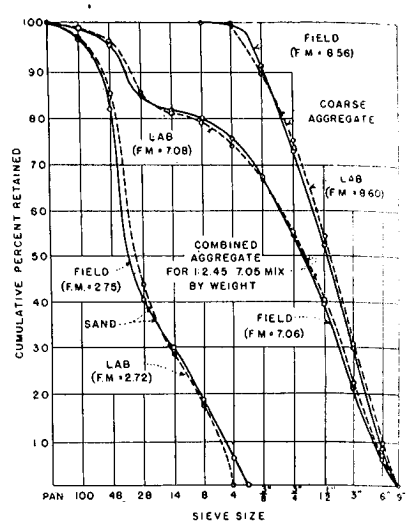


Fig. 3—Gradation of the mass mix showing the close relation of values obtained in the Denver laboratory and the field.

necessitated placing of the concrete on a slope in order to keep the working surface alive until another layer could be placed. The attainment of maximum density and uniformity is thus complicated, as there is a tendency toward the formation of porous areas along the slope between adjacent batches. This tendency is due to the fact that the surface concrete on the slope is unconfined and for this reason cannot be properly consolidated.

The specifications provided that, "In general, a wetter consistency than that corresponding to a slump of 3 in. at point of placement . . . will not be permitted for the main portions of the structure." Slumps from 1 in. up have been tried under actual operating conditions of placement in 8-yd. batches, and the conclusion has been reached that, all things considered, a slump of 2½ to 3 in. yields the most satisfactory results, eliminating the necessity for the use of vibrators. Concrete of 1- to 1½-in. slump is entirely practicable and will yield a superior concrete if properly placed and consolidated, but it cannot be properly placed in 8-yd. units with the mix proportions and placing equipment being used and under the climatic conditions at Boulder Dam. Even if it could, the net result would amount only to about 10 per cent increase in strength and corresponding improvement in related properties.

When the gain in strength, durability and impermeability of a drier mix are weighed against the increased harshness, cost of placement and tendency to nonuniformity in compaction due to decreased plasticity, the disadvantages will be found to outweigh the advantages, not because the ideal is impossible of attainment but because it is not practicable under the operating conditions prevailing on this project. It is far more important to have uniformity throughout the entire mass than to have slightly stronger concrete of questionable uniformity.

The foregoing is not a condemnation

of large units for placing mass concrete or of a 1- to 1½-in. slump concrete, but it is an attempt to point out that a happy medium based on a recognition of job conditions is often the only logical solution.

In the placing of mass concrete, the bonding of new concrete to old is a factor of considerable importance if watertightness is to be attained. Laitance or porous concrete along a horizontal joint provides a channel for seepage which may lead to objectionable consequences. Various methods for cleaning up the horizontal construction joints preparatory to a succeeding lift have been investigated by the bureau. As a result of past experience and recent experiments, it has been tentatively concluded that where concrete of proper consistency is obtained the clean-up shall consist of washing with air and water combined under high pressure as soon as the concrete has taken its initial set. However, if sloppy concrete has been used and laitance or inert material are present on the surface of the lift, or if the concrete has become hard, the film of inert or weak material shall be removed by chipping and wire-brushing. The potential watertightness of concrete of the regular Boulder Dam mix, under hydrostatic conditions applicable to the dam, has been amply demonstrated by permeability tests.

Contraction joint layout

The dam is divided into columns or blocks by radial and circumferential contraction joints. These blocks, for structural reasons, vary in size from 25x30 ft. at the downstream face at the base of the dam to 50x60 ft. at the upstream face. Concrete is required to be placed in 5-ft. lifts as the most satisfactory height for placing and cooling the mass under existing conditions.

The radial and circumferential surfaces of the contraction joints are interlocked by means of keys (see following article) formed to provide maximum cross-sectional area for resistance to shear after grouting. Metal grout stops are placed across radial contraction joints at both the upstream and downstream face of the dam and across the circumferential joints at each junction with a radial joint. In the vertical direction the stops are placed at 50-ft. intervals.

Concrete cooling

The stress distribution assumed in the design of the dam contemplates a monolithic structure devoid of cracks, as already discussed. This condition cannot be obtained until the internal temperature of the concrete at all points in the dam is reduced to a value varying from the mean annual air temperature at the downstream face to reservoir temperature at the upstream face. A study of these conditions indicates that there will be a theoretical temperature gradient through the dam, varying from 40 deg. F. at the upstream face, below the base of the intake towers (El. 900), to 72 deg. F. at the downstream surface of the dam above tailwater. The actual temperature of a narrow slab of concrete on the downstream face of the dam above tailwater and on the upstream face of the dam above El. 900 will fluctuate due to seasonal variation in temperature. Thus, it is evident that the internal temperature of the mass will not be the same at all points. The cooling system is being operated to produce as nearly as practicable the final temperature to obtain in the mass.

The cooling and shrinking of the concrete is accomplished by circulating water through 1-in. O.D. 14-gage tubing buried in the concrete. There are two stages in the process: (1) unrefrigerated river water is circulated as soon as concreting operations permit; this is followed by (2) refrigerated water at a temperature of 40 deg. F. The supply and return headers for the cooling system are located in a vertical radial slot 8 ft. wide in the center of the dam. Mains from the refrigeration plant connect with 6-in. headers and supply the 1-in. cooling-pipe system. The cooling pipes are spaced at 5-ft. intervals vertically and 5 ft. 9-in. intervals horizontally, and run in circumferential loops. The length of a cooling loop from header to abutment and return varies with the position in the dam, from about 600 ft. in the lower levels to about 1,160 ft near the crest. [Details of the refrigeration plant and the cooling system ar e described in a separate article, p. 748.—EDITOR.]

As already stated, the concrete placed in the inner gorge at the base of Boulder Dam contained standard portland cement. An average maximum temperature of 127 deg. F. was recorded in this part of the mass concrete. It is anticipated that the average maximum temperature of the mass concrete in which low-heat cement is used will not exceed 115 deg. F. next summer. An average maximum temperature of 80 deg. F. is predicted for this winter. These predicted values are based on an average temperature of 30 deg. F. The maximum temperature at any point, of course, is an extremely variable quantity depending on location, distance from horizontal and vertical surfaces, time these surfaces are exposed, weather conditions, wind velocities in the canyon, time artificial cooling is started and other factors.

Resistance thermometers in sufficient number for determining the control of the cooling operations are being installed in the mass concrete as the work progresses. In addition to the temperature data furnished by these resistance thermometers distributed throughout the mass, check tests on results of the cooling operations are being made periodically by disconnecting loops at various places, allowing 48 hours for the temperature in the concrete surrounding the loop to equalize, and then inserting thermometers distributed throughout the loop to equalize, and then inserting resistance thermometers 25 to 30 ft. into either end of the loop from the surface of the cooling slot for temperature readings.

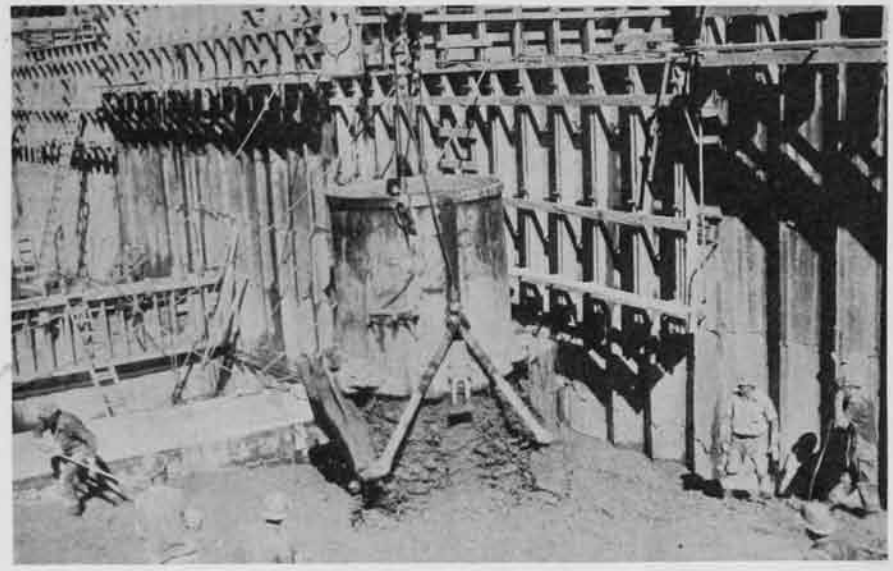


Fig. 4—Little evidence of segregation is indicated in the action of depositing 8 yd. of concrete by bottom-dump bucket. Note the keyways on the radial joint at the right and the form construction.

Deformations within the mass resulting from hydration of the cement and from construction operations are indicated by a system of strain meters buried in the concrete. These strain meters also serve as resistance thermometers and will later serve to indicate deformation in the mass caused by water load as the reservoir fills.

The widths of contraction-joint openings are being checked at various locations by means of Carlson joint meters that operate on the same principle as the Carlson strain meter (*ENR*, Oct. 15, 1931, p. 615), except that the struc-

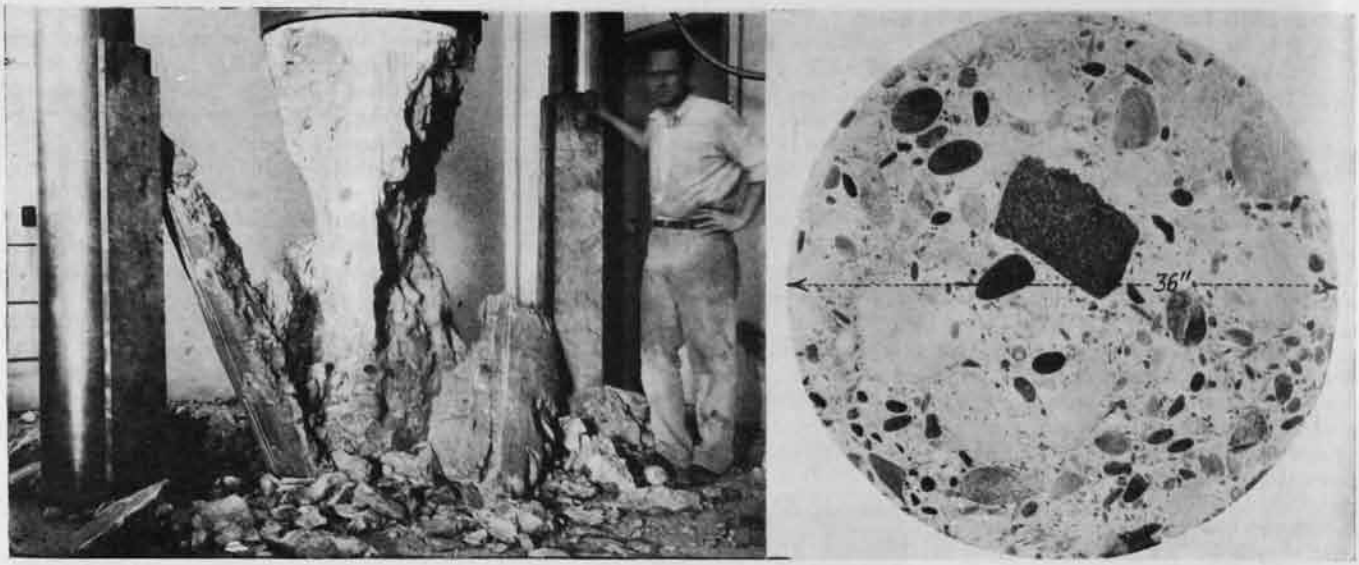


Fig. 5—Test of the mass mix including 9-in. cobbles in a 36x72-in. specimen (left) and a sawed surface typical of the mass concrete (right).

tural details are modified to permit greater movement between the anchor posts. This check-up of contraction-joint opening is not as comprehensive as the one made at Owyhee Dam, but it is believed sufficient to establish the order of width of joint opening up to the time of and during grouting operations. Contraction joint openings of the order of $\frac{1}{16}$ in. are already visible in galleries in the lower part of the dam. To date, the results of the cooling operations as measured by the apparatus agree with the calculated results remarkably well.

How the contraction joints are grouted

After the concrete in each 50-ft. vertical layer is cooled to the desired temperature, the cooling slot in the center of the dam will first be filled with concrete, and then the radial and circumferential contraction joint openings, in that order, will be filled with neat cement grout of varying proportions suited to the particular conditions encountered. This is to be accomplished through a system of pipes buried in the concrete adjacent to each joint and having outlets at intervals on the face of the joint. The area of joint served by each such outlet is 50 sq. ft. on the circumferential joints and 30 sq. ft. on the radial joints.

Experimental results of grouting fine cracks under accurate control indicate that grout films of excellent quality can be produced—the excess water being forced into the concrete—and that good coverage of the surface of the joint is possible for any joint opening more than 0.01 in. in width. Field cores drilled from across contraction joints in Gibson Dam, Montana, indicate that where the crack is wide enough to secure good coverage the film is of excellent quality.

The necessity for producing a crack of sufficient width for grouting purposes, without causing so much shrinkage in the mass as to produce cracks at other than regular contraction joints, is largely responsible for the block, or column, layout designed for Boulder Dam, and also for the stipulations regarding heat of hydration in the specifications for the purchase of special cement.

Experience in both the laboratory and the field has proved that for grouting fine seams the cement must be screened just prior to use if clogging of the seams is to be avoided. For this work vibrating screens covered with 200-mesh cloth are being installed, and the screened cement will be stored in four-ply paper bags to prevent hydration from exposure to the atmosphere. The storage period after screening will be limited to seven days.

The creation of a desirable film of grout in the contraction joint requires: (1) grout of the proper consistency to flow into and completely fill the joint opening; (2) time for the cement in the grout to settle out in the joint so as to give a film of desired density for proper consolidation under pressure; and (3) sufficient pressure to consolidate further the film and drive excess water into the mass concrete.

Conclusions

In the selection of aggregates, in the stipulations in regard to concrete plant, in the design of the mix, in the use of a blended low-heat cement of controlled composition, in the requirement for bottom-dump buckets and in the provisions relative to placement and curing, the uppermost thought in the construction of Boulder Dam has been to produce mass concrete of greater durability than any heretofore placed by this bureau.

Experience to date seems to warrant the following conclusions relative to mass-concrete construction for Boulder Dam:

1. That the structural qualities and gradation of the aggregates are the best ever obtained in a dam built by this bureau.

2. That the contractor's plant for the production of concrete is probably superior to any ever used on similar work.

3. That the net effective water-cement ratio (about 0.53 by weight for the special cement) is as low as conditions on the job warrant for the satisfactory placement of mass concrete of 1 bbl. per cu. yd. cement content.

4. That the strength obtained in the mass as tested in 36x72-in. cylinders (2,500 to 2,800 lb. per sq.in. at 28 days, moist-cured at 70 deg. F.) is ample for any stress condition that may result.

5. That a slump of about 3 in. in the forms is resulting in a more uniform product than would be obtained with a lower slump under the job conditions encountered.

6. That the special cement now being purchased and blended at the dam site has aided materially in securing a concrete that meets the exacting requirements of this work.

7. That in placing mass concrete in large units the use of a bucket having two or more compartments or one in which the amount discharged at any time could be controlled would result in more satisfactory and economical placement.

8. That in placing mass concrete containing cobbles the internal type of vibrator serves to effect a more satisfactory job of placement around the forms, especially when an occasional dry batch is encountered, than can otherwise be obtained; but that the vibrator as ordinarily used in the field of mass-concrete placement is more a tool for transportation by flow within the mass than a means of super-consolidation.

9. That watertightness of the dam as a unit is principally dependent upon the thoroughness of the clean-up and curing and bonding of the new to old concrete at the horizontal construction joints.

10. That uniformity, as in all other mass production, is the most important factor in the entire manufacturing process, and that all stipulations relative to the mix and the making should first give due regard to the effect on uniformity.

Million Yards of Concrete Placed at Record Rate

Elaborate cableway system transfers 8-yd. bucketloads to the columnar blocks forming mass of dam—Multiple use of individual forms for each column—Installation of cooling pipes complicates pouring—Aggregate and mixing plants function smoothly

Fig. 1—Foundations of the barrier that will block the Colorado. About 32,000 cu.yd. of concrete are required for each 5-ft. lift of the dam at this stage of construction. Concrete reaches the dam via the double-track railroad hugging the left canyon wall. Five cableways distribute concrete to the forms in 8-yd. buckets.

AGAIN shattering all existing records and precedents, as in the case of the preliminary operations, placing of 1,000,000 cu.yd. of concrete at Boulder Dam has gone forward at an average rate of more than 6,600 cu.yd. per day, and during the month of October 204,000 cu.yd. was placed. The maximum day's record for concrete placed in the dam proper is 7,883 cu.yd. At the main mixing plant in the canyon the four 4-yd. mixers discharge 16 cu.yd. of concrete every 3¼ min., with a 2½-min. mixing period, and are operated by a crew of only eight men. Following a train haul of 4,000 ft., the 8-yd. buckets are swung out over the dam and into position for placing by a system of cableways with a precision and speed that is especially notable considering the personal element and the operators' skill involved. The concrete, which was described as to its development and characteristics in the preceding article, is now traced from the mixer to the forms, together with an outline of the equipment and operations of the contractor's program.

General program

The concrete-placing program for the dam proper had to be arranged to cover the maximum dimensions of 660 ft. between faces and about 1,180 ft. along the curved crest. The dam is being constructed in the form of interlocking vertical columns, the joints between which are to be grouted. The size and arrangement of columns are shown in Fig. 2.

In this design the columns vary in size from 55x60 ft. near the upstream face to 25x30 ft. at the downstream face. The average area of the columns is about 36x40 ft. (1,430 sq.ft.). Considering a 5-ft. lift per column as the unit of concrete-placing operations, as it involves such common elements as form-raising, layout grouting and cooling pipes, clean-up and preparation, the number of the individual operations required is greatly increased over the number ordinarily necessary in building dams. The coordinates of the corners of each column remain constant from bottom to top, which permits repeated use of the forms in the construction of individual columns.

Plan to El. 720—The present concreting procedure, which will continue up to El. 720, the height of the cofferdams and the level of the railroad line from the mixing plant can best be outlined by describing the area now under placement (Fig. 1) and the reasons for maintaining the sequence of block raising. Preliminary placing operations during the first few months, in common with all construction operations, were not up to the present standard, being delayed by the establishing of the regular forms, the narrow width of the central section of the canyon limiting the number of blocks that could be poured and the installation of the cableway system.

The specifications allow a maximum vertical difference of 35 ft. in the top surface of the blocks. Further, the elevation of the rows of blocks (from up- to downstream face) is to be maintained in the same relative position. Thus, under present operations, the two rows of blocks on either side of an 8-ft. central slot, which contains the cooling pipe headers, are kept high, the next rows on either side are relatively lower, and so on, alternating to the abutments. Again, in each of these rows alternate blocks are maintained higher than others. An appreciation of this stepped system and its maintenance is important in following the form arrangement and the concreting procedure.

The high blocks of the high rows are commonly referred to as "leading blocks" and, of course, are formed on all four sides. The next lower blocks of the leading rows are maintained two lifts (or 10 ft.) lower and require forms only on the two sides, the up- and downstream faces being poured directly against the concrete in the leading blocks. The leading blocks of the low rows are formed on the up- and downstream faces and, lastly, the lowest blocks in the lowest rows require no forms at all, and each lift is placed against concrete on four sides. If there is no interruption in the placing schedule, the relative elevation of a group of blocks is that shown in Fig. 2. A field check is made each morning, so that all blocks that are out of step can be brought to proper elevation.

As the surface of the dam is raised, abutment blocks are continually being started. These, theoretically, begin

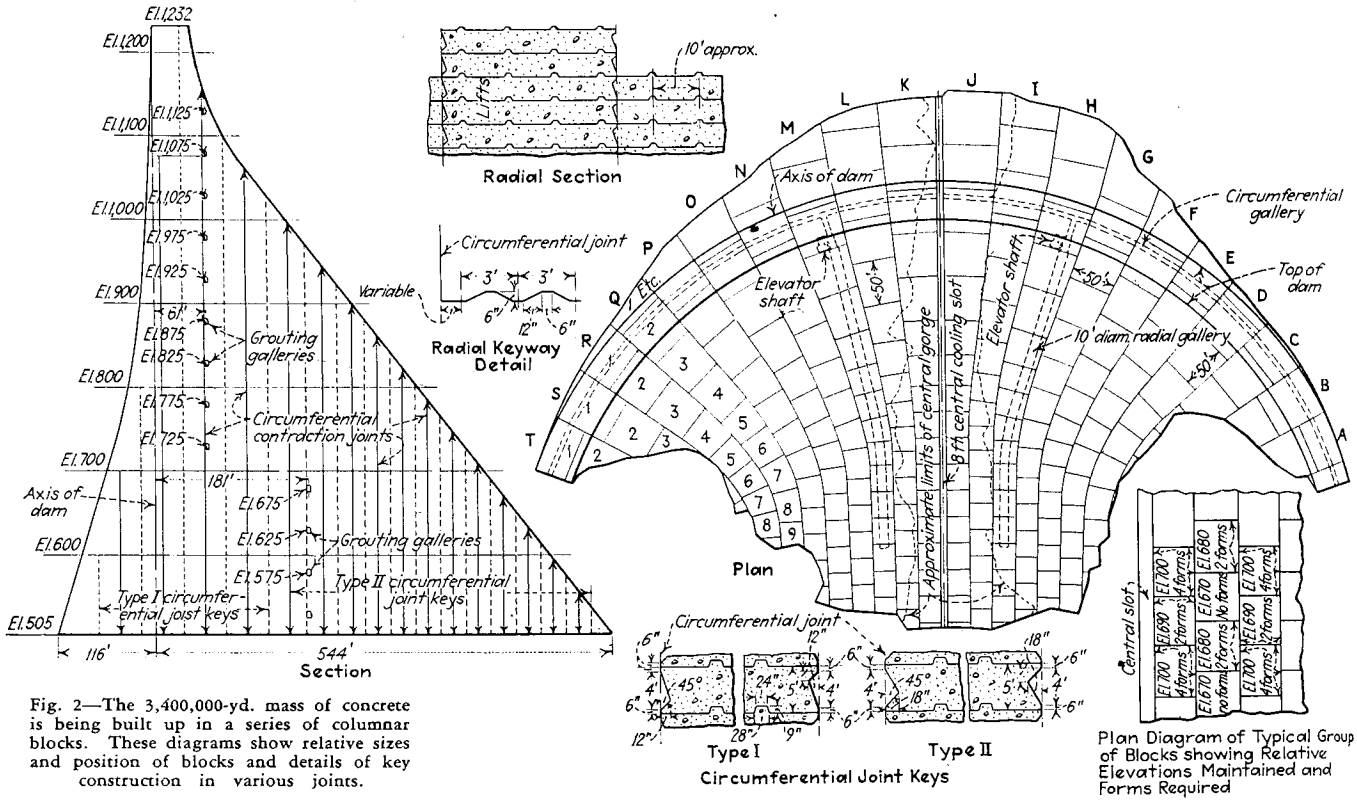


Fig. 2—The 3,400,000-yd. mass of concrete is being built up in a series of columnar blocks. These diagrams show relative sizes and position of blocks and details of key construction in various joints.

with a feather edge, which is actually widened out, and gradually widen as the abutment slopes back until they reach full size. Final stripping of the abutments in connection with these blocks requires the removal of loose rock and the usual clean-up just prior to pouring the lift. This final removal of rock averages 1 ft. in thickness. The contact between the concrete and the rock is provided with grout outlets similar to those in the construction joints in the dam. These pipes are continued up and the outlet boxes established along the rock line just prior to each pour.

The present area of pour is roughly 400 ft. long on the upstream face, 300 ft. along the downstream face and 500 ft. in the radial direction, containing about 165 blocks. The average time required to pour a 5-ft. lift in a 25x30-ft. block is 1½ hours. Even though concrete placing is always under way on two or three blocks at once, the pouring area is large enough to permit continuous placement of concrete despite the requirement of waiting 72 hours between subsequent pours on the same block. This area represents a concrete volume of about 32,000 cu.yd. per 5-ft. lift, and the yardage will remain constant for several months with the up- and downstream distance decreasing to compensate for the increasing width in the other direction.

Above El. 720—When the height of the dam has reached El. 720, the railroad line from the low-level mixing plant will have to be stopped at the upstream face. This will mean that the buckets of concrete cannot be handled directly by the cableways from train to point of pour, except for blocks near the upstream face. Otherwise, the cableways would have to transfer loads and operate with head-tower travel, which would be a slow process. To overcome this difficulty, a different operating program is required for the next 230 ft. up to El. 950, at which height storage will be started in the reservoir and the operation of the low-level mixing plant discontinued.

A large steel stiff-leg derrick, with a 136-ft. boom, operated by a 500-hp. hoist, will be constructed with its base at the level of the intake-tower foundation on the Nevada side of the canyon. This derrick will pick up the concrete buckets from the end of the railroad track at the upstream face of the dam, pour a few adjacent blocks directly and transfer the buckets to cableway No. 6, the second of the upstream pair of cableways (Fig. 3). Cableway No. 5 will pick up the buckets direct from the railroad trestle as before. The two cableways on the downstream half of the dam will be served from the high-level mixing plant.

When concrete reaches El. 950, the low-level mixing plant and the railroad will be eliminated by the beginning of storage in the reservoir, and above this elevation the high-level mixing plant, augmented by two additional mixers to its full size of four 4-yd. units, will be used with the present cableways to complete the dam and other structures.

Preparing concrete

Aggregate Plant—The design and operation of the aggregate plant has not been materially changed since it was described in *Engineering News-Record,* June 2, 1932, p. 783. It has continued to prepare the four sizes of coarse aggregate by dry screening, using water only for washing sand. Although the designed capacity of the plant is 500 tons per hour, it has produced as high as 700 tons for extended runs.

Cement Handling—To eliminate any variation in color and chemical characteristics of the cements received from the four producing plants in southern California, a blending plant was erected at the site of the high-level mixing plant under a separate contract. The operation is designed to provide a cement going into the dam, which will maintain, in general, the same proportion of cements supplied by the mills. The cement from each plant is stored in a separate silo and removed by a screw-conveyor system in a predetermined proportion. Action of the screw conveyor provides the mixing operation. From the blending plant the cement is pumped to the two mixing plants.

The pumping distance to the high-level plant is only about 100 ft., but the line to the low-level plant in the canyon is 5,700 ft. long with a 510-ft. total vertical fall in that distance. The rated capacity of this 9-in. line is 450 bbl. per hour, but actual capacity has often exceeded 550 bbl. One pump station is located at the beginning of the line, and a second is at mid-point where the line reaches canyon-floor elevation. Each of these plants is rated to consume 2,000 cu.ft. of air per minute which is sup-

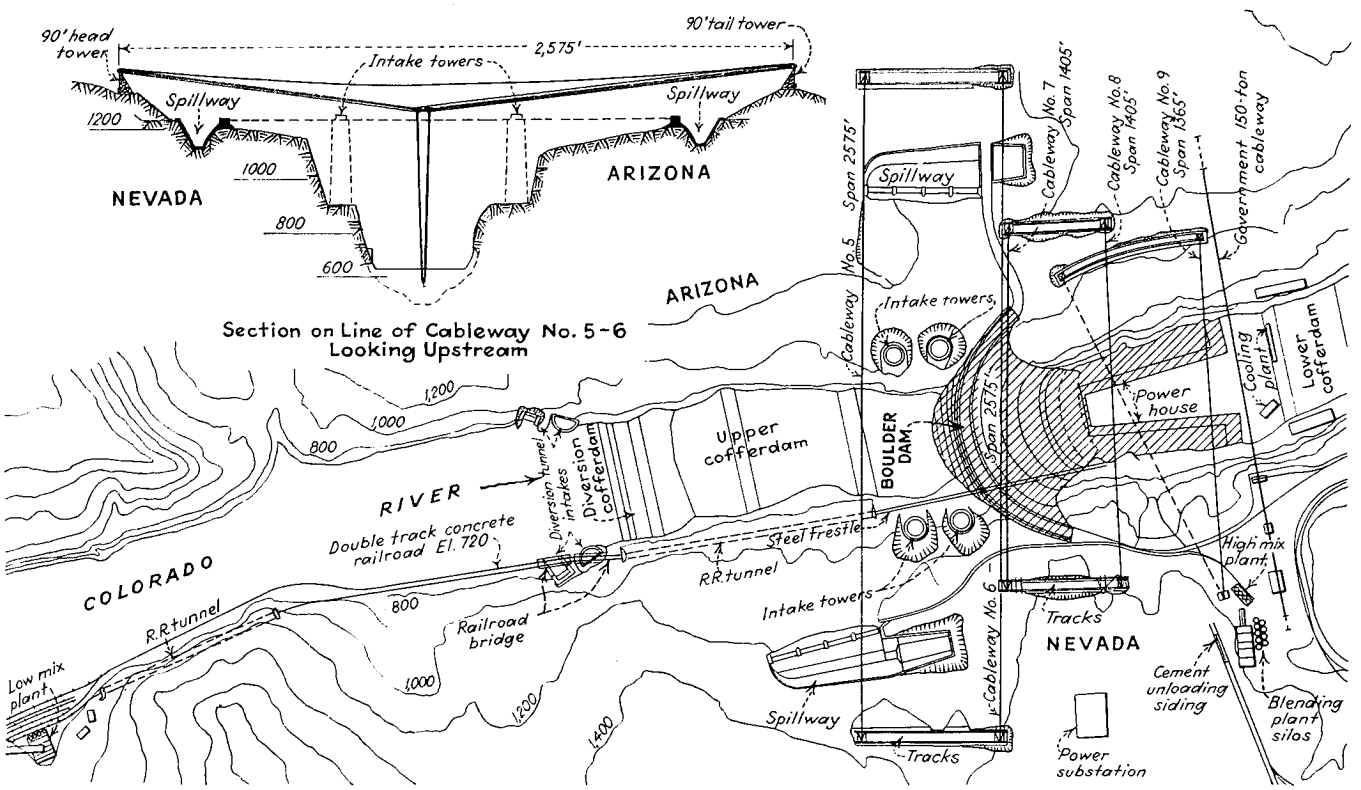


Fig. 3—Layout of cableway system used for handling all forms and concrete for the dam, spillways, intake towers and power house. With the exception of the 150-ton unit, the cableways are to be used for the construction period only.

plied from the permanent compressor air system.

Mixing Plants—The batching equipment and operation at the main mixing plant in the canyon about 1 mile upstream from the dam site were described in *Engineering News-Record* April 14, 1932, p. 534. This set-up is at present duplicated at half size at the high-level mixing plant. The mixer installation consists of four 4-yd. units at the low-level plant and two at the upper plant, although plans call for doubling the capacity of the upper plant soon. The batching equipment is designed to operate both manually and automatically. The producer of the equipment, recognizing the unprecedented character of a completely auomatic batching installation, provided the alternative of manual control. However, the automatic control has functioned with little difficulty and is being used exclusively at a considerable saving of labor cost at the plant.

The crew at the low-level plant, which turns out more than 2,000 cu.yd. per shift, consists of one man at the track hopper where the aggregate cars unload, one conveyor-system oiler, two men at the aggregate hoppers over the plant, one man at the batchers, two mixer operators for the four mixers and one mechanic for the conveyor system. At the high-level plant the crew is the same, with the elimination of the conveyor mechanic and track hopper man, as the plant has a gravity feed from the aggregate trains.

Careful time studies show that the time required for loading and discharge of the mixers averages 50 sec. With the present 2½-min. mixing period, the complete cycle of operation for the 16 yd. of concrete is about 3 min. 20 sec. Slump of the concrete as placed is required to be about 3 in. As loss in slump from mixing plant to point of bucket discharge averages 0.6 in., the slump of the concrete when mixed is 3.6 in. Details of the mix are covered in the preceding article.

Train Haul—From the mixing plant to the cableways at the dam the concrete buckets are moved for 4,000 ft. by single-car trains consisting of a standard-gage flat car pulled by an electric locomotive equipped for both battery and third-rail operation (Fig. 4). This locomotive arrangement has the advantage of eliminating the third rail around the plant and crossings and, at the same time, removing the peak loads on the direct-current generating station. The cars are built up with a steel superstructure that provides four compartments to dock buckets. These pockets are open on the canyon side (Fig. 4) to facilitate getting the buckets in and out with the cableways. On the move to and from the plant the cars always carry two buckets in alternate compartments spaced to match the direct discharge from the mixers.

A double track (Fig. 3) extends from the plant to the dam at El. 720, the crest of the cofferdams. This route required the driving of two 1,000-ft. double-track tunnels and a bridge of two 135-ft. steel-truss spans to cross the upstream portals of the Nevada diversion tunnels. In the dam site proper the tracks are carried along the canyon wall on one-leg steel trestle bents. Running time for loaded trains is about 3 min. to the dam, averaging 13 m.p.h. Seven trains are operated, and there is no delay at either terminal.

Arriving at the mixing plant with two empty buckets in alternate compartments, the train runs under the mixers and receives two 4-yd. batches to half fill each bucket. It then moves immediately under the other mixers and finishes loading. The first pair of mixers is reloaded at once, and by the time the next train moves into position the next batch is ready.

Buckets—The design of the 8-yd. bottom-discharge buckets (Fig. 6) was the work of F. T. Crowe, general superintendent for the contractor. The bucket is of all-welded construction of ¼-in. steel plate, 6 ft. in diameter and 8 ft. high. The bottom consists of two semi-circular doors, hinged at the sides. Cables for handling the loaded buckets hook to long lines attached directly to the doors. As an additional safety measure, there are two catches which lock the doors closed and would not permit them to open, even though the load were inadvertently shifted to the other cables. The other line is attached directly to the top of the bucket. Each of these hoisting cables runs through spreaders to sheaves supported by a four-part line.

In operation, the two hoisting lines are coupled to the bucket and the load picked up by the cable attached to the doors. When lowered to the surface of the concrete at the point of pour, the safety latch either releases automat-

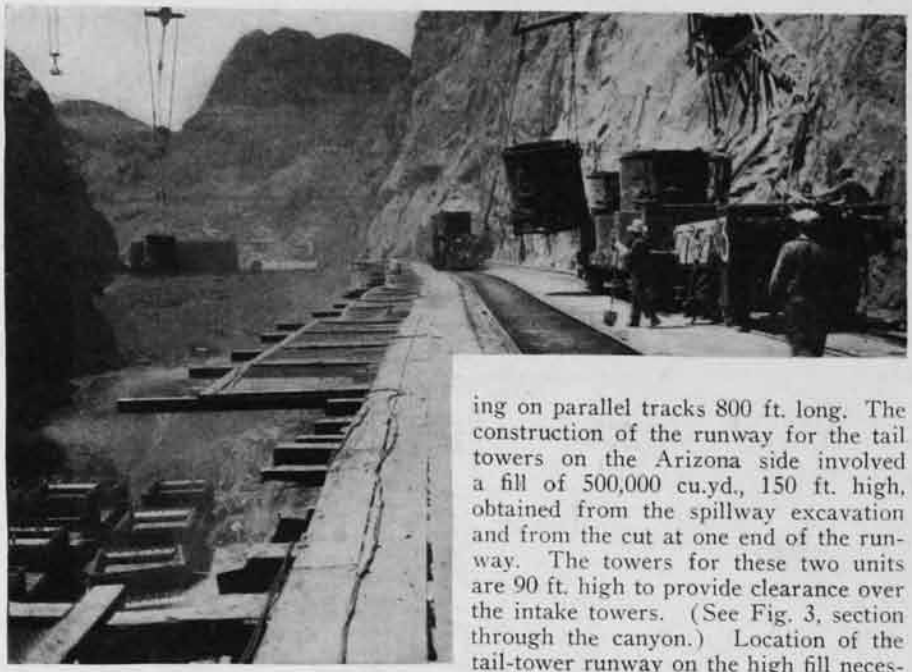


Fig. 4—Arriving at the dam, the buckets are picked up and moved to the forms by one of several cableways. The screen is for the protection of men below.

ically or is tripped by hand. The take-up is then made on the lines attached to the top of the bucket, which literally picks it up from around the concrete. After the bucket has been lifted well clear of the forms, the cableway operator shifts the load back to the door lines again, which closes them and sets the safety latch. On return to the train the lines are removed and shifted to the next bucket.

Cableways

To solve the problem of handling concrete and materials in the canyon, meeting the necessary requirements of speed and flexibility, the contractor selected a system of five cableways spanning the canyon. The general layout of this system and its coverage of the dam and power-house sites is shown in Fig. 3. The two longest units, designated as Nos. 5 and 6, required a span of 2,575 ft. to cover the two spillways. These two cableways are identical units with head and tail towers traveling on parallel tracks 800 ft. long. The construction of the runway for the tail towers on the Arizona side involved a fill of 500,000 cu.yd., 150 ft. high, obtained from the spillway excavation and from the cut at one end of the runway. The towers for these two units are 90 ft. high to provide clearance over the intake towers. (See Fig. 3, section through the canyon.) Location of the tail-tower runway on the high fill necessitated provision for occasional reballasting of the track and allowance for slight irregularities in rail grade. The wheel truck frames are mounted with ball-and-socket connections under each tower for equalizing the loads. The cable pull is taken through the tower to horizontal wheels running against a timber member that is adjustable for slight irregularities caused by settlement and is anchored to concrete deadmen buried in the fill.

Cableways Nos. 7 and 8 have spans of 1,405 ft. and operate on concentric radial tracks. Again, the required location of the two tracks presented problems: the Arizona runway includes a cut about 100 ft. deep and the head-tower track on the Nevada side required a deep cut and sections of steel trestle to bridge low points. Cableway No. 9 is a radial unit with a fixed head tower on the Nevada side, a span of 1,365 ft. and an 800-ft. length of track on the other side of the canyon. This cableway covers most of the power-house area and extends to the 150-ton permanent cableway of the government, described in another article in this issue.

All of these five units of the contractor's cableway system are standardized in as many mechanical features as possible. They all have a rated capacity of 25 tons with some allowance for occasional overload. Head towers and all operating equipment are located at the Nevada side (Fig. 3). A 3-in. locked-coil track cable is used, with provision for periodic rotation to equalize wear. The cables have a breaking strength of 550 tons and operate with a loaded deflection of 6 per cent. The endless rope is 1 in. in diameter, and the hoisting lines are $\frac{7}{8}$-in. in diameter.

The main hoist for each cableway is run by a 500-hp. motor equipped for regenerative braking, magnetic reversing control and counter-torque deceleration while lowering. The hoisting speeds are 300 ft. per minute for raising and 420 ft. for lowering. The track carriage has a maximum speed of 1,200 ft. per minute. For moving the towers along the runways, a 100-hp. motor is provided in each tower; they are moved by properly synchronized remote control at a speed of 50 ft. per minute through a three-part line. Air for operating brakes and clutches is provided by motor-driven compressor units in each head-tower hoist house. The cableway operator, in every case, is located in the head tower and cannot see the load, which is being directed entirely by bell and telephone signal.

The cableway layout, design of the towers and the erection of the entire system was carried out by Six Companies, Inc. The cableway operating units including hoists and carriages were furnished by the Lidgerwood Manufacturing Co.

Forms

Aside from the radial and circumferential keyways (Fig. 2), the form system used for the dam consists of

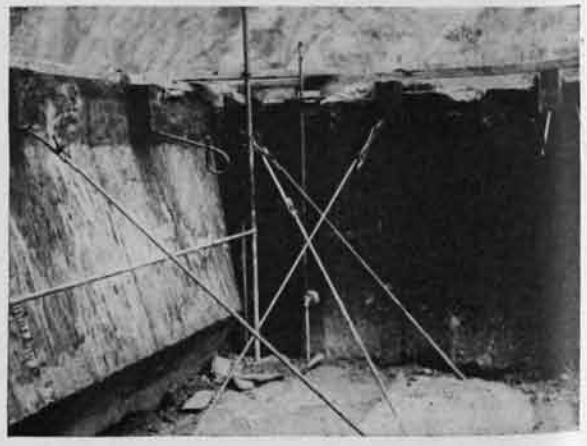


Fig. 5—Details of forms fastenings: Cooling pipes are laid on the surface (left) immediately before the lift is placed. She-bolts and hooked rods (center) embedded in the top of the lift provide for holding the cantilever forms for the next lift. Outlets for the grout system are nailed to the forms. Note the keyways produced by the forms.

metal-lined wooden panels of the usual cantilever type, providing for a 5-ft. lift, with the vertical timbers extending down another 5 ft. against the last pour. In addition to cantilever action, the forms are partly tied in at the top. Near the top of each pour she-bolts are left in the form with hooked bars (Fig. 5) that are buried in the concrete. When the form is raised, these bolts, at 3-ft. spacing, are used as the main support for the cantilever action, with the timber tail pieces bolted to the next lower row.

The corners of each of the columnar blocks of concrete in the dam extend vertically from the lowest point of the block to the top. This design feature permits forms to be designed and built for each separate block and used for successive lifts without recutting. The limit of re-use has not been determined, but some of the forms have been moved up for as many as 30 lifts with only minor repair to damage caused principally by the buckets.

The forms are lifted by steel loops left in the top, using two or three tripods and chain jacks. When first placing the forms in position, or if for any reason it becomes necessary to move a form laterally, it is done by a cableway using a spreader beam of timber. The top of each form section is capped with a 12-in. plank that is used as a walkway.

Concrete placing

Under present concreting procedure the buckets are delivered by train on the trestle along the Nevada canyon wall at El. 720 and handled directly by cableways Nos. 5, 6, 7 or 8. Each cableway delivers buckets to the same block for the entire 5 ft. lift, which eliminates interference and excessive moving of the towers. It also tends to speed cableway operation because the range of vertical and horizontal motion is repeated. There are usually three or four blocks under pour, in addition to some of the edge blocks handled separately by concrete from the high-level plant; clean-up operations, abutment preparation and form-raising are also going on at the same time.

The usual placing crew for each block consists of ten men and a foreman in the form (seven-man crew for small blocks), two signal men to direct the cableway operations and the two transfer men at the train. As soon as the full bucket is hooked on, the signal man stationed at the track directs it to be raised and started out over the dam (Fig. 4). After that the directions for the movements of the cableway are taken over by the other signal man stationed on the form, who is interconnected on the same telephone circuit. He directs the spotting, landing and discharge of the bucket. If the block is one on the Arizona side of the canyon, the trip is about 400 ft., and it is important to get the bucket out and back with minimum delay.

Fig. 6—Concrete buckets are brought to rest on the surface of the lift (left), which releases the safety catches, and the take-up is then made with the lines attached to the rim, which has an action of lifting the bucket off the concrete (right). Note the consistency and the details of the forms.

Directed by telephone orders from the signal man on the block, the operator moves the carriage on the track cable out along the cable at full 1,200-ft.-per-minute speed; the 20-ton load of bucket and concrete slowly gathers momentum on the end of the 500-ft. vertical line and starts swinging across the canyon. Based on judgment and practice, the signal man directs the carriage to be stopped about the center of the canyon and the bucket continues on its slow long swing like a huge pendulum. Finally, when it is almost directly over the block under pour, the carriage is again ordered forward and arrives directly over the bucket as it reaches the far point of the swing. So nicely is the timing done that in practically every case there is hardly any perceptible swing of the bucket as it comes to a stop under the carriage and over the block.

Then, with a little final maneuvering to put it in exact position for emptying, as directed by the foreman, it is lowered to rest on the concrete (Fig. 6). When each lift is started, the buckets are landed on the horizontal keys left on the preceding pour to eliminate crushing the cooling pipes. This is done until the concrete has reached a depth of about 18 in., when the bucket is allowed to be placed on any point on the block. When the bucket is lowered onto the concrete, the safety dogs automatically release or are tripped. The take-up is then made by lifting the bucket from the lines attached to the rim, and the doors open, discharging the 8-yd. batch as the bucket rises (Fig. 6).

As the load is released, there is a natural surge of the cableway, but the operator continues to take up on the line, and the rebound does not bring the bucket to within a dangerous proximity to either crew or form. As soon as the bucket is clear, the load is transferred back to the lines attached to the doors and they close, eliminating the possibility of droppings as it returns to the track. Direction of the returning empty bucket is again taken over by the signal man at the track who controls its landing.

Fig. 7—In the confined space of the abutment blocks that are not up to the full size, the buckets are too difficult to handle and concrete is placed with 4-yd. agitators.

The signal men directing cableway operations are mostly boys proved by a trial to have quick faculties and a natural sense of rhythm so essential to the efficient handling of the cableways. They are trained for the work by using a duplicate set of head phones and having them sit beside the regular signal man for a shift and listen to the orders given to the hoist operator.

As a result of the large 8-yd. mass and the 3-in. slump, the concrete moves into final position, following the raising of the bucket, without much handling. A little shoveling is done and the cobbles are pushed down. Vibrators are not used except occasionally near corners or around drain pipes and forms for galleries.

Original specifications called for depositing the concrete in 1-ft. layers over the block. Operations in the field proved that the surface of the concrete dried too rapidly between the deposit-

ing of these thin layers to make this placing possible. The plan now in use is to start at the downstream side of the form and deposit the entire 5-ft. thickness of the lift, letting the concrete take its natural slope in an upstream direction. Placing is then carried forward and finished against the upstream form. This procedure has the advantage of maintaining the concrete during pour on a slope up from the upstream face, also providing a wedging action against the upstream face of the form.

Curing—Each lift is finished off with 26x5½-in. horizontal keys 10 ft. apart. As soon as the concrete has taken its initial set, the surface is washed with an air and water jet. Before the next lift is placed there is another hosing accompanied by brushing and any necessary picking.

Curing water on the sides of the blocks is provided by sprinkling from perforated pipes attached to the bottom of the forms that move up for each succeeding lift. The top surface of the block is kept wet by hose sprinkling, and in the high temperature and low humidity of the canyon this becomes a problem of no small proportions. At times during the summer there were as many as seventeen men sprinkling the top of the blocks during the day shift and twelve on night shift. The water supply for washing and curing is obtained by pumping from wells in both cofferdams (river water filtered through these earth dams) and delivered to the dam. The waste water from these operations goes into the shaft sunk below foundation level and from there is lifted by pumps into a diversion tunnel. The iron content of this water produces a mahogany brown stain on the surface of the concrete, which tends to blend it into the natural rock of the canyon.

Cooling System—The unprecedented requirements of installing a system of cooling pipes in the concrete introduced problems that had to be solved by experience. The system of cooling provides header pipes extending up and downstream in the 8-ft. central slot at about 10-ft. intervals vertically, connecting with loops of small pipes extending to the abutments on either side. These loops of small pipes are placed between each 5-ft. lift of concrete and at about 5 ft. 9 in. spacing in the horizontal direction. The design principles behind this cooling-system provision were outlined in the preceding article, and the description of the refrigerating plant and the operation of the system are described in the following article. The method of installing the pipes in the concrete needs a brief explanation.

The 1-in. O.D. tubing that was finally adopted as the pipe for the loops in the concrete (original plans called for 2-in. standard pipe) were first installed by embedding them 1 ft. into the top of each lift after it had been placed. This method of installation resulted in considerable trouble and damage to tubing and connections. As a result, the system was changed and the cooling-pipe loops are now installed on the surface of the lift just prior to the placing of the next concrete. These pipes are laid in position and fitted together to extend between the side forms on the leading blocks. Connections are made with a coupling providing an expanding gasket that tightens around the end of the tubing as the nut on the end of the coupling is tightened. As an indication of one of the many minor problems involved in this new departure in dam construction, there was considerable trouble and study involved in securing the right type of gasket for this coupling. An aluminum-foil gasket was first tried, which proved satisfactory; but as an economy measure a change was made to a fiber gasket, which at first appeared to be satisfactory, but later was found to swell upon becoming wet, preventing insertion of the ends of the pipe in the coupling. As a final step, a rubber gasket was finally adopted.

The ends of the tubing are placed in 5-in. tin pie plates that are nailed against the outside of the form. When the form is stripped, these plates are left in place, and the ends of the tube are then available for connecting, as the succeeding blocks on either side are raised.

Huge Refrigeration Plant Reduces Heat of Hydration

Artificial cooling of concrete an innovation at Boulder Dam—Chemical heat dissipated by pumping cold water through 300 miles of 1-in. pipe — Two stages of cooling provide efficient and economical operation

THE BOULDER DAM PROJECT has been the scene of many an innovation in engineering and construction, but the scheme of artificially dissipating the chemical heat generated by the setting of 3,400,000 cu.yd. of concrete overshadows them all. To extract the heat of the hydrating cement from this mass of concrete, thereby reducing the temperature stresses and bringing the temperature of the dam to the ultimate annual mean within a relatively short period, permitting effective grouting, a large-size refrigerating plant has been completed and is delivering cool water through a pipe system embedded in the concrete. The dam design problems resulting from heating and subsequent cooling have been discussed in the preceding articles.

The present system provides a two-stage cooling operation using (1) water cooled by natural evaporation (average wet-bulb temperature is about 65 deg. F.) until the economic temperature differential is reached; and (2) refrigerated water at about 40 deg. There is only one cooling-pipe system, totaling 300 miles of pipe, embedded in the concrete; cross-valves allow the two supplies to be cut in and out. When the cooling has reduced the concrete temperature to the desired point, circulation is stopped and the level is ready for grouting. Thus in the general construction procedure the uppermost 35 to 50 ft. of the dam, measured from the highest block, will be under construction with the cooling-pipe system incomplete and natural dissipation of heat taking place from the sides of the blocks. In the next 50-ft. section below, the pre-cooled water will be in circulation, and in the next lower 50 ft. cooling is being further accelerated with the refrigerated water. For the 50-ft. level below, grouting operations would probably be in progress. This general scheme indicates roughly the probable sequence of cooling and grouting procedure. It is estimated that a twelve weeks' total period of circulation will be required for the two cooling supplies to produce the desired temperature in the concrete. This temperature would normally be the estimated mean annual of about 70 deg. on the downstream face exposed to the air, with the probable further refinement of cooling the upstream face to about 40 deg. corresponding to the reservoir water.

Original specifications

Specifications for the refrigerating plant and the cooling system covered by the contract were necessarily general as a result of the limited time available for preparation of the details and the unprecedented character of this design requirement. They called for a complete refrigerating plant capable of reducing the temperature of 2,100 gal. of water per minute from 47 to 40 deg. F. This plant was to be built in three units capable of individual or combined operation, and the capacity of the equipment was to provide for any

losses in plant or transmission to the actual cooling pipes. The requirement was to remove excess heat above 72 deg., starting at a minimum period of six days after concrete had been placed. It was estimated that the average temperature rise resulting from hydration of the concrete would be about 40 deg. F. above placing temperature. The providing of the cooling-plant system, including the cost of equipment, building and entire operation of the plant, was bid as a lump sum. The bid of the Six Companies Inc. for this item was $360,000.

The cooling-pipe system called for in the original specifications provided loops of 2-in. standard pipe or tubing spaced at 10-ft. vertical intervals and about 11 ft. apart in a horizontal plane. It provided that the pipe, furnished by the government, should be cut, threaded and installed by the contractor to withstand a pressure of 100 lb. per sq.in. Specifications further provided that the size of pipe, spacing and amount of concrete to be cooled might be changed subsequent to the contract. This in general, covers the provisions for cooling as required by the original specifications. The following description outlines the plant and cooling system as now built and actually in operation.

Revised system

To provide a more flexible cooling system and at the same time a more economical one, the contractor has designed and built, with the approval of the government, a system which provides for (1) a cool-water supply of 70 deg. or less resulting from passing desilted river water over a cooling tower; and (2) water cooled by the ammonia refrigerating process to about 40 deg.

The plant is located on the Nevada side of the canyon on rock foundation above backwater elevation immediately upstream from the downstream cofferdam. This site was used because cooling will continue after storage in the reservoir and power-plant operation are started, which will require removal of the cofferdam. The cooling tower was built on the crest of the downstream cofferdam, about 200 ft. from the refrigeration plant. This unit did not demand the same permanence because when the cofferdam is removed an ample supply of pre-cooling water will be available from the power penstocks, and the cooling tower will no longer be required.

Plant—The capacity of the refrigerating plant is rated at 825 tons of refrigeration. This unit, commonly used in refrigeration practice, is equal to the amount of heat required to melt 1 ton of ice in 24 hours, or may be expressed as 220 B.t.u. per minute. The plant consists of three 275-ton compressors, which are remodeled air-compressor units used during the driving of the diversion tunnels. These units were

Refrigeration equipment for cooling of 5,400,000 yd. of concrete in Boulder Dam is located at bottom of the canyon just below the dam. Cooling tower for pre-cooling water for first stage of heat dissipation is shown at top center, located on the downstream cofferdam. After storage has commenced in the reservoir, this cooling tower will be dismantled. Refrigeration plant can be seen against canyon wall at extreme right.

purchased especially for this dual service and were adapted to refrigeration service by the simple substitution of ammonia cylinders for the original air cylinders. The plant layout will permit the addition of a fourth unit if necessary. The electric motors driving these compressors are 250 hp. each for the refrigeration work, and the motor size was also selected with this purpose in view, as normally they would have been of 200-hp. size for ordinary air-compressor service.

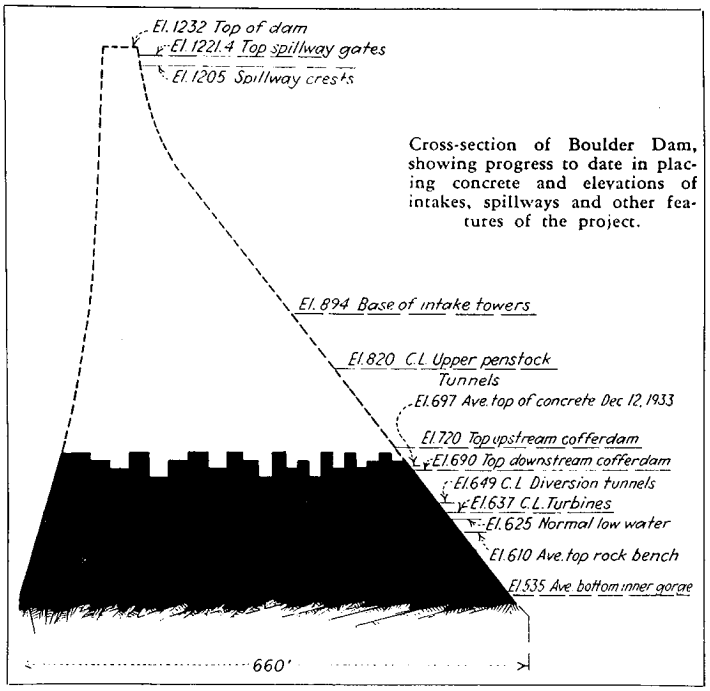
The rated 825-ton capacity of the present plant, when reduced by an estimated loss of 50 tons in plant and pipe lines, leaves an actual plant capacity of 775 tons as compared to the original specification requirement of 620 tons.

The atmospheric type of cooling tower erected on the crest of the cofferdam is built of redwood and is 150x16 ft. in plan and 43 ft. high. The Six Companies' specification to the manufacturer required it "to cool 6,000 g.p.m. from 87½ deg. to 80 deg. with a 75-deg. wet-bulb reading and a 5-m.p.h. wind velocity." The low humidity in the region, which runs about 12 to 15 per cent, coupled with the natural draft in the canyon, combine to make this method of cooling very effective. During the month of September it was possible to cool water as low as 65 to 70 deg. with this tower. Considering the volume of water and the relative

The cooling tower and header pipe yard, located on the crest of the downstream cofferdam, as seen from the Nevada wall of the canyon.

temperatures produced by this cooling tower, the pre-cooled system provides up to about 900 tons of refrigerating capacity in addition to the 825 tons produced in the plant.

Water supply for this entire cooling system was an important problem. After studying various possibilities it was decided to reduce pump maintenance and provide more continuous operation by recirculating the pre-cooled water rather than to waste it as it came from the dam. The wasting of such a flow on its return from the dam would have required the use of river water to make up the flow. On the other hand, in the present recirculating system it is possible to secure the small amount of make-up water from the sump between the cofferdams, providing a silt-free supply. The basin of the cooling tower was built especially large to provide a desilting action. During maximum operations of the entire cooling system there will be circulated over the tower 3,000 g.p.m. of the pre-cooled water and 3,000 g.p.m. of condenser water from the refrigerating plant.



Cross-section of Boulder Dam, showing progress to date in placing concrete and elevations of intakes, spillways and other features of the project.

Pumping plant

In the closed, refrigerated water system the pumping plant consists of three 750-g.p.m. electrically operated centrifugal units and an additional stand-by unit to handle the 2,100-g.p.m. flow. The friction loss for the 50-ft. lift of cooling system is estimated at 130 ft. Since this system provides a closed circuit on the pumps, there will be no additional pumping head, except friction, as the system is raised for each successive 50-ft. lift of cooling.

The open pre-cooled system requires a more extensive pumping layout because of the increasing head as the cooling process is raised in the dam. For the initial operations, below El. 750, the pumping will be done with three 750-g.p.m. centrifugal pumping units (one stand-by is provided). Between El. 750 and El. 950 another duplicate system of pumps will be introduced to handle the additional head. When the dam has reached El. 950, storage is scheduled to start in the reservoir and the lower cofferdam and the cooling tower will be removed. With the dam above this height the reservoir water will be used for the water supply. With the head produced by the reservoir, the pumping installation is estimated to be able to handle the head to the crest of the dam. If water storage is not begun in time to provide sufficient head for the plant, another duplicate set of booster pumps will be added to this system. The water taken from the reservoir will be comparatively free from silt, and as a result of the unlimited supply the return from this system will be wasted into the river. In addition, the water required for the condensers of the refrigerating plant will also be taken from the penstocks and will be wasted into the river.

The water supplies from the pre-cooled and refrigeration systems will be pumped in two main 14-in. headers and two similar return mains from the plant about 1,000 ft. to the downstream toe of the dam. A central slot 8 ft. wide is left through the dam during construction to provide for the cooling-system header pipes. The four main pipes extend upward on the downstream face of the dam at the slot and are carried up as the dam is raised. From these main headers and returns, 6-in. horizontal headers are extended into the slot to the upstream face hung on J-hangers attached to the concrete. The 14-in. and 6-in. headers of the refrigerating system are insulated with a 2-in. cork covering to reduce refrigeration loss.

In the lower levels of the dam the vertical spacing of the 6-in. headers is varied because of the smaller volume of concrete per foot of elevation in the lower part of the canyon. The lowest header serves a concrete depth of about 25 ft., and the next about 20 ft. Above this level the dam widens to the main canyon walls, the volume per foot lift is greater and the headers will be spaced at 10-ft. vertical intervals, to serve two layers of cooling pipes. It is possible that at the higher levels the spacing may be increased to 15 ft. as the volume of concrete decreases.

The 6-in. horizontal headers connect directly with the cooling-pipe loops in the concrete. These individual loops of 1-in. O.D. pipe run all the way from the central slot to the abutments and return. The connection between the header and the end of the cooling pipe is made through rubber hose capable of handling a 100-lb. per sq.in. pressure. The hose type of connection was used rather than pipe to make installation easier, reduce effect of vibration and make repairs easier in case of material falling down the slot and breaking connections. These hose connections fasten directly to the loops or tubing embedded in the concrete.

Pre-cooled water from the cooling tower was circulated through the lower lifts of concrete beginning Aug. 10, 1933. On Oct. 11 the refrigerating plant started operation, and that night it pumped 44-deg. water at the rate of about 1,000 gal. per minute into the two lowest headers, representing about a 50-ft. depth of concrete from the lowest foundation. This water returned to the refrigerating system at a temperature of about 74 deg. This represented the initial operation of the refrigerating plant, and only two of the three machines were in operation. For this initial output the plant was producing about 400 tons of refrigeration. As the plant operation continued the plant has delivered as high as 1,000 tons.

FINANCIAL STATEMENT OF BOULDER DAM PROJECT. OCT. 31, 1933

Appropriations	
Act of July 3, 1930	$10,660,000
Act of Feb. 14, 1931	15,000,000
Act of April 22, 1932	6,000,000
Act of July 1, 1932	7,000,000
Act of July 22, 1932 (Emergency Construction Act, 1932)	10,000,000
Act of Feb. 17, 1933	8,000,000
Act of June 16, 1933 (allotment from Public Works)	38,000,000
Total	$94,660,000
Collections	130,068
Total available	$94,790,068
Cash disbursements	42,722,361
Treasury cash balance	$52,067,707
Investments (including outstanding obligations)	
Flood control, storage, etc., diversion works, dam, outlet works, etc.	$39,264,975
Power production	1,979,703
Railroad, highways, buildings, engineering, research, etc.	4,489,836
Boulder City and other physical property	1,275,531
Interest during construction	2,101,001
Investigations, Colorado River Basin	178,542
Total capital investment	$49,289,588

Penstock Fabrication by Welding and X-Raying

Steel slabs 2¾ in. thick are bent and welded into 30-ft.-diameter pipe at rim of Black Canyon—76 miles of welds on 45,000 tons of pipe inspected by X-ray—Stresses relieved in oil-fired oven

DESERT surroundings provide an incongruous atmosphere for the modern steel-fabricating plant that is producing the record-breaking penstock pipes for the Boulder Dam project. Located on the project principally as the result of transportation problems, the plant of The Babcock & Wilcox Co., which holds the $11,000,000 contract for fabricating and installing the penstocks, is well started on welding the 45,000 tons of steel into pipe sections varying from an 8½-ft. diameter and ⅜-in. thickness to the maximum of 30-ft. diameter with 2¾-in. thickness. The key to the plant production is the coordination of the output with the installation of the penstock tunnels, as a result of the extreme difficulty of handling and storing the large 30-ft. sections after fabrication. Many of the details of the steel-handling and welding technique are of unusual interest to civil engineering readers; in addition the steps in the process of building these important units of the Boulder Dam project form an integral part of the complete story.

The plant site was selected as the first location on the government railroad back from the canyon where a level space was sufficient for the plant and for the extensive storage yards necessary in storing the completed sections. This station, locally called Bechtel, is about 1½ miles back from the canyon rim and is below the last of the five tunnels on this railroad line. This position in relation to the tunnels was important in the matter of rail transportation to the site, but subsequent plans have provided for handling the completed sections, by special truck and trailer units, from the plant to the government cableway that will place them on the platforms at the portals of the construction adits.

The shop building (Fig. 1) is a steel frame and galvanized-steel-covered structure 520 ft. long, 85 ft. wide and 55 ft. high to chord of roof truss. The steel columns are spaced at 25-ft. intervals along the side, and their design involved heavy sections because of the great loads, in which a lift will be handled by two 75-ton cranes.

As a lean-to building on one side of the main shop, an area 150 ft. long by 20 ft. wide is provided to house the office of the shop, testing laboratory, machine shop, compressor plant and washroom. The main shop and lean-to involved about 750 tons of structural steel, 67,500 sq.ft. of galvanized-steel covering, 23,000 sq.ft. of glazed steel sash and 30,000 yd. of excavation. It is impossible to outline a formal layout of the equipment because many units are portable and are moved to take care of changes in the fabricating system resulting from working on different pipe sizes. The general description of the fabricating process, outlined in the following, indicates the relative position of the major units. Fig. 2 is a general view through the shop, looking toward the head end, with work under way on 8½-ft. pipe.

Adjacent to the shop is the office building, a single-story timber-frame building (Fig. 1). In addition to these buildings at the plant site, the contractor also constructed twelve four- to six-room houses and seven four-apartment buildings in Boulder City for the use of married employees. A 100-room dormitory completely equipped with air-conditioning in every room is also provided for this organization.

Plant operation and output is dependent upon the work of installation in the penstock tunnels because of the limited storage space available within reach of the heavy cranes capable of handling the large-size pipe. It is impossible to handle this pipe, with special sections weighing up to 150 tons, except with the shop cranes, which will run on extension rails 600 ft. beyond the end of the building. The smaller pipe sections can be stored and rehandled with standard locomotive-crane equipment, and the plant began operations on this size of penstock. This procedure had the advantage of allowing the plant operations to begin on the smaller-size material, which can be more easily stored until needed.

Since the work of installation must progress from the upper end of the penstocks, using the 30-ft.-diameter sections, fabrication of these pipes has awaited the lining of the 37-ft.-diameter penstock tunnels. This lining is now in progress on both sides, and it is estimated that in the spring of 1934 both 37-ft. penstock tunnels will be ready for the installation of the welded pipes. In the meantime the plant has fabricated practically all of the smaller-diameter 13- and 8½-ft. pipes for both the Nevada and Arizona sides of the installation. Work on the large-size sections for the first installation on the Nevada side is now in production.

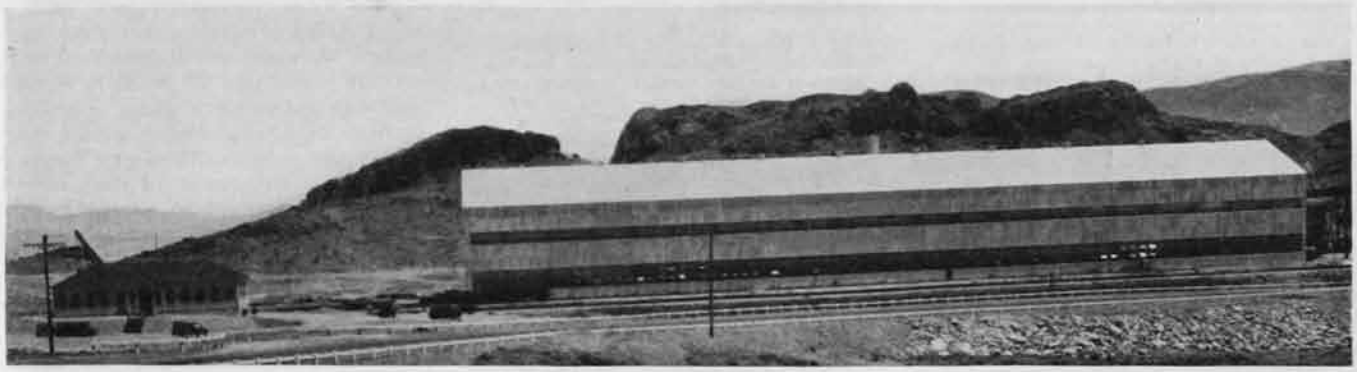


Fig. 1—Steel plate enters one end of this completely equipped fabricating plant in sheets and emerges at the other end as welded pipe sections, some of 30 ft. in diameter, thoroughly inspected and tested. Plant, located near rim of canyon, provides for straight-line operation. Pipe contractor's office building is at left.

Fabrication

Preliminary Steps—Steel is shipped in flat plates from Eastern plants; the largest plates are 32 ft. long by 12 ft. wide and 2¾ in. thick. These largest plates weigh about 23 tons apiece, and two of them constitute a freight carload. Three of them are fabricated into a 12-ft. length of 30-ft. pipe, and two such rings are welded together to form a single pipe section. The plate is unloaded by locomotive crane and stored in the yard at the west end of the plant.

Moved into the plant, the plates are handled throughout the fabrication process by two of three 75-ton electric cranes. Each plate is first laid out and marked to the required pattern, and the

Fig. 2 (above)—Interior of shop during fabrication of 8½-ft. pipe sections, first to be built. View is toward receiving end of plant, with welding machines at left.

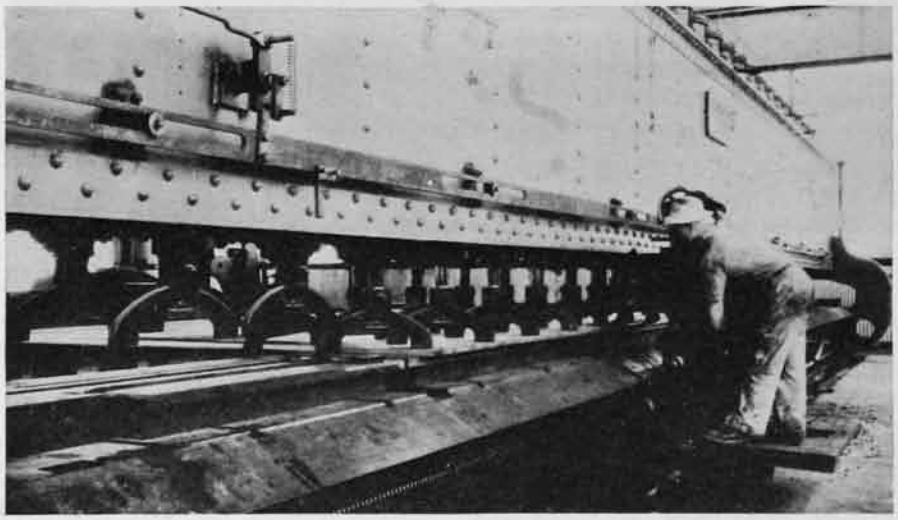


Fig. 3 (below)—Special planing machine trims edges of plates and cuts welding groove at the same time. Pneumatically operated plungers hold the sheets in place.

edges are then planed. The special planer (Fig. 3) for this work is equipped with a double set of cutters on the carriage for operating in both directions without loss of motion on the return. The plates are clamped into the planer frame by pneumatically operated plungers. This operation not only produces the planed edge but also provides the special outline of the edge weld.

From the planer the plates move to the vertical plate-bending roll, where they are shaped to cylindrical form. This roll is the most powerful ever designed for the purpose and can impose a load of 3,500,000 lb. on the plate. It will handle all the thicknesses and sizes of plate up to the 30-ft.-diameter section. The design and operation of this machine were described in *Engineering News-Record*, March 9, 1933, p. 307.

To form the special conical sections of pipe and to bulldoze the edges of the thick plates before starting them into the roll, two 1,500-ton presses are provided which work as a unit (Fig. 6). These presses are connected by cast-steel girders, weighing about 55 tons each, and they operate as a unit. The press equipment weighs about 300 tons, and the action is provided by a 30-hp. motor driving a rotary-pressure pump to provide oil pressure at 2,000 lb.

Welding—Following rolling, the plates are welded together, the number of welds and operations depending on the size of pipe to be fabricated. Preliminary steps consist of bringing the rolled sections to final shape and dimensions and spot-welding them, preparatory to placing them in the automatic machines. The welding space cut out by the planer provides the conventional V-shaped groove on the outside of the plate. The welding is done by automatic machines mounted on gantry units that operate either on the top or inside the pipe sections (Fig. 5). The pipe sections are mounted on rollers for turning to bring the one or more longitudinal seams under the arc or for welding the girth seams on the smaller diameter pipe.

The automatic-feed mechanism provides for a continuous operation on each passage of the arc. The flux-coated electrodes are provided in 12-ft. lengths for the machine; and as the ends are equipped with a threaded joint, the process is not interrupted by a stop to change rods. After each passage of the arc, the bottom of the weld is chipped clear of slag down to homogeneous metal before the next layer of metal is applied. Welding is done in accordance with the A.S.M.E. code for unfired pressure vessels, class I.

The 8½-ft. diameter pipes have a comparatively simple fabricating procedure, with only one longitudinal weld, and are joined into 20- or 30-ft. sections with one or two girth seams. The 20-ft. sections of 13-ft.-diameter pipe are required by specifications to have a stiffener at the center of each length, which will be used in supporting the pipes on the seats in the tunnel, leaving the joints clear for field connecting operations. This stiffener requirement permitted several possibilities of design, and the final arrangement provides a 1-ft. section of stiffener ring at the center, welded to two lengths of pipe. This stiffener ring is rolled separately from a special steel shape resembling the flange of a T-beam, with all but the start of the stem removed. In welding up one of these sections there are two girth seams required to connect the sections of pipe to the stiffener ring and, finally, the ring is completed by welding on what corresponds to the stem part of the T-beam. In assembling the pipe sections and the stiffening ring an elaborate system of spiders is used to bring the three into alignment before they are spot welded.

X-Ray—Following the completion of each welded joint, either a longitudinal weld or the subsequent girth seams, every inch is photographed by X-ray for inspection. This work will require the photographing and checking of more than 400,000 lin.-ft. of weld on this contract. The two 300,000-volt capacity X-ray machines are portable and are moved about to the welded pipe sections as required (Fig. 7). Beginning at a marked point on each longitudinal weld, the machine photographs a 30-in. section of weld and is then moved to the next position or, in the case of a girth weld, the pipe is rotated the equivalent distance.

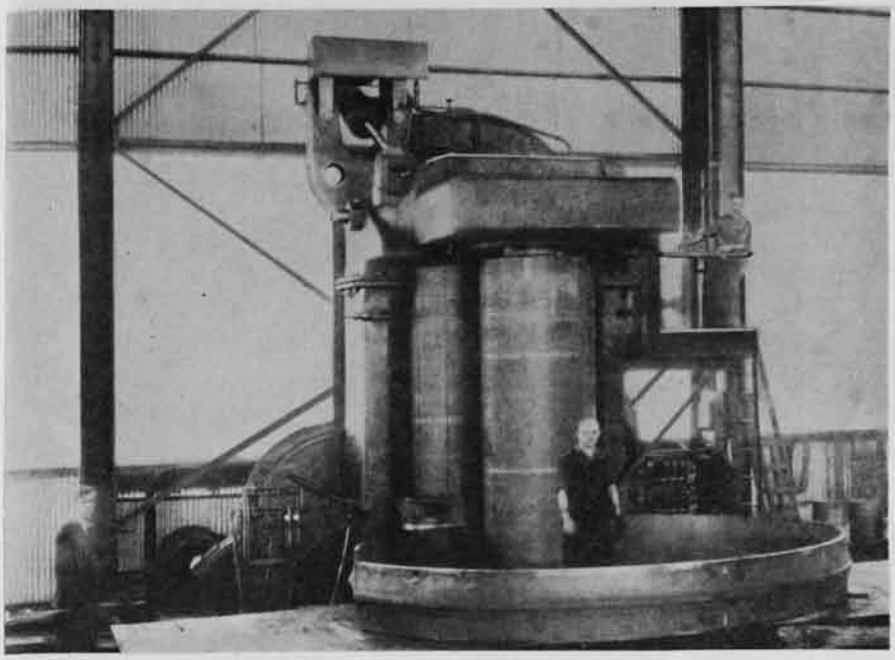


Fig. 4—Fabrication of the huge pipes requires this vertical bending roll, the largest ever built. The view shows rolling of stiffener rings for 13-ft. sections, which will be welded between two lengths of pipe. A ringed stem unit is later added to the stiffener ring to form a circular T-beam.

As soon as the X-ray of the particular weld is completed, the films are developed in the adjacent laboratory and inspected. This is done as promptly as possible, to insure approval of the weld before further work has been done on the section. In case the X-ray photograph reveals any flaw in the weld, it is chipped out and rewelded by hand.

Fig. 5—Automatic welding machine set up for longitudinal seam on a 30-ft.-diameter pipe section. The girth seams are made in the field with pins. Welding rods come in 12-ft. lengths with threaded ends for coupling into continuous rods, eliminating delay in changing rods. Two legs of spider used to shape pipe to perfect roundness before welding can be seen within the pipe section in the picture.

B. D. Glaha Photo

Stress-Relieving—After X-ray inspection of the welds and the approval of each section, the pipes are given a stress-relieving treatment by heating them to a temperature of about 1,200 deg. F. The specially built furnace is the largest of its kind, measuring 36x41 ft. in plan on the inside with a height of 28 ft. 3 in. The furnace is located at the end of the fabricating plant, and the door forms the front wall, moving out on rails to open. This wall-door combination also is integral with the car that carries the pipes as they are placed by the cranes. The furnace is operated as required by the output of the fabricating process. Its capacity will include sixteen sections of the 8½-ft. pipe, four of the 13-ft. pipe, and a single section of the 30-ft.-diameter pipe.

Heat is furnished by oil burners, and the hot gases are circulated through the furnace by a blower and valve system that reverses the flow on a timed cycle.

QUANTITY AND SIZE OF PENSTOCK PIPE

Length, Ft.	Diameter, Ft.	Thickness, In.
4,700	30	1 1/16—2 3/4
1,900	25	1 5/8—2 1/16
5,600	13	1/2—1 7/16
2,300	8½	5/8—3/4

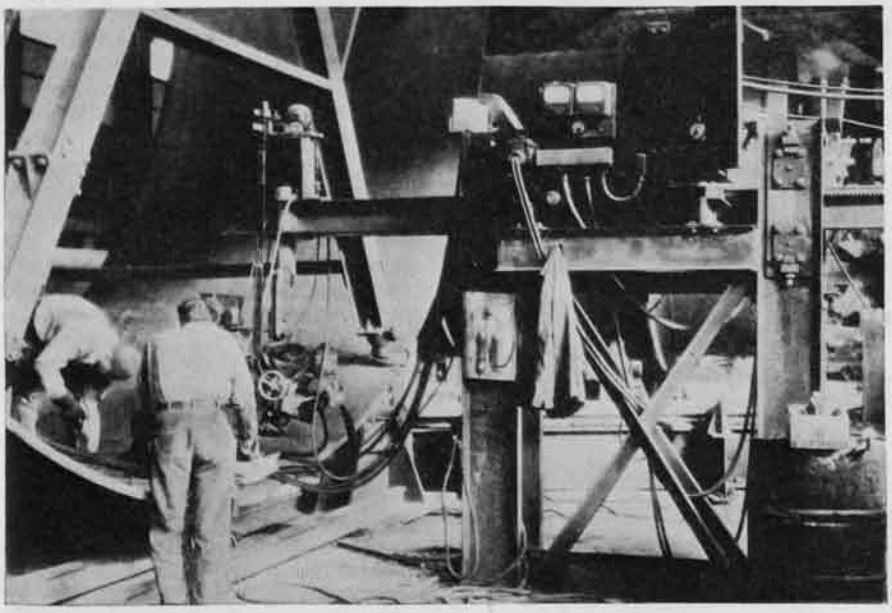
An automatic control can be set to reverse the gas flow at intervals of 1 to 10 min., but the usual run is made on about a 5-min. reversing period. The principle of reversed flow, first feeding the hot gas from one side of the furnace and then from the other, provides for equalizing the temperature of pipe being treated. The furnace is lined with insulating firebrick, including the necessary gas ducts, to provide minimum heat loss and minimum heat-storage capacity. The latter is important, as may be judged by the fact that at least one additional furnace would be required if ordinary firebrick were used. Fuel consumption is estimated at about 700 gal. of oil or less for the six-hour heating period, bringing the furnace up to the 1,200-deg. required heat, and about 35 gal. per hour for the subsequent soaking period. Automatic temperature control, with recording instruments within the furnace, maintains the temperature within 20 deg. of the desired point.

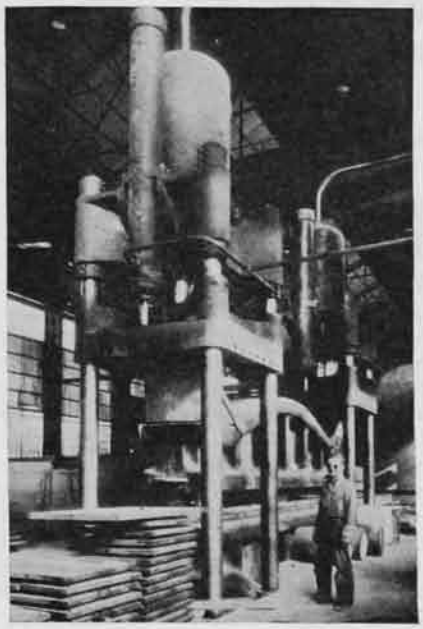
After the furnace, containing the pipe sections, has been brought to the 1,200-deg. point, this temperature is maintained for a period of time depending upon the thickness of pipe being treated. The furnace is then allowed to cool to a temperature of about 600 deg. during a three-hour period, after which the pipes are removed.

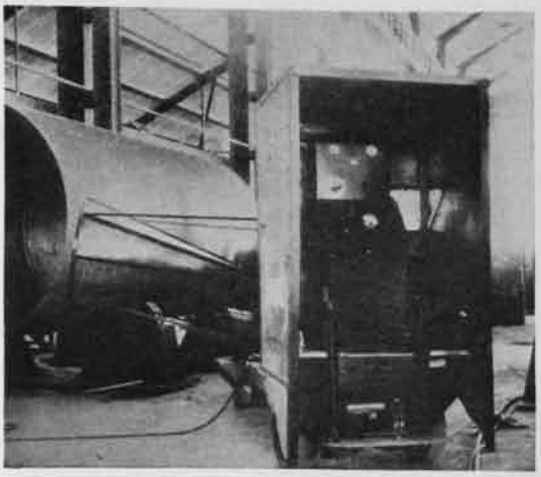
The final step is the accurate milling of the ends of the pipes to provide the final field fit. On the 8½- and 13-ft.-diameter sections this is done in the

Fig. 6—Heavy plates for the larger pipes are given initial bend by these two 1,500-ton hydraulic presses acting as a unit.

B. D. Glaha Photo







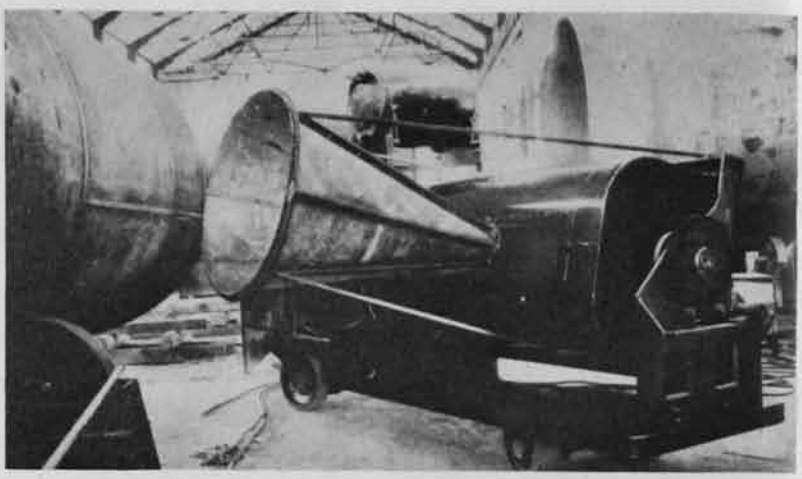


Fig. 7—Every inch of the 400,000 lin.-ft. of welds required in fabricating 45,000 tons of pipe is photographed by these X-ray machines for inspection. Welded seams are X-rayed in 30-in. lengths. Films are developed immediately after exposure to permit defective welds to be replaced before pipes leave welding frame.

storage yard with a motor-driven tool held by a spider in the end of the pipe section. The larger-size pipe will be milled with a large special lathe permanently mounted in the end of the shop.

Testing—One weld specimen is taken from each fabricated length of pipe and is tested in accordance with the A.S. M. E. boiler construction code, unfired pressure vessel section. This testing is done in a completely equipped laboratory, including a 300,000-lb. testing machine, adjacent to the shop, under the supervision of the government inspectors. Briefly, the tests include a tension test of the joint and a tension test of the weld metal itself, which are both required to equal that of the original plate. There is also a bending test, cold, which must show an elongation of the weld metal of at least 30 per cent without developing cracks. The specific gravity of the weld metal must equal 7.80 as a minimum.

The pipe sections are finally shot-blasted inside and given a primer coat of water-gas tar and a final coat of coal-gas tar applied hot.

As mentioned at the outset, the storage for these fabricated sections requires a large area, and handling is difficult. The first pipes to be installed are the largest-size, 30-ft.-diameter sections for the main penstock, but these sections can be handled only by the shop cranes. This made it impossible to fabricate them and store them in large quantities prior to erection.

Furthermore, there was the decidedly practical advantage of starting shop operations on the smaller sections, and this was done by completing all of the 8½-ft. and 13-ft. sections leaving the plant free to fabricate and handle the large sections as soon as the tunnel is available.

Spillways in Canyon Walls to Handle Floodwaters

Two side-channel outlets provide 400,000-sec.-ft. discharge capacity—Drainage system is important design feature—Automatic steel drum gates will hold reservoir level 24 ft. above fixed spillway crest

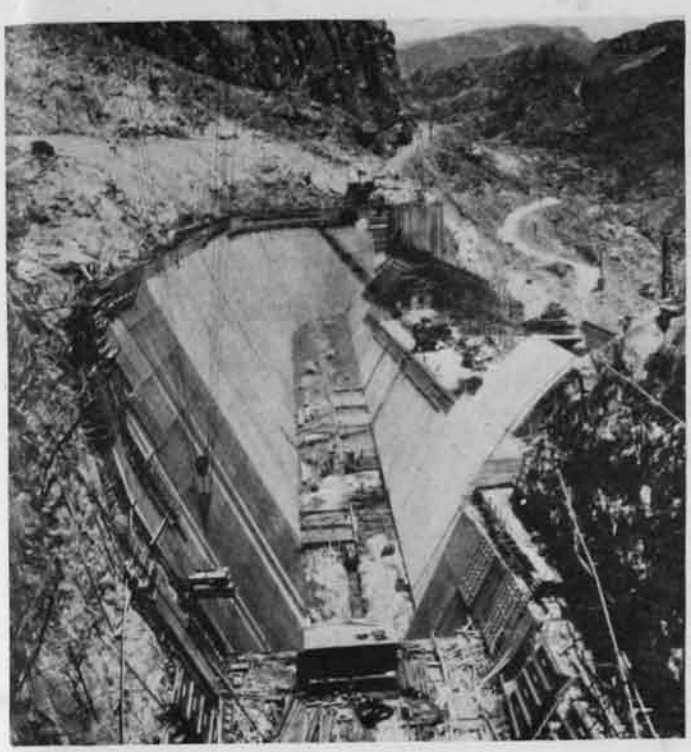
By D. C. McConaughy
Senior Engineer, U. S. Bureau of Reclamation, Denver, Colo.

DESIGNED to handle a discharge of 400,000-sec.ft., the two side-channel spillways for Boulder Dam will provide a capacity 50 per cent in excess of the great flood of 1884, which constitutes the peak runoff of which any tangible evidence remains. Further, this spillway capacity does not include the effect of 9,500,000 acre-ft. of reservoir capacity reserved for flood control or the 120,000-sec.-ft. discharge capacity of the power house and outlet valves. Each spillway has a 400-ft. length of weir crest and an over-all length of about 700 ft. from upstream end to the portal of the inclined discharge shaft. The two contain about 150,000 cu.yd. of concrete and required excavation of 700,000 cu.yd of rock Discharge of each is through an inclined tunnel, varying from 50 to 70 ft. in diameter, to the present diversion tunnels, which will act as permanent spillway outlets. Four 100x16-ft. steel drum gates on each spillway will provide automatic regulation to hold the reservoir level 24 ft. above the fixed crest of the weirs. Principal features of design, operation and construction are outlined in the following.

Design

The need for accurate and conservative spillway design can be appreciated from the fact that the reservoir will store 30,500,000 acre-ft. of water and raise the surface level about 600 ft. above the original river channel. In this reservoir 9,500,000 acre-ft. of capacity will be reserved for flood control, and the combined outlet capacity of the power-house openings and the outlet valves will equal 120,000 sec.-ft. Requirements for spillway capacity were based primarily on a study of the 1884 flood. It is estimated that this maximum peak was from 250,000 to 300,000 sec.-ft. compared to an average annual peak of about 100,000 sec.-ft. Studies of flood probabilities indicate that intervals of 200 years will occur between floods of the 1884 peak flow, and that the interval between floods of comparable volume may exceed 1,000 years. The final designed spillway capacity of 400,000 sec.-ft. is in addition to the capacity of the power-house outlets and the ponding effect of the flood-control capacity in the reservoir. With these provisions it is estimated that a flood similar to that of 1884 would be reduced to a maximum discharge of 75,000 sec.-ft.

A detailed account of the hydraulic-model testing program that formed the basis of the spillway design was presented in *Engineering News-Record*, Aug. 10, 1933, p. 155. Characteristics of the site indicated the feasibility of the side-channel type of spillway, and the final result of the design studies supplemented by the model tests provided two identical spillways, each with a 400-ft. clear crest length (Fig. 2). The channel



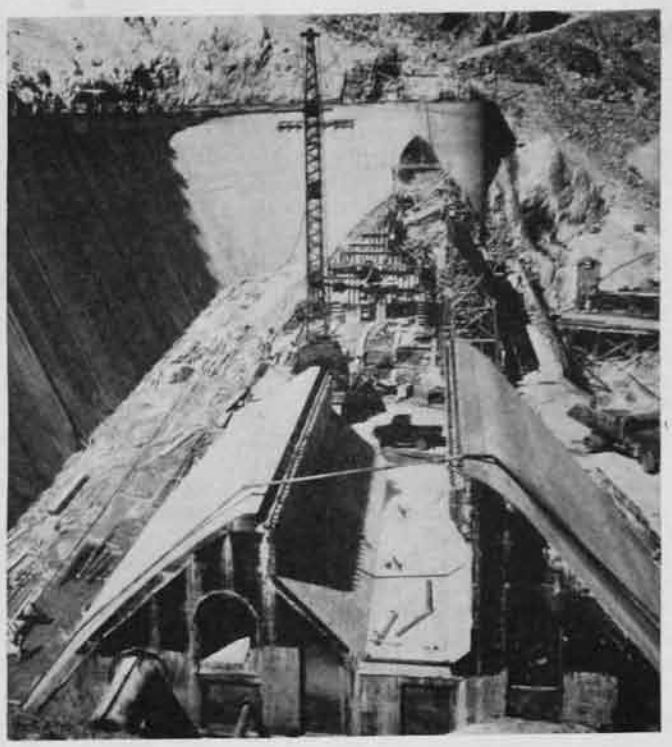


Fig. 1—General view of Nevada spillway (left) and weir crest and gate recess (right). Pier construction between the four 100-ft. gates has not been started. Lining operations with 4-yd. agitators handled by cableway are in progress (left). Total length is about 700 ft., and the lining on the back side, opposite the downstream gate, is 128 ft. from top to bottom.

has a uniform bottom width of 40 ft. At the upper end the depth is 75 ft., and the floor slopes on a 12 per cent grade to a depth of 128 ft. at a point opposite the lower end of the crest, depth being measured from the top of the channel lining.

The face of the weir that forms part of one side of the channel is a parabola tangent to a ½:1 slope; the lining forming the other side is laid on a similar slope. These slopes provide a width of 125 ft. (elevation of weir crest) at the upper end and 165 ft. at the lower end. From the downstream end of the last 100-ft. gate section a 55-ft. length of channel was added to improve hydraulic conditions and reduce the disturbance at the entrance to the transition leading to the inclined tunnel. At the lower end of this section of channel a step about 36 ft. high was introduced to provide increased depth, reducing the disturbance caused by cross-flow. A pipe provides for draining this sump, following flood discharge, into the main drainage manway. The crest of this step is the beginning of the parabolic curve forming the bottom of the transition leading to the 50-ft. inclined tunnel.

On the weir side the topography at each site necessitated the construction of a gravity dam of overflow profile that had a maximum height of 75 ft. on the Nevada side and 85 ft. on the Arizona side. Design and construction of these overflow weir sections were practically the same as for a dam of similar proportions. At quarter points on the crest of this overflow section are three piers dividing the crest into 100-ft. sections corresponding to the length of the steel drum gates. These piers are 11x27 ft. in section and are 36 ft. high.

Lining and Drainage—The sides and bottom of the spillway channel and transition are lined with a 24-in. thickness of concrete (18-in. minimum). The lining of the inclined shaft is 36 in. thick. Nominal reinforcement was used in the lining with the exception of the 50-ft. circular shaft, in which no reinforcement was used, and in the arched roof of the covered transition, which was very heavily reinforced. The channel lining was built in panels 14x15 ft. in plan dimensions, and each panel is secured to the rock by hooked 1⅛-in. square bars grouted into holes drilled into the rock a minimum distance of 5 ft. These dowels anchor the slab and assisted in holding the reinforcing steel before concreting.

Because of the importance of these spillways, the volume of water to be handled and the high head on the lining an elaborate system of drains is pro-

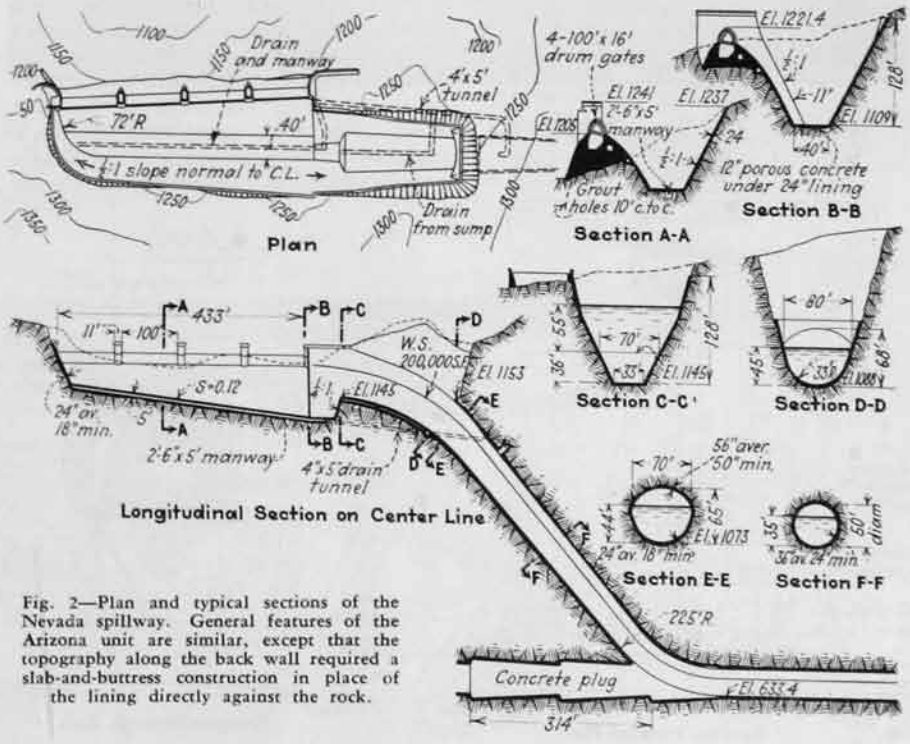


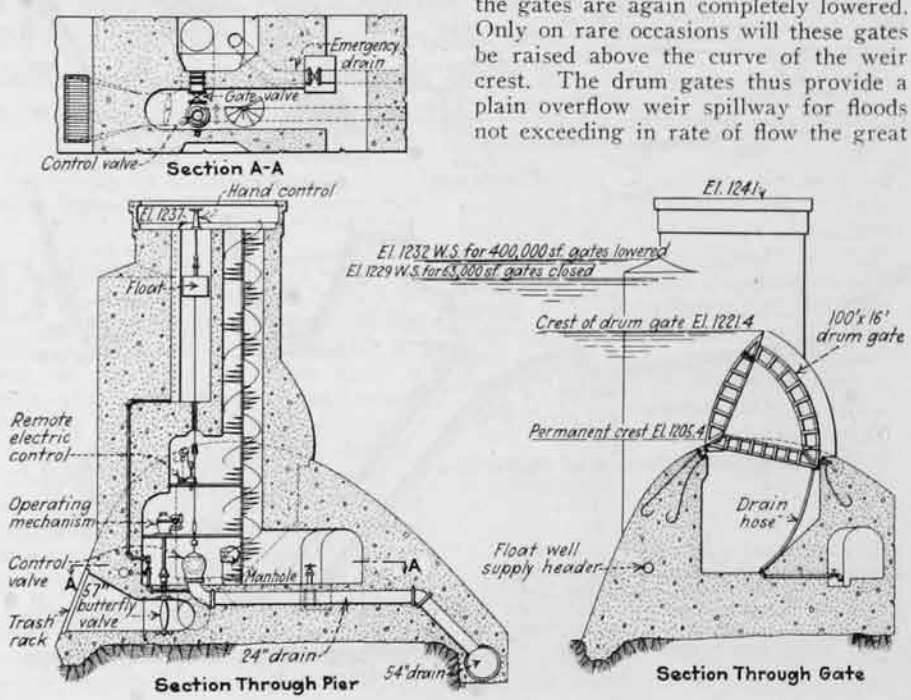
Fig. 2—Plan and typical sections of the Nevada spillway. General features of the Arizona unit are similar, except that the topography along the back wall required a slab-and-buttress construction in place of the lining directly against the rock.

vided. Running vertically under the construction joints in the lining are lines of porous concrete drain tile 6 in. square with a 3-in. hole in the center. This concrete tile is made of six parts of aggregate to one part of cement, tamped very dry into the forms. The result is a porous mixture that has the necessary strength and offers maximum space for drainage. The lines of tile extend down behind the joints to the bottom and across the floor to a 2½x5-ft. manway extending under the center of the channel floor. In addition to these drains, the whole channel bottom was underlaid with a minimum thickness of 12 in. of this same porous concrete.

The manway extends to the lower end of the channel, turns at right angles into a tunnel in the canyon wall, picks up the drainage outlets from under the weir structure and extends in a 4x5-ft. tunnel (concrete-lined), which turns at right angles to parallel the flow in the spillway and finally turns again at right angles to discharge into the top of the inclined tunnel 350 ft. below the end of the spillway (Fig. 2). This drainage tunnel discharges into the top of the inclined shaft (at capacity flow the shaft does not run full) to avoid disturbance of the hydraulic characteristics.

Gates—Each of the eight spillway gates (four for each spillway) is a bouyant structural-steel vessel 100 ft. long with flat bottom and two curved faces (Fig. 3). The resulting section resembles the conventional projection of a spherical triangle with each side about 17 ft. long. The gates are built up of structural-steel members, the outer surface of ½- and ⅝-in. plate being supported directly on built-up plate girders at 28-in. centers.

Fig. 3—Principal features of the drum gates and the operating arrangement.



In the lowered position the top side of the gates will provide a curved surface to complete the outline of the weir crest. Hinged at top and upstream side to the concrete weirs, these gates will float in recesses in the weir section (Fig. 1) and will operate to provide a maximum depth of 27 ft. over the fixed crest. The gates will be provided with spring seals at both ends and at the downstream lip to prevent leakage into or from the recess chambers. Possible leagage into the gates will be drained by flexible hose connections.

Automatic control (manual operation optional) provides for the raising and lowering of the gates in accordance with floodflow. When the water surface of the reservoir reaches a predetermined level, it enters the recess chambers and causes the gate to float up in advance of the rising water surface. When the gate has reached its maximum position pressure of the water against the bottom holds it in position until an additional rise in the reservoir, operating through the control mechanism, opens a valve and releases water from the recess chamber, allowing the gate to lower. This additional rise may be selected at will; in actual operation it is intended that the reservoir water surface will be about 7.5 ft. above the crest of the gate, corresponding to a discharge of about 63,000 sec.-ft. for both spillways.

The reservoir water surface will be maintained at this elevation until the gates are completely lowered. After this has occurred a rise of about 3 ft. in the water surface is required to discharge the designed capacity of 400,000 sec.-ft. At maximum discharge the head on the weir crest is about 27 ft. As the flood peak decreases, the gates automatically rise to their maximum position and then, as the water-surface level recedes still further, they fall again so that when the flood has passed the gates are again completely lowered. Only on rare occasions will these gates be raised above the curve of the weir crest. The drum gates thus provide a plain overflow weir spillway for floods not exceeding in rate of flow the great flood of 1884, and at the same time provide a huge reserve capacity.

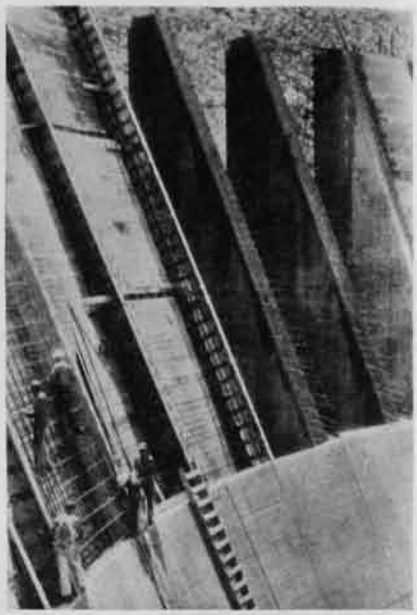


Fig. 4—Topography of the Arizona site required the back wall to be built as a slab-and-buttress dam. The view is the work at the curve at the upstream end.

Excavation—Removal of 600,000 cu.-yd. of solid rock by open-cut operations was required to provide for the two spillways. Drilling was done almost entirely by jack-hammers sinking downholes. The blasted rock was loaded by electric shovels into trucks for disposal. The removal of this yardage of rock outside the canyon area, as required by specifications, was the principal problem involved. Construction roads over steep grades with many sharp turns were necessary to make available side canyons at high elevations for the storage of this excavated material. On the Arizona side a large volume of this excavated rock was used as a fill to provide for the runway of a traveling cableway tower.

Concrete placing over such a large area provided a problem. Concrete from the high-level mixing plant was delivered in 4-yd. agitators on trucks and either moved directly by cableway to the pour behind the forms (Fig. 1) or transferred to 2-yd. buckets for more convenient handling. Forms consisted of timber panels, which were held in position by a separate system of rods doweled into the rock. The concrete paving on the floor of the spillway involved no unusual construction problem.

The Nevada spillway structure fitted well into the topography of the canyon, the back wall requiring only the concrete lining against solid rock. On the Arizona side the topography of the location did not conform so well with the required design of the spillway channel. This necessitated a slightly different design for the back side, which was carried up as a reinforced-concrete slab supported by buttresses (Fig. 4). With water in the spillway channel, this wall construction will act as a slab and buttress type of dam.

Progress on Small Tunnels and Intake Towers

Penstock tunnels driven and lining started—Bulkhead and stoney gates installed at diversion tunnel portals—Derricks and additional cableway will handle concrete for intake towers

CONCENTRATION on concrete production during the past six months has not delayed the prosecution of other features of the Boulder Dam project to keep them in step with the general accelerated program. In addition to the construction of the spillways (p. 590)—and the establishment of the penstock-fabricating plant and the start of this work (p. 751), the operations of the past months include the completion of the extensive program of tunnel-driving on the smaller penstock units, the start of lining these tunnels, including the Nevada inclined shaft from spillway to diversion tunnel, the installation of diversion tunnel gates and preparations for the building of the four intake towers. The general methods involved and the progress on these featured are briefly outlined.

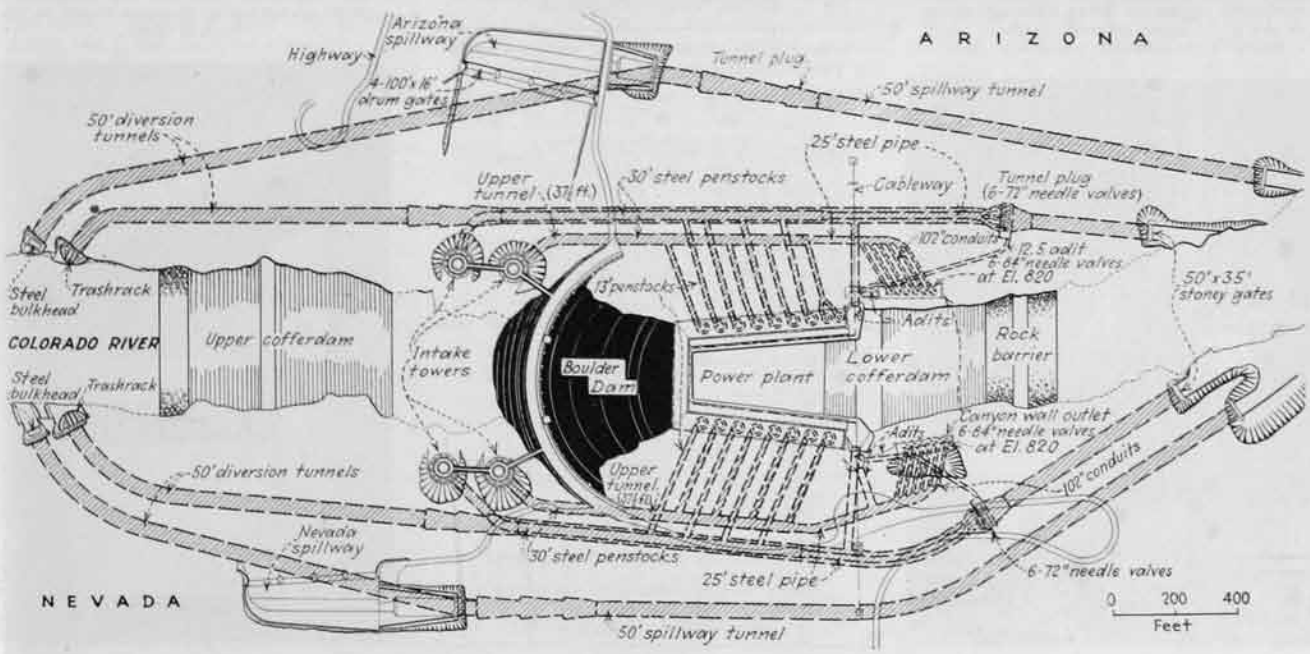
Penstock tunnels

In addition to the four major diversion tunnels, the tunneling program on the project included: (1) One 37-ft. penstock header (30-ft. pipe) on each side of the canyon extending from the downstream intake towers for about 800 ft. to the location of four branches to the power house and then decreasing to a 25-ft.-diameter outlet header and terminating in six 11-ft.-diameter tunnels for 8½-ft. outlet pipe; (2) sixteen 18-ft. tunnels (13-ft. pipe), four from each penstock header tunnel, as just mentioned, and eight from the inner diversion tunnels; (3) two 50-ft.-diameter inclined shafts from the spillways to the outside diversion tunnels; and (4) four 26x43-ft. construction adits to provide access to the penstock header tunnels for installation of steel pipe. The location of these various units is shown in Fig. 1.

The largest units of this tunneling program are the 37-ft. inside diameter (41-ft. rough) penstocks which begin at the upstream end with a vertical curve from the base of the intake tower and divide into smaller branch tunnels at the lower end. This layout necessitated the construction adits both for tunnel-driving operations and the installation of the 30-ft.-diameter steel penstock header pipe. These tunnels were driven both ways from the adit with a rail-mounted jumbo, rebuilt from one of the pieces of equipment used in lining the diversion tunnels, mounting 30 drills. Each 14-ft. round required about 120 holes and took out all of the face except a 5-ft. depth of invert section. Mucking was done with a 2-yd. electric shovel loading into trucks (Fig. 2), which moved out to the portal of the adit and dumped the

Fig. 2—Muck in 37-ft. penstock tunnels is handled with electric shovels and trucks. These tunnels start at vertical curve from the bottom of intake towers and end in a group of small outlet tunnels. They were driven from adits.

Fig. 1—Plan showing location and relation of various units of Boulder Dam project.



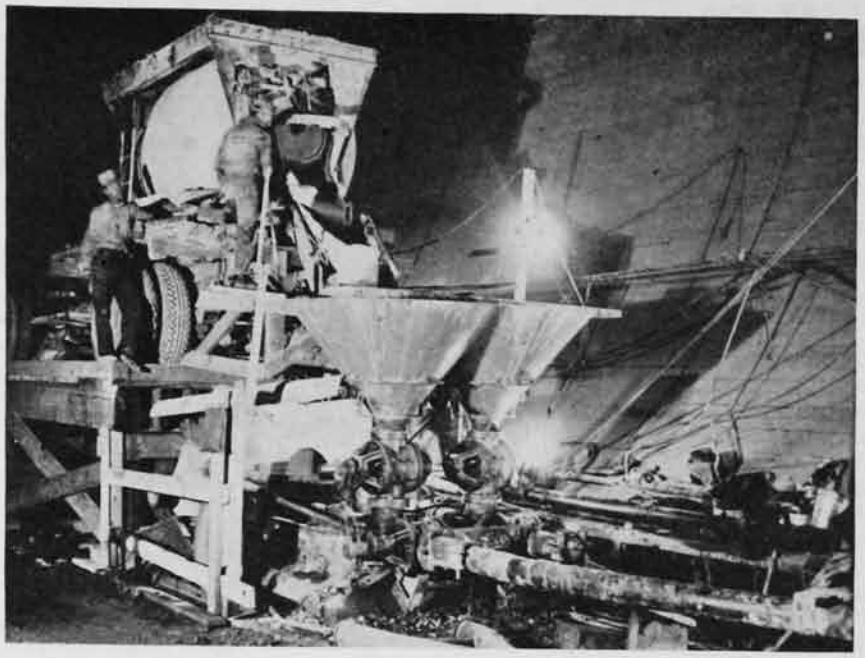


Fig. 3—The concrete pump is a new type of equipment in use at Boulder Dam. Rig shown here placed lining in riser shafts loading to canyon-wall outlets from inner diversion tunnels. Concrete for lining inclined penstock tunnels is now being pumped from lower portals.

excavated material into the canyon for removal. Ventilation was carried on with blowers and pipes and involved no particular problem.

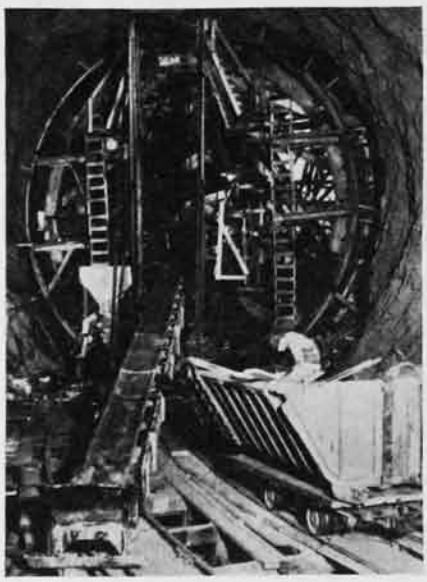
The 2-ft. concrete lining has been started in both tunnels. A full-circle form is used, remodeled from one of the diversion-tunnel forms (Fig. 4). The form provides for pouring a 20-ft. section at one time and is mounted on steel needle beams for moving ahead after each pour. Concrete for this lining operation comes from the high-level mixing plant and is delivered by cableway to the portal of each construction adit. On the Nevada side the concrete transferred to trains is taken into the tunnel to the form and there dumped into the hopper of a conveyor-belt system, which discharges through a series of chutes into the sides of the form. The closing arch section is placed by pneumatic gun. This form was set up and started at the upper or intake tower end and will more down toward the construction adit.

On the Arizona side the lining form set-up is the same, but no tracks will be laid in the tunnel and trucks will be used to move concrete from the adit to the form. This different hauling arrangement has been intentionally provided to settle a question of the relative economy of rail transportation as compared to the use of trucks for this work.

The eight 18-ft. inside diameter penstock tunnels on each side divide into two groups, four descending on a slope of 33 to 46 deg. with the horizontal from the 37-ft. penstock header tunnels, and the other four alternating and extending horizontally from the inside diversion tunnel. These eight tunnels are 60 ft. apart and terminate on the canyon wall for the present, but ultimately will connect directly to the eight turbines in the power house. The drilling of the horizontal tunnels was done with a truck-mounted jumbo drilling a 14-ft. round for a full-circle section. The inclines to the upper penstock header tunnels were driven with a center heading on columns, followed by ring-drilling one round behind, with the muck dragged down to the portal by a slack-line cableway.

Mucking in the horizontal tunnels was done with a regulation mucking machine equipped with a lengthened conveyor belt discharging into trucks. All of this tunnel muck was discharged into the canyon for final removal. A 9-in. fan and a 12-in. blower pipe carried into the face provided ventilation. Truck engines were stopped during loading, and no trouble with gas was experienced.

Fig. 4—Belt conveyor carries concrete into steel-form section in lining sides and invert of the 37-ft. upper penstock headers. Arch lining is placed with pneumatic guns.



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Executive office, Denver
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J. L. Savage, chief designing engineer
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Ivan E. Houk, engineer on technical studies
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Boulder City field office:
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Ralph Lowry, field engineer
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Fig. 5—Stoney gate on the downstream portal of the inside diversion tunnel on the Nevada side.

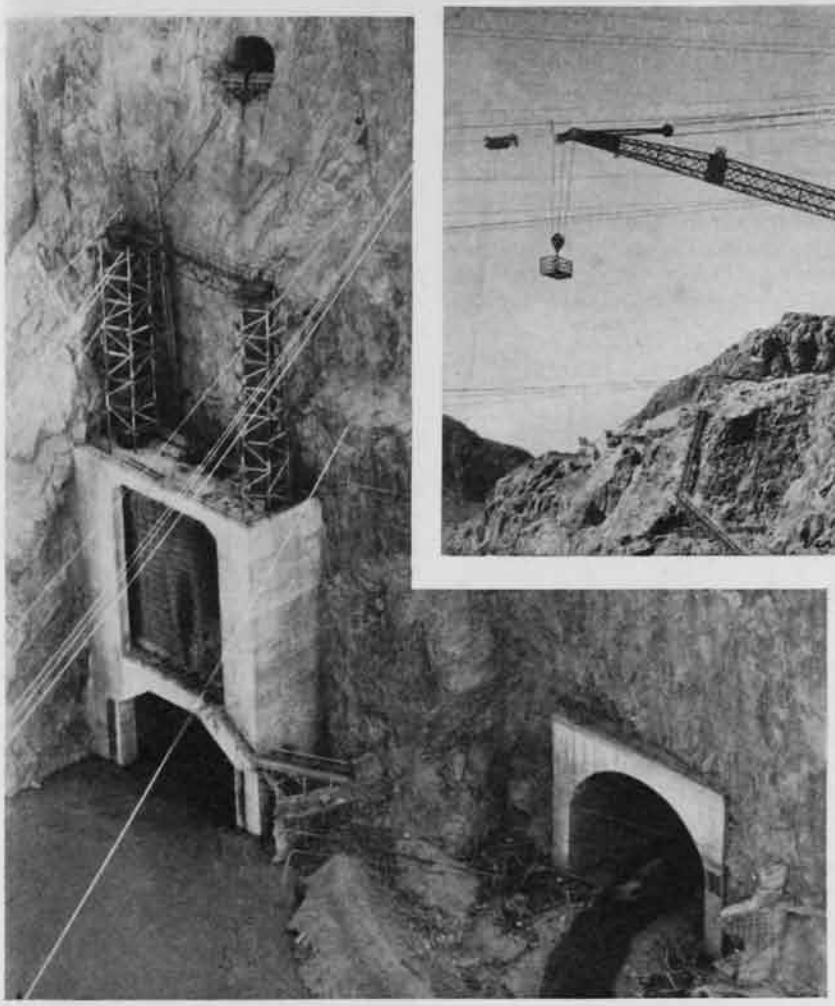


Fig. 6—Steel bulkhead gate in position at the upstream portal of the outside diversion tunnel on the Arizona side. This gate and a similar one on the other side will be lowered only once into final position to start storage in the reservoir. Low flow in the river permits a temporary cofferdam to make the other tunnel available for trucking.

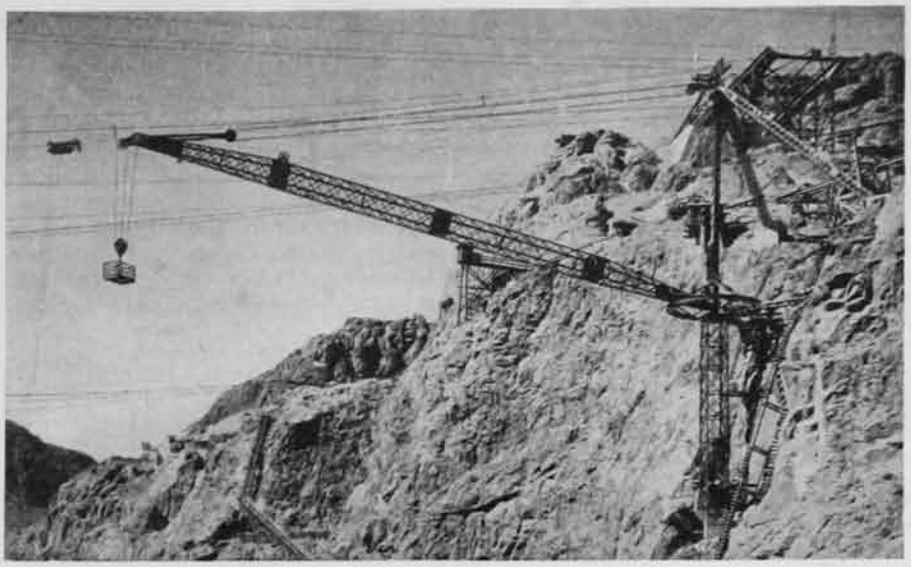


Fig. 7—Perched high on the canyon wall, this derrick is located above the site of the two intake towers on the Nevada side. It will be used to handle forms and concrete for the two towers. A similar derrick on the other side of the river will take care of the Arizona towers. A cableway will span between the two to transport concrete to the far side.

The 18-in. lining of these 18-ft. tunnels has now been started on the Nevada side, beginning with the inclined tunnels, as these must be completed first to permit proper sequence in placing the steel pipe sections, which probably will start in the 37-ft. Nevada penstock tunnels. To avoid interference with the operations inside the 37-ft. tunnel, this lining is being done from the downstream portal, using a concrete pump discharging into a full-circle timber form (Fig. 3), which is moved up the incline on steel needle beams as lining advances. It is planned to use this equipment against as high a head as possible and then complete the lining of these inclines from the upper end. The full-circle timber forms are moved ahead on steel needle beams.

The smallest tunnel units are the 8½-ft. horseshoe (excavated 13x13 ft.) outlets, six on a side, from the end of each penstock header to the canyon wall, which will discharge through 84-in. needle valves at gate houses. These tunnels are at El. 820, the same level as the 37-ft. penstocks, about 180 ft. above original riverbed. The outlets will be used to regulate streamflow and reservoir draft in conjunction with the discharge through the power plant. These tunnels average about 150 ft. long, are 27 ft. apart and are level. They were drilled from the portal end, using drills on bars. Nine-foot rounds advanced full-face headings. Excavation was handled by mucking machines loading into trucks that backed in and out of the tunnels dumping into the canyon. The trucks were a close fit in these small bores. After placing the 8½-ft. steel pipe sections, these tunnels will be backfilled with concrete.

Diversion tunnel gates

The two steel bulkhead gates at the upstream end of the two outside diversion tunnels and the two stoney gates at the downstream portals of the inside diversion tunnels have been installed and tested. The 50-ft.-diameter tunnels will be plugged at roughly midpoint after having served their primary purpose of river diversion; ultimately the two outer tunnels will be used for spillway outlets, and the inner pair will be used for penstocks.

After testing, the bulkhead gates (Fig. 6) will be lowered only once to begin storage in the reservoir. These 50x50-ft. gates are of heavy structural-steel construction designed to withstand the static head of 295 ft. (height to the intake tower discharge) and to close under a head of 60 ft. of water. The frame consists of horizontal cross-girders 55 ft. long and 12½ ft. wide, and the vertical members are 50½ ft. long by 10½ ft. wide. The skin plate of the gate is of steel 1¼ in. thick.

Erected in raised position, these gates are supported on I-beams, and at time of closure water will be introduced into hydraulic cylinders, the supports will be removed and the water released gradually to lower the gate into closed position. An elaborate system for securing tight closure is provided, including the use of cooling sprays to reduce the temperature of the gate to that of river water. In final position this gate is sealed with a rubber and bronze gasket. Each of these bulkhead gates weighs 2,180,000 lb., and the additional weight of the cylinders, wedges and steel frame is another 1,000,000 lb. The pair of gates, exclusive of the expense of erection, cost approximately $260,000.

The stoney gates on the lower end of the inside diversion tunnels (Fig. 5) are designed for raising and lowering operations under a balanced water head of 35 ft. and are for the purpose of shutting out backwater from the river below the power house to permit maintenance work on the penstocks. Each of these stoney gates is 50 ft. wide by 35 ft. high and consists of seven horizontal structural-steel girders 6 ft. deep at the center, connecting with vertical girders 3½ ft. deep on the sides and covered on the downstream face by a ⅜-in. steel plate. Two carbon-steel earplates extend above the upper edges of the vertical girders and connect with

the hoisting chains operating by sprocket drive through gears connected with a 10½-hp. motor. These operating chains, 83 ft. long, run from the gate round the hoist sprocket to a counterweight, consisting of a steel hanger and nine precast concrete blocks weighing 11,200 lb. each.

The suspended weight of each stoney gate and chain is about 260,000 lb., and the normal hoisting speed is 0.89 ft. per minute with a total lift of 58 ft. Cost of the two stoney gates complete, exclusive of erection, was about $64,000.

The deep cuts in the canyon walls for the four intake towers being completed, work has progressed toward construction of these 384-ft. shafts. To deliver concrete for these structures located high on the canyon wall and to provide convenient handling for forms and other equipment, the contractor has erected a steel stiff-legged derrick (Fig. 7) on each side of the canyon to handle a pair of towers. These derricks are located above the top of the towers, and the reach is sufficient to cover both. On the Nevada side the 180-ft. boom will reach to the track from the high-level plant to handle concrete. To transport concrete to the Arizona side and not interfere with operations on the dam, a cableway with fixed towers will be erected to deliver to the other derrick.

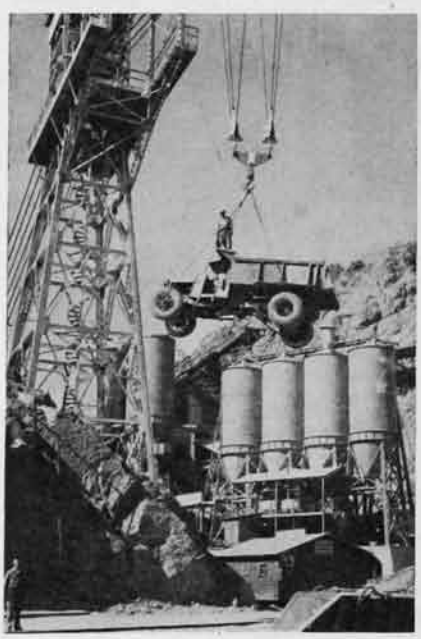
Record-Size Cableway Spans Black Canyon

FOR HANDLING penstock pipe and power-plant equipment during the construction period and for permanent maintenance work, the government has constructed a 150-ton cableway at Boulder Dam. This record-breaking installation (five times the capacity of any previously built) spans the canyon at the downstream end of the power houses and is on the line of the four construction adits driven to provide access to the penstock tunnels. The span between towers is 1,200 ft., and the vertical distance from the top loading platform to the lowest construction adit is 605 ft.

Since its completion several months ago, the cableway has been used by the dam contractor for miscellaneous operations (Fig. 1), but shortly after the first of the year installation of penstock pipes will begin.

Design and operating characteristics, as required by the specifications, were described in detail in *Engineering News-Record*, Oct. 6, 1932, p. 408, including a plan and profile of the installation. The special features of the final design and installation are outlined in the following:

Fig. 1—Everything moves by cableway in the dam-site area. The government 150-ton cableway, by far the largest ever built, is doing odd jobs, such as lowering trucks to the bottom of the gorge, until it is needed for its main task of handling penstock pipe and power-house units. Temporary hoist line shown here will be replaced by 16-part line before any real lifting is done. Steel cement silos in the background are part of high-level mixing plant.



Cables, anchors and other equipment

Cables—The track is composed of six 3½-in., 6x37, lang-lay parallel cables spaced on 18½-in. centers. Each of these cables is connected to anchor bars, and adjustment for equal tension is provided by means of hydraulically operated jacks actuating toggles between the socket of the cable and the anchor bar at the anchorage (Fig. 4). Each track cable has a breaking strength of 1,070,000 lb., making a total breaking strength of 3,210 tons for the six-part track. Under the design load of 150 tons the tension on the track cables will exert a 2,000,000-lb. pull on each anchorage.

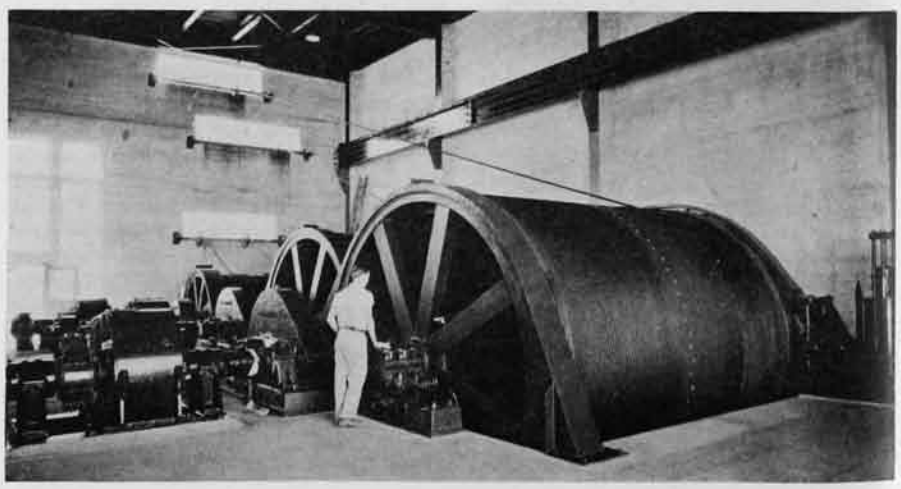
The hoist cables and endless rope are of 1⅛-in. diameter and operate from the carriage to hoisting drums for moving the load along the track and for lowering and hoisting. These ropes are supported at 100-ft. intervals by carriers attached to the main carriage (Fig. 3).

Anchors—Excellent rock at both ends of the cableway made feasible a mushroom type of anchor consisting of a 60-ft. length of 7x9-ft. tunnel opening into an 18x18x10-ft. chamber. After anchor steel had been installed in this opening, the chamber and tunnel were backfilled with concrete to a depth of about 50 ft. On the Nevada side there is a 90-ft. structural-steel tower supporting the cast-steel saddle curved for proper contact. On the Arizona side no tower was required, and the clear span starts at the concrete saddle.

Operating Equipment — The hoist house containing all the operating machinery is located on the Nevada side of the canyon between the anchorage and head tower. Each of the two main-hoist drums is 13 ft. in diameter and 17 ft. long, providing sufficient area to wind the hoist rope in a single layer. These drums are grooved for each turn of cable. A special feature of the drum construction is the use of structural-steel members with welded connections, as shown in Fig. 2.

Each of these drums is operated by a 125-hp. d.c. motor through a geared

Fig. 2—Two main-hoist drums are 13 ft. in diameter and 17 ft. long, equipped with solenoid brakes. Conveying line drum can be seen next to far wall. Note welded structural-steel construction of drum spokes.



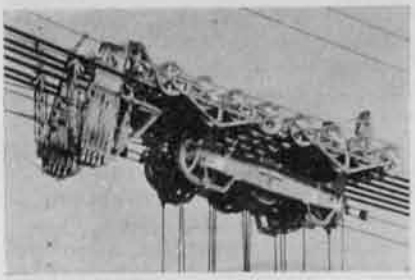


Fig. 3—The carriage rides the six-track cables on 48 wheels. Besides the track wheels there are enough line sheaves in this rig to provide a 16-part 1⅛-in. line for hoisting 150-ton loads.

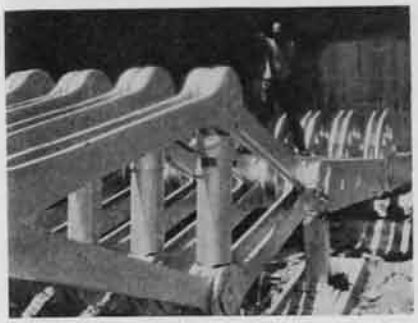


Fig. 4—Hydraulic jacks within adjustable toggles provide for equalizing the sag of the six track cables. This installation is at the Nevada anchorage.

speed reducer. The two drums and their separate motors are synchronized by an electric control mechanism to provide equalized hoisting at all speeds. From these hoisting drums the 1⅛-in. ropes are reeved in sixteen parts on the line supporting the fall blocks. Operating speed for the hoist is 120 ft. per minute for small loads and 30 ft. per minute for the maximum 150-ton design load. In addition, there will be two inching speeds for picking and spotting heavy loads, which provide a minimum movement of 5 ft. per minute.

A separate drum for the conveying line, 8 ft. in diameter and 10½ ft. long, is driven by a 400-hp. d.c. motor operating through a herringbone gear reducer. This drum carries the two 1⅛-in. ropes for movement of the carriage along the track. The speed of the carriage is 240 ft. per minute, with additional provisions for creeping speeds on approaching any station.

The hoisting equipment is provided with service and emergency brakes designed to decelerate and sustain full load under all operating conditions, including the interruption of power service. Under normal deceleration of load, dynamic breaking is provided before using the service brakes, but the latter will function automatically in case the dynamic breaking fails. The service brakes are of the solenoid-operated type. In addition to these brakes, there is an emergency brake for each drum held normally in released position and also capable of decelerating and holding the maximum load in any emergency.

Control—Operation of the cableway is by remote control either from the main control station, which is supported on cantilever I-beams over the canyon, with a view of all loading platforms, or by interlocking change-over switch to any of the other four stations at the loading platforms. In the main control house there is a permanent installation, and the equipment at the other control stations will be of the portable type. Interlocking is provided in changing the control from various stations, and any loss of power provides for automatic setting of brakes.

Organization—The cableway was designed in the Denver office of the U. S. Bureau of Reclamation under the general direction of R. F. Walter, chief engineer. The contract for furnishing and erecting the cableway equipment was carried out by the Lidgerwood Manufacturing Co., Elizabeth, N. J. The government, under separate contract with the Six Companies Inc., provided the excavation for anchors, hoist house and tower, in addition to the concrete for this feature. The Lidgerwood Co. also contracted with the Six Companies Inc. for erection of the cableway.

Gorge Excavation Confirms Geological Assumptions

Original advice on geological features of Black Canyon checked by subsequent investigations—Removal of river fill reveals tight and sound canyon floor ideal for foundation of dam—Evidence points to movement of entire river sediment during floods

FIVE YEARS AGO a board of engineers and geologists, reporting on the feasibility of constructing a huge dam on the Colorado River, recommended the Black Canyon site as the most favorable (*ENR*, Dec. 13, 1928, p. 887). As the dam under consideration was to be by far the greatest ever built, proper selection of a site was one of the most important engineering problems involved in the whole project. At that time the canyon walls were formidable, defying intimate inspection. The gorge floor, upon which millions of yards of concrete were to be safely carried to impound millions of acre-feet of water, was buried far below swirling muddy waters and an unknown depth of river sediment. Six months ago that canyon floor was artificially scraped clean, revealing geological formations for open inspection.

Every major contention and assumption made by the board five years ago regarding the geology of Black Canyon as adapted to the site of the dam has been confirmed by intimate examination of the gorge in the dry. The rock formation is thoroughly capable of bearing the load and resisting the thrusts of the dam. Watertightness of the walls and floor is beyond all expectations. Preparation of the foundations required little more than removal of overlying sediment. Professor Charles P. Berkey, a member of the original board, has submitted an official report of the geological features of the site to the Bureau of Reclamation, following a personal inspection of the excavated river gorge. This report, made May 31, 1933, is abstracted in the following.

On the whole, the results of all the later work connected with the structure confirm the essential accuracy of the original statement of the Colorado River Board with respect to the good quality and the excellent working behavior of the rock forming the canyon walls, the tight character and favorable behavior of the river fill, the soundness of the floor of the gorge and the general physical feasibility of the undertaking so far as geological factors were concerned. If the items covered in the first report of that board were written now with all of the advantages of subsequent construction experience and full exposure of the site, none of them would require material modifications to fit the actual facts as found. In no case have new or unexpected conditions introduced geologic surprises of sufficiently serious character to require change of plan or design, marked revision of estimate or method of handling of the main structure.

Major geologic features

Character of the Abutment Rock — The canyon walls at the side of the dam were judged to be essentially sound before the abutments were cleaned and excavated to the desired form, but actual excavation, bringing into close observation and review every foot of the bearing surface, leaves nothing to conjecture. The rock is sound and reasonably uniform and unusually free from objectionable or large weaknesses. Such fractures, joints and variations of quality as exist are distributed in heterogeneous manner and do not establish continued lines of weakness and consequently can

Fig. 1—River fill at dam site proved to be compact, tight and remarkably stable, providing ideal foundation for cofferdams. Stratification of sand and gravel layers is well illustrated by this view. Broken rock on top of fill is from canyon-wall scaling.

be easily covered or bridged over. Even the major joints and slips are for the most part tight, and many of them are rehealed. Such of them as do open can be grouted without unusual difficulty. The abutments under development, therefore, have proved to be exceptional in every respect.

The Rock Floor—Now that the rock floor is uncovered it is possible to check in detail the points that could only be estimated heretofore. There is no doubt but that the foundation as a whole is sound. The gorge does not follow a fault zone, and the rock of the floor is similar in all essential respects to that of the lower canyon wall. Wherever it is more jointed than elsewhere, the stream has eroded deeper. There is also an inner gorge, marked by a deep pot-hole erosion, forming a narrow and somewhat tortuous channel along the center line at a depth of 75 to 80 ft. below the rock benches on either side. In places the outer lips of the rock terraces are pitted profusely with shallow pot-holes, but for the most part the side benches are comparatively smooth and surprisingly flat and uniform. In striking contrast the inner gorge is deeply pitted and fluted along the side walls and is markedly uneven in form and depth (Fig. 3). The average depth is about 75 ft. below bench level. Both the bench and inner gorge vary in prominence with the quality of the rock. Wherever the rock is crossed by a crush zone or is considerably jointed, there erosion has cut most or all of the bench away. In consequence, there are notches in the bench reaching in favorable places almost or quite to the main canyon wall.

Fig. 2—Finding of a sawed plank on rock bench at top of inner gorge, buried deep in undisturbed river fill, gave conclusive proof of great depth of scour in recent times.

It is especially satisfactory, therefore, to note that at the precise site of the dam the bench has better form, is higher and wider, and is less cut up by erosion depressions than it is immediately above or below. Furthermore, it appears that nowhere else within the range of exploratory study have so many additional advantageous features been found. Evidently the dam has been located at the right place. If the floor had been stripped as it is now, before the exact site was selected, it could not have been located more accurately to take advantage of the best local physical conditions.

Special Erosion Features — Pot-hole erosion is of itself no unusual phenomenon. It is in fact a common formation of erosion in a rapid stream flowing over fairly uniform massive rock. The more striking feature is the bench form at either side with its abrupt change of profile, both at the inner and outer margin. This bench or terrace form is a fairly constant feature of the canyon bottom, for it is shown by the borings on almost every section line, both in Black and Boulder canyons. The sharpness of the form, however, was not disclosed until the floor was uncovered. This clearness of form seems to mean that the mass of sediment across the whole gorge actually moves in great flood tides, subjecting the entire width of floor to scour, while in addition there is a concentration of whirling movement in the center that sets up pot-hole erosion to a greater depth.

The assumption that the whole mass of river fill has moved in present times seems at first difficult to believe and was doubted by most observers. That question, however, is virtually settled now by two observations: first, the essential continuity and similarity in quality and condition of the river fill from top to bottom; and second, the finding of a sawed plank of lumber lying under the gravel on the edge of the inner gorge, a place that it could not have reached in any imaginable way except by burial during some comparatively recent flood (Fig. 2).

The river fill

The sand-gravel-boulder mass filling the bottom of the gorge to a depth of approximately 120 ft. has been from the beginning a feature of considerable uncertainty and difference of opinion. There was no way of telling from the borings or any other source whether or not it would stand up well against excavation or whether instead it might slump and ravel badly when exposed. Neither could it be definitely ascertained whether much or little water would be furnished through it into the major excavation. It was rather commonly believed that the lower portion of the mass was not moved in present-day floods and might be much older and more compacted than the upper portion, which of course is known to be affected by modern scour and fill. It has been an agreeable discovery on completing the excavation to find that the whole stratified mass is essentially tight, furnishing surprisingly little water in this immense excavation; that it is also unusually stable, standing up well in almost vertical walls 10 to 30 ft. high, and that, despite this behavior, it is virtually uncemented from top to bottom, permitting easy excavation without special loosening (Fig. 1). With such behavior it is clear that the cofferdams that rest on this river fill are safe as far as these foundations are concerned, and that special trouble from this source need not be feared even in flood time.

The Spillway Breccia—Over a small area in the vicinity of the spillway on the Arizona side the local rock exhibits a decidedly more porous condition and a more varied volcanic fragmental make-up than elsewhere on the dam site. There are many very large blocks included in the cumulative mass and a

great variety of igneous rock types. Sedimentation structures in this mass are either lacking entirely or are obscure and patchy in distribution. Furthermore, the fragments composing the rock present extremely varied physical conditions because of the vigorous chemical attack on the mass subsequent to its accumulation. The most reasonable explanation of this formation is that the mass of rock in the vicinity of the Arizona spillway represents an accumulation in and over one of the local volcanic vents of that time. Even after the accumulation was made, volcanic gases continued to escape through the loosely fitted mass of mixed material until these forces died down. There is nothing extraordinary about the occurrence. There is no reason to expect special difficulty or troublesome behavior. The mass is amply strong to support the structure designed for it and sufficiently stable to serve its purpose. It is not as tight as the average of this formation, but its porosity is no great detriment to its proposed service.

Minor features

Hot Springs—At several places within the walls of the inner gorge, warm water issues from crevices in the rock. Temperatures of 88 deg. F. and 99½ deg. F. were found at two points just above the upstream toe of the dam at a time when the river water had a temperature of 62½ deg. F. Much smaller amounts of water issue from other streams at several places along the inner gorge walls, but none of these appears to have abnormal temperatures. These springs can be handled by blocking off, building up ahead of course, but some other outlet would surely be found either above or below the dam in a roundabout manner through the related joints of the foundation and the abutment rock, and no anxiety need be entertained on that point. In case the waters are found injurious to concrete, they can be drained away from the dam.

Slabby Rock — At numerous places along the lower side of the gorge the rock exhibits a peculiarly regular slab-like cleavage. These slabs or plates are not very regular in form, but they do give the rock a prominent structural appearance that suggests some special cause. Examination shows that the physical make-up and original bedding structure of the rock has virtually nothing to do with the slabbing formation. The plates are as likely to cut across the structure as to follow it. It is possible that weathering has been the cause of this formation, but this is not very convincing, for there are many places equally as exposed which do not show the effect at all. It is possible that the rock has been suppressed to a more critical internal condition than the average at these places, so that when the force is removed it tends to expand and rupture. In this manner it might develop a sort of crude cleavage, as sometimes happens with the so-called "popping rock" of deep tunnels. According to this view, the river gorge is a great channel cut down deep into the somewhat unevenly crowded and strained rock, some portions of which in the course of a long time and with the help of weather, have registered readjustment by splitting up in this peculiar manner. Removal of loose slabs from the floor wherever they exist is recommended.

Mud Seams and Fault Zones—An occasional joint in the bottom of the gorge has enough spread to allow mud to collect in it. There is nothing unusual about this, but the fact that the walls do not fit tight together and also that the filling substance is soft clay, which would interfere with grouting, raise a question of treatment for support of such a great structure as this dam. The rocks involved are sound enough. The occurrence of mud seams does not indicate decay or excessive weakness. It is essentially a superficial feature, probably due to the pressure phenomena already discussed. Joints reaching the surface and standing at steep angles will be bridged over by the dam. Where the mud seams lie flat, the overlying rock can be excavated to solid material without much trouble.

Fig. 3—Erosion of deep inner gorge produced walls of characteristic fluted structure.

Although there is no major fault in the site or in the immediate vicinity, there are many small displacements and slips of secondary and very minor significance in the canyon wall. There is no evidence of recent movement along any of these lines, and although there is no likelihood that water circulation of consequence could be established along any one of them, it is advisable to provide for grouting of the extension of one of these on the Arizona side, the course of which carries it behind the abutment on that side. No other places seem to invite such treatment. This is because they were tighter to begin with, or farther removed from the dam and therefore out of range.

Summary

The foundations and surrounding features of the excavation of Boulder Dam are reassuring in every important particular. The rock of the floor is as good as that of the canyon wall. There is no major fault or other weakness at the present time along the bottom channel. The erosion phenomena are normal, and the forms produced are those belonging to rapid streams. The river fill is surprisingly tight and stands well, thus insuring safe support of the cofferdams. There is little water to handle from the excavation. There is not the slightest doubt about the general stability of the foundation and abutment rock. As far as the physical features and conditions are concerned, the site has developed more favorably than was predicted for it.

No surprises have been disclosed. Although most of the ground has turned out to be sound and uniform and has behaved exceptionally well under construction, the Arizona spillway has encountered more porous and somewhat weaker rock than any other section of the work. Fortunately, it is not sufficiently unstable to require any important change of plan, although special care in handling this section is being taken.

Although there are many soft spots in the rock, marked chiefly by individual constituent fragments that have been altered since the rock was placed, there are no continuous weaknesses and little or no soluble or easily destroyed material. This condition does not introduce any complications, for all such minor weaknesses are bridged over, making the average quality only of practical significance. The rock of the foundation does not soften materially under submergence and, although moderately porous, it is virtually impervious. There is some jointing, and such water circulation as there is follows these structures. They are neither very numerous nor very open, and they tend to tighten with depth, but their existence makes a program of grouting necessary.

The rock floor is sound and fully competent to carry the load contemplated, with only the usual precautions in providing a good bearing surface and making provision for grouting. The abutments are similar to the floor in character of rock and structural quality, and they require similar treatment. Any belt of more numerous joints than usual and any crushed stone coming close to the dam should receive special attention in grouting to check effectively the water seepage.

The sum total of evidence available from construction supports the original opinion that this site is one of the best on the river, that its physical support and surroundings are excellent, and that perfect operating behavior is to be expected when the work is completed.

6

Boulder Dam Association
801 JUNIOR ORPHEUM BLDG.
Los Angeles, Calif.

WASHINGTON HEADQUARTERS
RALEIGH HOTEL, ROOMS 309-310

MEMBERSHIP LETTER NO. 4

WASHINGTON, D. C., *February 16, 1924.*

TO MEMBERSHIP BOULDER DAM ASSOCIATION.

Greeting: 1. Certain California papers have recently carried articles stating that we could procure a low dam which would care for all silt and adequately protect Imperial Valley, and alleging that those directing present legislation had overestimated their ability, etc. This is the same old cry to prevent Colorado River development, according to expressed opinion of Imperial Valley people—anything to prevent hydroelectric power being allocated preferentially to governmental subdivisions in lawful accord with the Federal Water Power Act—anything to prevent the All-American Canal—and probably without these opposers yet realizing that their contentions would make it impossible to bring Colorado River water to Southern California for domestic and municipal use. These articles are sent out by those who have consistently opposed us from the beginning, who have never once offered any constructive idea applicable to this great project, who know but little what can be done physically, electrically, or in the delivery of water. Nor do these objectors have any adequate idea of what adequate flood protection means.

The surprising thing about those newspaper articles is that their localities, in many instances, need this added domestic water supply if they are to prosper and grow as they may, and it seems so short-sighted to deliberately oppose the possibility of procuring this added water supply. What is the incentive, what the reason for such knocking at home of home requirements?

It is refreshing to hear the clarion call of the Santa Ana Register to this need of more water, and certainly every city and location in Orange County could properly join the chorus with Editor J. P. Baumgartner, as could the Palo Verde Valley, the Pass country, Redlands, Colton, San Bernardino, Riverside and all its county, Ontario, Pomona, El Monte, Puente, and on down the line to the sea, and assuredly Los Angeles, Long Beach, and Pasadena are not only interested but they should not sleep until they help to bring this to pass.

Cease knocking at home, get a broader vision, have faith that your city and town and section will grow in proportion to its pure water supply, and then take the word of a man and an engineer like Wm. Mulholland, that this project is feasible and needed and ought to be accomplished now, and can only be so accomplished by a high dam.

This conclusion has not been arrived at hastily or without study—it has been figured by as good an authority as the State of California possesses.

If anything big and worth while is worth doing, do your part in this, which we know you will.

2. The following telegram is self-explanatory:

(Western Union Telegram.)

WASHINGTON, D. C., *February 4, 1924.*

F. H. McIVER, *Secretary,*
Imperial Irrigation District,
El Centro, Calif.

Concerning article in Valley papers of January thirtieth just received, please advise board and papers as follows: First, we do not know or presume to say what Doctor Work will do. Second, there is no agreement, nor has any agreement been even suggested, looking to elimination of canal feature of project. Entire delegation and interests represented by them standing as unit for entire project. Canal feature is proving helpful. Third, there is no agreement, and no agreement has been even suggested, as to division of power between public and private interests. Swing-Johnson bill follows established National policy declared in Federal Water Power Act for distribution of power benefits. Departure from this established policy, especially in view of Teapot Dome scandal, would be fatal to measure authorizing project. Please ascertain source of article in question. It is highly important to trace all efforts, such as article plainy represents, to break ranks of friends of Boulder Canyon project. Please secure immediate publication in all Valley papers.

Geo. A. Hartman, American Legion.
Q. C. Webster, President Imperial County Farm Bureau.
S. O. Buck, Imperial Valley Farm Bureau.
T. A. Panter, Assistant Chief Electrical Engineer, Los Angeles.
Thos. C. Yager, Coachella Valley County Water District.
S. C. Evans and W. J. Carr, Directors, Boulder Dam Association.
B. F. Fly, Yuma Project.
Mark Rose, Imperial Valley Irrigation District.
Ralph L. Criswell, Los Angeles City Council.
Wm. Mulholland, Chief Engineer Los Angeles Water Department.
W. B. Mathews, Special Counsel, Los Angeles Water and Power.

BOULDER DAM ASSOCIATION,
By
Executive Director.

6

Boulder Dam Association

801 JUNIOR ORPHEUM BLDG.

Los Angeles, Calif.

WASHINGTON HEADQUARTERS
RALEIGH HOTEL, ROOMS 309-310

MEMBERSHIP LETTER NO. 5

Put with other letters of like kind.

FEBRUARY 19TH, 1924.

TO MEMBERSHIP BOULDER DAM ASSOCIATION.

Greeting: Read carefully these two side by side statements:

First Paragraph of Section 7 of Federal Water-Power Act.

(PREFERENCE IN ISSUING LICENSES OR PERMITS—STATES AND MUNICIPALITIES—PROJECT BY UNITED STATES.)—That in issuing preliminary permits hereunder or licenses where no preliminary permit has been issued and in issuing licenses to new licensees under section 15 hereof the commission shall give preference to applications therefor by States and municipalities, provided the plans for the same are deemed by the commission equally well adapted, or shall within a reasonable time to be fixed by the commission be made equally well adapted, to conserve and utilize in the public interest the navigation and water resources of the region; and as between other applicants, the commission may give preference to the applicant the plans of which it finds and determines are best adapted to develop, conserve and utilize in the public interest the navigation and water resources of the region, if it be satisfied as to the ability of the applicant to carry out such plan.

Section 2 of Swing-Johnson Bill.

That the Secretary of the Interior is empowered to receive applications for the right to use for the generation of electrical power portions of the water discharged from said reservoir and available for the generation of electrical power at said dam, and, after full hearing of all concerned, to allocate to such applicants such portions of such power privileges as, in his judgment, may be consistent with an equitable distribution thereof among the various interested States and among the various interested communities in each State. The said Secretary, in making such allocation, may give consideration to the plans of the various applicants, having regard to their relative adaptability to utilize such power privileges in the public interest, and at reasonable cost to the communities served: *Provided,* That subject to such allocations he shall give preference to applications made by political subdivisions.

You have read in all the papers the late disclosures of graft in high places, where millions were made by merely signing a lease. We attended several of the Senate debates on Teapot Dome, where incidentally were mentioned coal and forest and mines as casually as you would mention a small town lot, and the disgrace and shame voiced by Senator after Senator at the unlawful and disloyal acts of high officials, even Cabinet Officers, rocking, as they said, "the very foundations of our Government," was not calculated to make a visit to Washington at this time one of pleasant memory.

Read now from a news item of January 4, 1924, where one of our public bodies said in objecting: "Consider facts, your bill further undertakes at this time to dispose of power; that is, to the extent of giving municipalities and legal subdivisions a preference over public service corporations." "We feel that you should fairly look at the facts." *"The facts are that the private power companies throughout the United States have great strength in Congress,* and we feel that it would be the part of wisdom to make no allocation of power in this bill beyond providing that

power generated shall *hereafter* be allocated by the Secretary of the Interior, *without declaring a preference, thus leaving to the future the fight over power.*" "We should if possible postpone this fight until such time as the dam is an assured fact." "If the fight takes place before it is an assured fact, the erection of the dam may be postponed for many years."

Ye Gods! Private interests have such strength in Congress that American communities, such as California's six southern counties, such as Yuma County, such as numerous cities, farm bureaus, Legion posts, labor organizations, and civic bodies, should hang their heads, still their voices, and bemean their action through fear of "INFLUENCE!"

Whose Senator and whose Representative rocks in this boat—who are so influenced!

We deny this imputation, and it was certainly a redeeming factor that so many of our Senators stood up like men and denied *Oil* influence and denounced those besmirched. Does *POWER* own these men where *OIL* failed? Should such a *FEAR* appeal to any reputable and self-respecting body of men? Do you expect us to cringe and surrender? No; a thousand times *NO!* Congress has shown its fearlessness and the parallel above shows conclusively that we are but following the orderly method of established law.

BOULDER DAM ASSOCIATION,

By John L. Bacon

President.

Boulder Dam Association

801 JUNIOR ORPHEUM BLDG.

Los Angeles, Calif.

WASHINGTON HEADQUARTERS
RALEIGH HOTEL, ROOM 303

MEMBERSHIP LETTER NO. 6

FEBRUARY 28TH, 1924.

TO MEMBERSHIP BOULDER DAM ASSOCIATION.

Greeting:

FIRST. Hearings on the Swing-Johnson Bill have been progressing steadily before the House Committee on Irrigation and Reclamation. The Committee has very kindly been giving us three days a week. Members of the Committee are keenly interested in the project and ask many questions. We are trying to conclude our presentation in favor of the bill next week.

SECOND. As yet Dr. Work has made no report on the bill. We are expecting his report very soon.

THIRD. Considerable publicity of a favorable character has been appearing in the Eastern press. This is quite significant.

FOURTH. Last week the Senate after a two day's debate, by a vote of 46 to 9, overruled the powerful Finance Committee which recommended against a power plant in connection with the Yuma project. Without a record vote, similar action was taken as to an Idaho project. This is highly significant of the present temper of Congress.

FIFTH. Our greatest enemy is delay. The failure of the Secretary of the Interior to present his long overdue report on the bill has been very vexatious. Committee hearings at best are slow. Some opposition to the bill has developed on the ground that the Colorado River Compact has not been ratified. As it appears practicable to insert a provision in the bill that will fully protect the Northern States in this situation, it is hoped that such opposition will disappear and that delay on this account will be obviated.

SIXTH. Since the last letter, the following have testified in behalf of the bill before the committee:

MAYOR S. C. EVANS, of Riverside.

MR. RALPH L. CRISWELL, Member of City Council of Los Angeles.

MR. Q. C. WEBSTER, Chairman of County Farm Bureau of Imperial Valley.

MR. JOHN T. TAYLOR, Vice-Chairman of American Legion Legislative Committee.

MR. MARK ROSE, Director Imperial Valley Irrigation District.

John L Bacon

President Boulder Dam Association.

Boulder Dam Association

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John L. Bacon

President Boulder Dam Association.

Boulder Dam Association
801 JUNIOR ORPHEUM BLDG.
Los Angeles, Calif.
WASHINGTON HEADQUARTERS
RALEIGH HOTEL, ROOM 339

MEMBERSHIP LETTER NO. 7

MARCH 19, 1924.

TO THE MEMBERS OF BOULDER DAM ASSOCIATION:

Greeting:

First. Since the last letter the following witnesses favorable to the Swing-Johnson bill have testified before the House Committee:

S. O. BUCK, representing Imperial County Farm Bureau, covered flood menace and needs of Imperial Valley for prompt relief.

ELMER HEALD, representing Legion interests, explained the interest of ex-service men in the project.

G. A. HARTMAN, also representing Legion interests, emphasized the valley's needs for flood protection and relief from Mexican difficulties.

JOHN L. BACON, mayor of San Diego and president of the association, covered generally the urgent needs of the Imperial Valley, explained the flood menace; and outlined the needs of San Diego for a domestic water supply, which he pointed out could be secured in connection with the All-American Canal, San Diego not being located so it could secure such water from the proposed Mulholland Aqueduct.

COL. B. F. FLY, representing Yuma, Arizona, interests, showed the immediate concern of Yuma in the project.

W. J. CARR, of Pasadena, vice president and director of Boulder Dam Association, testified regarding Pasadena's water and power needs; and also argued that Congress, by appropriate provision in the bill, had the power to fairly protect Northern States' water interests, and that hence it was unnecessary to delay legislation until the ratification of the Colorado River compact.

THOMAS C. YAGER, representing Coachella County water district, showed the need of Coachella Valley, both for flood protection and for water for irrigation, which would be made available by the All-American Canal, and also the willingness and ability of the district to pay its part of the cost of the canal.

CONGRESSMAN WALTER S. LINEBERGER, of the Ninth Congressional District, urged prompt and favorable action on the bill, and expressed the immediate interest of Long Beach in its enactment, both from the standpoint of domestic water and power.

Second. Mr. R. H. Ballard, vice president and general manager of Southern California Edison Company, appeared pursuant to committee summons. He testified that his company had filings on the Colorado River for over 3,000,000 horsepower; that one agency should develop the power resources of the river, and that he thought his company was the best agency. He objected to the Swing-Johnson bill because of its preference clause in favor of public agencies. He complained

(For Use in Local Papers if Desired)

All Southern California should grasp the importance of the All-American Canal feature of the Swing-Johnson Bill, according to a statement just issued from Washington by John L. Bacon, mayor of San Diego and president of the Boulder Dam Association.

Mayor Bacon's statement is as follows:

"Persons who do not know the reasons for construction of an All-American Canal may feel that the Boulder Canyon project has been weighted down with it unnecessarily. The contrary is true. The canal feature of the bill wins instant approval of Congressmen generally and brings strong support to the bill in its entirety that it could not gain otherwise.

"To store the flood waters on the Colorado at Boulder Canyon at the expense of the Government and then permit a large percentage of that stored wealth to flow to the enrichment of Mexican lands, held in large tracts by capitalists but cultivated by cheap Oriental labor, would permit of no defense whatever. The construction of the All-American Canal will provide the means by which the great volume of water in the Boulder Reservoir can be applied to hundreds of thousands of acres of American lands now but desert wastes.

"Of this vast area, which will be added to the wealth-producing territory of Southern California, more than 200,000 acres in Imperial and Coachella Valleys are public lands which under the Swing-Johnson Bill will be made available for settlement by ex-service men of the Spanish-American and World Wars and the Philippine insurrection. It is estimated that prosperous homes for more than 15,000 ex-service men will be established under its terms.

"The American Legion indorses the bill for that reason, and fully two-score of ex-service men in Congress will vote for it.

"Testimony showing the helplessness of Imperial Valley farmers in the matter of control of their own canal through Mexican territory has made a strong impression on Congressmen who have heard it. Not a voice has been raised in the House Committee in even the slightest suggestion that they are not entitled to relief. The financial burden on American farmers involved in that intolerable situation has been instantly recognized as an additional unnanswerable argument for the canal.

"It must be borne in mind that all the cost of the canal will be met by the lands directly benefited by it—a million acres of the Imperial and Coachella Valleys. The canal will cost the Government nothing ultimately. It will cost the outside communities who will buy Boulder Dam power nothing.

"Opposition to the canal rests on the narrowest base of all phases of opposition to the Swing-Johnson Bill. Practically speaking, the sole opponents to it are the owners of the Mexican lands. Harry Chandler is their spokesman. No one here can see where he can muster more than a couple of Congressmen on that issue. On the other hand, many Congressmen will be driven into our ranks by the very attempt to sacrifice American agricultural population to capitalistic exploitation of Mexican lands with cheap labor.

"It is certainly true that no Representative or Senator will dare stand up in debate and defend the contentions of the Chandler group in their fight against the canal. I can't make the statement too strong that the All-American Canal is a logical and necessary appendage to the Boulder Storage Dam and that it adds immeasurably to the Swing-Johnson Bill."

JOHN L. BACON.

quite bitterly because Los Angeles was cooperating with other cities in Southern California and thought instead it should cooperate with his company. He said he was not opposed to the Government building the dam if cities and other public agencies were not given preferential rights to purchase the power privileges.

Third. The long delayed report of the Secretary of the Interior on the bill has at last been made. It is of a decidedly favorable tenor. Especially is this so in respect to the All-American Canal feature of the project, which seems to have appealed to the Secretary just as it has to Congressmen.

Fourth. This week Mr. A. B. West, president of the Southern Sierra Power Company, and Mr. Phipps, of Colorado, who is interested in certain western power companies, appear pursuant to committee summons.

Fifth. We are bending every effort to conclude committee hearings at the earliest possible date.

Sixth. The American Farm Bureau Federation, which has been active and very influential in the Muscle Shoals fight, favors the Boulder Canyon Project, and its active support will undoubtedly prove very helpful.

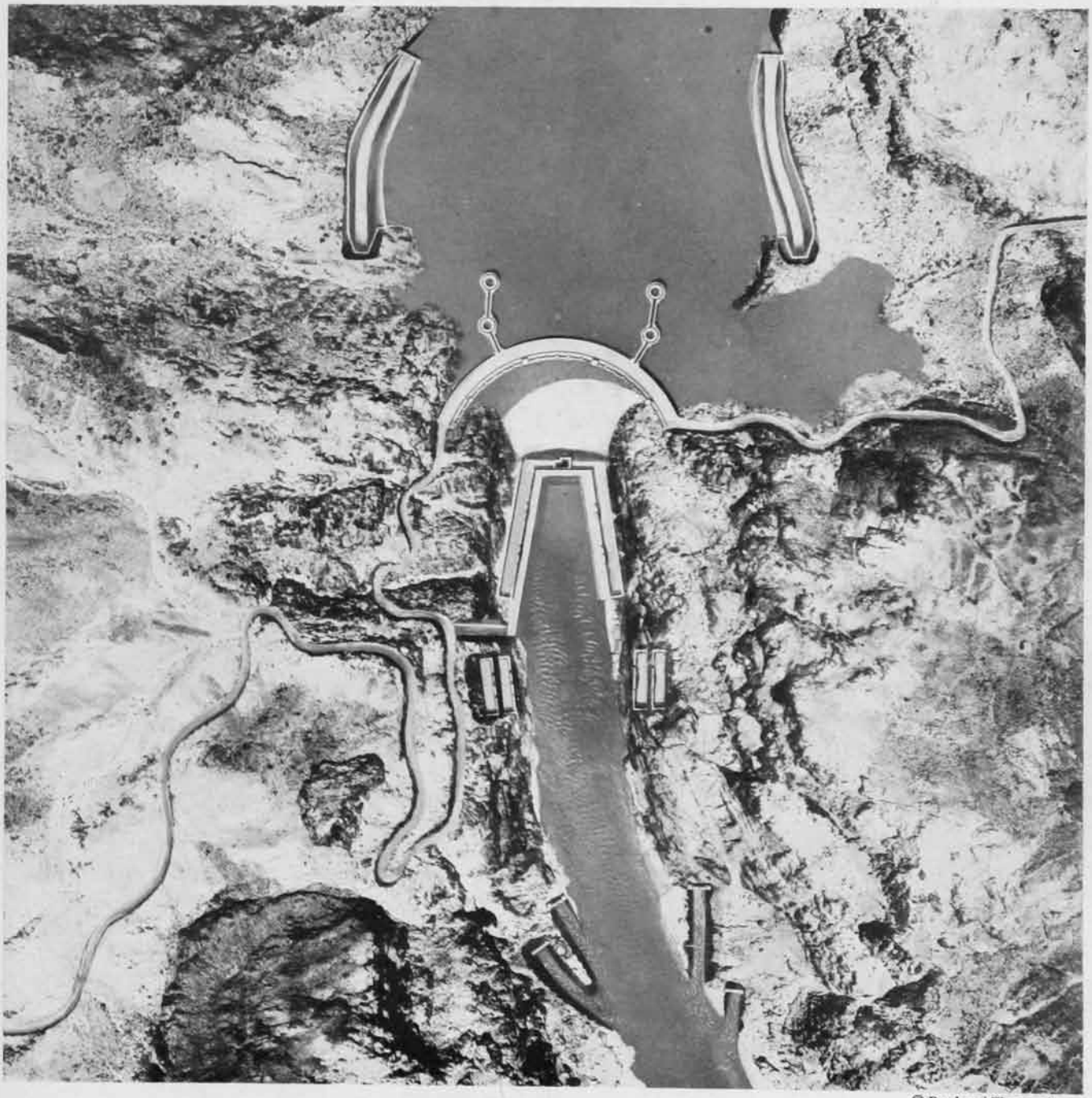
Seventh. What originally was figured as a two or three weeks' committee hearing, developed into a hard fight, with many ramifications. It is forming along favorable lines. The association plans to keep steadily on the job of urging the project. Your representatives are hopeful of getting real results at this session.

John L Bacon

President Boulder Dam Association.

NEW RECLAMATION ERA

VOL. 22. NO. 2 FEBRUARY, 1931



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AIR VIEW OF HOOVER DAM AND RELATED WORKS AS THEY WILL APPEAR WHEN COMPLETED

Secretary Wilbur says . . .

THE GREATEST ENGINEERING JOB ahead of this department is the construction of Hoover Dam in the Colorado River. This structure will raise the water level 582 feet, generate 1,200,000 horsepower of electricity, cost, with its power plant, over $100,000,000, and will pay for itself by its own falling water. The result will be flood protection to Arizona and California lands, reclamation of deserts, improvement of navigation, and the bringing of needed water for domestic supply to the coastal plain of Southern California. Power sale contracts were successfully negotiated which will reimburse the United States for the cost of the dam and power plant if the rates set in these contracts continue to be maintained when the readjustment periods prescribed by the law are reached.

Next to the control of the Mississippi, this is the greatest attempt at solution of a whole region's water problem that the country has before it. The necessity for flood control and the thirst for water have made it necessary and possible to erect this structure in the middle of a desert, transport its power 250 miles, and sell it over an oil and gas field in order that the falling waters of the Colorado may earn the cost of their own capture. The engineering is in the hands of an organization which has built over 100 of the world's great dams without a failure. They will successfully divert the river through four great tunnels, each 50 feet in diameter, together capable of carrying the Mississippi's flow at St. Louis; will build this dam, and will go on to other big jobs for this Nation, all in their stride. It will be a monument to the engineering genius of many men, headed by Dr. Elwood Mead, Raymond F. Walter, John L. Savage, Walker R. Young, and their predecessors, Arthur P. Davis and Frank E. Weymouth.

Extract from the Annual Report of the Secretary of the Interior for the fiscal year ended June 30, 1930.

NEW RECLAMATION ERA

Issued monthly by the DEPARTMENT OF THE INTERIOR, Bureau of Reclamation, Washington, D. C.
Price 75 cents a year

RAY LYMAN WILBUR
Secretary of the Interior

ELWOOD MEAD
Commissioner, Bureau of Reclamation

Vol. 22, No. 2

FEBRUARY, 1931

Interesting High Lights on the Federal Reclamation Projects

COLONIZATION work on the Lower Yellowstone project is being continued by the Lower Yellowstone Development Association, several prospective settlers having been shown over the project during the month.

SHIPMENTS of dressed turkeys from the Orland project for the Christmas trade were active during the holidays. Nine cars were shipped by rail and one produce house forwarded 63,000 pounds by truck.

EARLY in the month a general meeting of water users on the Sun River project was held in Fairfield for the purpose of informing the settlers of work accomplished during the year, financial condition of the irrigation district, and plans for the coming year. The meeting was well attended and much constructive interest was shown in all matters pertaining to the welfare of the project.

THE new radio broadcasting station on the Grand Valley project started operating the latter part of the month.

MORE extensive feeding to livestock of beet pulp on the Belle Fourche project is very noticeable, and dairymen generally are coming to realize the value of this pulp in rations that include hay, molasses, and grain.

THE sugar beet campaigns have been completed on the North Platte project with the exception of the factories at Torrington, Wyo., and Gering, Nebr. Final figures for the project place the average yield at 14.5 tons, and the total payments for beets at $4,024,000.

THE Great Western Sugar Co.'s factory at Lovell, Shoshone project, closed a very successful campaign on December 31.

33646—31——1

THE Minidoka project reports the sale of rural property during the month as follows: One 40-acre farm 2 miles southeast of Rupert at $4,000; one 80-acre farm near the Paul sugar factory at $10,000; one 10-acre farm 1½ miles south of Burley at $6,000; one 40-acre farm 4 miles south of Rupert at $4,200; a highly improved farm of 50 acres 1½ miles northwest of Rupert at $10,000.

This Era Features Boulder Canyon Project

It seems especially appropriate that, following the calling for bids for the construction of Hoover Dam and appurtenant works on the Boulder Canyon project, more space should be given in this issue of the New Reclamation Era to this great work which will have such an important bearing on the economic and industrial development of the Southwest. Our readers will accordingly find this issue of the Era devoted largely to the Boulder Canyon project, bringing up to date various aspects of the work from the legal, engineering, economic, and accounting viewpoints, with a resume of the whole in Doctor Mead's address before the Massachusetts Institute of Technology.

Each subsequent issue of the Era will carry current information of general interest concerning the progress of construction on the project works.

DURING November the Mini-Cassia Dairymen's Association on the Minidoka project purchased 40,461 pounds of milk butterfat at 39 cents a pound, and 17,588 pounds of cream butterfat at 32 cents, a total of $21,408. About 64 per cent of the butterfat was marketed at Burley and the remainder at Rupert.

A LARGE number of inquiries concerning settlement opportunities on the Riverton project were received at the project office during the month.

ON the Lower Yellowstone project the completion of the advance crop report showed an excellent condition. About 28,681 acres were irrigated, producing crops valued at $957,756, or $33.39 per acre. An additional 6,268 acres were dry-farmed, producing crops valued at $28,106, or $4.48 per acre. The total crop value was $958,862. This is the largest gross value ever produced on the project. The outstanding crops were: Sugar beets, $86.92 per acre; beans, $24.58 per acre; and alfalfa, $17.04 per acre.

THE efforts of the Malta agencies to secure settlement of the Milk River project continued. Three additional 2-year options were obtained to farms embodying fair prices and very reasonable terms of payment. A number of applications from dry farmers for project farms have been received and it is expected that several more will be located before spring.

THE erection of a new school building on the Shoshone project is anticipated, the building to comprise a gymnasium, junior high school, and agricultural and farm shop at a total approximate cost of $70,000.

THE annual meeting of the Phillips County Farm Bureau on the Milk River project was held and officers for 1931 elected. This organization indorsed the plan of the Malta Irrigation District and Commercial Club in attempting to settle the project with good bench-land farmers who had contemplated leaving the country.

MEETINGS of stockmen on the Sun River project were held at which it was proposed to form organizations of water users to lease all available pasture lands from the United States and administer them for the benefit of the local water users.

Hoover Dam, the World's Largest Irrigation Structure

Address by Dr. Elwood Mead, Commissioner, Bureau of Reclamation, before the Massachusetts Institute of Technology, Cambridge, Mass., January 9, 1931

THE first impression of the Boulder Canyon project is size. About every dimension is a superlative. The dam will be 730 feet high, nearly twice the height of any dam yet built. It will be 650 feet thick at the base. The All American Canal, which will carry the stored water to irrigators in Imperial Valley will be 200 feet wide, 22 feet deep, and carry 15,000 cubic feet of water per second. This canal has to pass through a windswept ridge of shifting sand where the excavation will be more than 200 feet deep. The aqueduct that is to carry water to Los Angeles and surrounding cities will be over 200 miles long, and will carry 1,500 cubic feet of water per second, which will have to be lifted 1,200 feet in order to cross the Sierra Divide. It will cost over $200,000,000.

GREATEST ARTIFICIAL RESERVOIR

The lake above the dam will be 115 miles long, 582 feet deep, and will hold 30,500,000 acre-feet of water, enough to cover the State of New York to the depth of one foot. It will be the largest artificial reservoir in the world, more than 11 times the capacity of the Elephant Butte Reservoir in New Mexico, and 12 times that of Assuan in Egypt.

These structures are given heroic proportions because a turbulent river has to be controlled and because the water needs of the Southwest are great and urgent. The reservoir must be large enough to hold the greatest flood. The flow below the dam must be regulated. No floods to break the levees and menace the homes, but always water enough to irrigate 2,000,000 acres of land and meet the requirements of many millions in cities. This dam is the basis of a civilization under which unnumbered generations will live. With it there is no known limit to growth and wealth, without it people must be notified to go elsewhere; the latter to Los Angeles is unthinkable.

Into this reservoir there will be dropped each year 100,000 acre-feet of mud. It has been made large enough to hold this deposit for two centuries without interference with its capacity as a regulator.

It is an enterprise which carries a challenge to the engineer, no matter where he lives. The specifications just issued have therefore been awaited with intense interest by both the profession and by contractors. The manner in which they deal with the obstacles of climate, of location, of size and stresses, were an acid test of the ability of the Reclamation Bureau to carry out monumental undertakings in its field. One verdict has been rendered. It is a statement in the Engineering News-Record of December 25, which says: "It is the most advanced, the boldest and most thoroughly studied hydraulic enterprise in engineering history." Let me quote further from the News editorial: "With 5,000,000 cubic yards of concrete, 30,000 tons of structural steel, and over 70 miles of grouting holes, with rock tunnels ranging from 50 to 70 feet in diameter, and 2,000 tons of needle valves, the structure that is to be set in the path of the turbulent Colorado in a sheer walled narrow gorge at the bottom of an inaccessible desert canyon in the remotest region of the United States constitutes a work ranking with the greatest ever attempted by human hands." The designing engineer is known to his associates as Jack Savage. He has in succession designed the four highest dams in the world; Hoover Dam is simply another step in his progress.

The canyon walls at the water level of the river are only 300 feet apart. The velocity of the river's flow through this bottleneck is about 20 feet a second. The upper cofferdam which turns the river into the tunnels will be 80 feet high, and when the river is diverted 7,000,000 cubic yards of mud and gravel will have to be taken out of the space between the two coffers to uncover the rock on which the dam will rest.

INTENSE HEAT TO BE OVERCOME

This project, like Panama, has a climate. The summer wind which sweeps over the gorge from the desert feels like a blast from a furnace. How to overcome this and provide for the health of workers has had much attention. At the rim of the gorge, where much of the work must be done, there is neither soil, grass, nor trees. The sun beats down on a broken surface of lava rocks. At midday they can not be touched with the naked hand. It is bad enough as a place for men at work. It is no place for a boarding house or a sleeping porch. Comfortable living conditions had to be found elsewhere, and these are found on the summit of the Divide, 5 miles from the dam. Here there is fertile soil; here winds have an unimpeded sweep from every direction; here there is also an inspiring view of deserts and lonely gorges and lofty mountain peaks. When the dam is completed and a marvelous lake fills the foreground, the view from Boulder City will be so inspiring and wonderful as to be worth traveling around the world to see. The water supply for the city has to be brought from the river by a vertical pumping lift of 2,000 feet. The 10-mile railroad from the city to the dam is a marvel of skillful location, as is the paved highway which connects Boulder City and the dam. It is expected that another highway will soon be built on the east side of the river to connect the dam with Kingman, Ariz.

POWER TO BE CARRIED 225 MILES

Power for construction is to be furnished by the Southern Sierras Power Co., which will carry it 225 miles. This power equipment will be built for permanent service. When the power wheels have been installed at the dam, current from them at a much higher voltage will be carried on this line in the opposite direction.

WORKERS TO BE HOUSED IN MODEL TOWN

The town planner of Boulder City is S. R. De Boer, who has a high reputation as a city planner in the mid-west. The houses and offices of the bureau staff have been designed by a southern California architect and will follow the general lines of those in the Panama Canal Zone. Generous provision has been made for lawns and trees for shade and windbreaks, but planting of these will have to wait for the spring of 1932. Water for irrigation can not be provided early enough in 1931. In all, the bureau will spend $2,000,000 creating comfortable living conditions for workers. None of the money will be wasted. It means health and vigor of workers. The specifications require contractors to house 80 per cent of their workers in the town. It will be administered much like the national parks; it will be entirely a Federal city with three commissioners, one of whom will be a representative of the contractor of the dam. Lots for residences and business purposes will be leased with rigid restrictions as to use. It will be a temperance town. The number of stores, shops, and moving-picture theaters will be restricted; otherwise every business would be overdone. The money received from leases will help pay operating expenses.

The heat under which concrete will be mixed and put in place, added to its chemical heat in setting, has led to provisions for inserting small pipes in the concrete as it is placed which will be filled with a freezing mixture. Later on these pipes will be filled with concrete.

CONSTRUCTION COSTS TO BE REPAID

Let us now consider how the money that is to go into this enterprise is to be repaid. This had careful attention from Congress. The law requires the Secretary of the Inte-

rior to enter into contracts which in the Secretary's opinion will return all the money spent on the dam with 4 per cent interest within 50 years, and all the money spent on the All-American Canal in 40 years without interest. Contracts approved by the Attorney General have been made for repayment of the money spent on the dam. It will come from the water supplied cities and towns, and from power already contracted.

The power plant will generate 660,000 firm horsepower with an uncertain but large amount of seasonal power to be sold during the period of high water in the river. The price of firm power is 1.63 mills a kilowatt-hour, and 0.05 of a mill for each kilowatt-hour of seasonal power. The power and water income from the contracts already signed will in 40 years bring an income of $373,500,000. Of this, the United States will receive $228,260,000 to repay money advanced, with interest. Arizona and Nevada will each receive $31,235,000. Operation and maintenance will absorb $16,120,000, and there will be a surplus of $66,650,000 which will be the net profit of the Government for going into this enterprise, to be disposed of as Congress may hereafter direct.

OPERATION OF COLORADO RIVER COMPACT

In the Southwest water is gold. These great sums of money have caused the arid States to recognize the value of flowing water. It is giving rise to a political and economic struggle over its control. States, communities, and individuals have a changing conception of the nature of property rights in water. The first reaction of the upper States to this enterprise was to oppose it. They said that the Government dam and reservoir would create vested rights that would enable users of this water to interfere with later development of irrigation on the upper part of the river. To overcome that objection representatives of each of the seven States and of the United States met and under the guidance of President Hoover, then Secretary of Commerce, formed a compact which created a new water law for the arid region. The compact divides the stream into two sections, and allots 7,500,000 acre-feet a year to each section; 1,000,000 acre-feet is left for subsequent distribution. That deals with 16,000,000 acre-feet, which is the average annual flow of the river. Later on the 7,500,000 acre-feet allocated to the lower section was divided between Nevada, California, and Arizona, and representatives of the four upper States are working on a division of their 7,500,000 acre-feet share. These rights so allocated are perpetual. They set aside the doctrine of riparian rights and the doctrine of prior appropriation which had hitherto governed the division and use of streams. Six of the seven States and the United States ratified the compact. Arizona has not done so, but has brought suit in the United States Supreme Court, claiming an ownership in the river which if recognized would make it a dictator over all future development. It is not believed that this claim will be recognized.

DAM TO BE COMPLETED IN SIX AND ONE-HALF YEARS

Notwithstanding the suit in the United States Supreme Court, work is going steadily forward. Congress in 1930 appropriated $10,660,000 and the present appropriation bill carries an additional $15,000,000. The contract for the dam and tunnels will involve close to $50,000,000 and will be one of the largest ever let in this country. The tunnels are to be finished in two years, the dam in six and one-half years. Considering its magnitude it has very few elements of uncertainty for the contractor. The Government is to buy and furnish cement and structural steel; the contractor therefore assumes no risk from fluctuations of prices. The four tunnels which will carry the river past the dam during its construction have been so thoroughly prospected by means of diamond drill cores that contractors know the kind of material to be removed. The cofferdam is the one hazardous feature of the project. It is to be built according to plans provided by the Reclamation Bureau, and when so built all subsequent hazards of its failure or being overtopped by floods are assumed by the Government. The power machinery is to be provided by the contractors for power. Owing to its size it will be something of a problem to install it, but some of the contractors have for a year been studying the situation and have already designed their equipment. It will have the highest towers of any work ever undertaken and the overhead cables will lift 30 to 40 tons.

BUILDING progress in the city of Yakima, Yakima project, has been on a steady increase for several years, and permits issued during 1930 amounted to $1,651,215. This figure is $407,670 above that for 1929.

ON the Vale project 127 inquiries relative to project lands were received during the month by the representative of the Vale-Owyhee Government Projects Land Settlement Association. Twenty-one interested persons called at the representative's office during the month, 200 acres were sold, and 2 new settlers arrived on the project to establish homes.

Reclamation

The following statement was approved by the land reclamation division of the American Society of Agricultural Engineers at its meeting in San Francisco, Calif., January 7, 1931:

The reclamation of lands for agricultural production has been and will continue to be a vital factor contributing to national wealth and stability. The urge for such development is chiefly economic, thus receiving greatest public support during periods of greatest national prosperity. This public tendency contributed in the past to urgent and often hasty preliminary studies of tentative projects which later led to unwise development, resulting in subsequent embarrassment to the projects in meeting their financial obligations.

The land reclamation division of the American Society of Agricultural Engineers believes in the soundness of Federal support and supervisory development of agricultural areas by reclamation where these are economically feasible. We desire to direct attention to the necessary lapse of time which occurs between the inception of a project and the time it comes into maximum fruition. This period may be as long as 25 years.

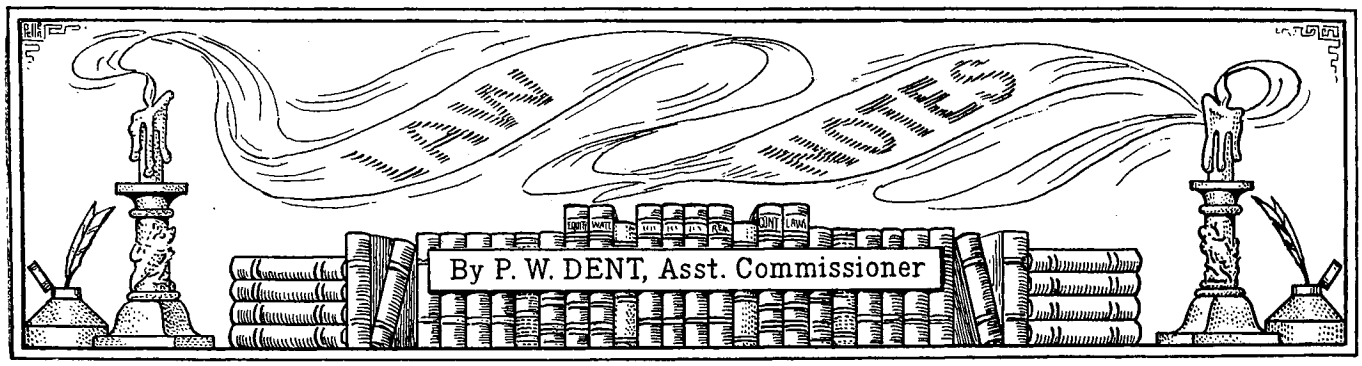
Accordingly we urge that the Federal Government maintain and adequately support the proper agencies to make and develop long-time engineering and economic studies of probable reclamation projects in order that such projects as may be approved will be undertaken at times when their period of development may fit into national economic progress.

The land reclamation division wishes to commend the Federal and State Governments for their splendid services to reclamation development and we pledge our support to these agencies in carrying out the responsibilities outlined in this statement.

Public Land Opening Vale Project, Oregon

The Secretary of the Interior has announced the opening to entry on February 9, 1931 of a small tract of public land comprising 5 farm units on the Bully Creek West Bench Division of the Vale Federal irrigation project, Oregon. The farm units have an irrigable area ranging from 44 to 72 acres.

At this opening ex-service men who have served in the United States Army or Navy in any war will be granted a preference right of entry of 90 days.



Federal Condemnation of State Property

IN State of Missouri *v.* Union Electric Light & Power Co., 42 Fed. (2d) 692, decided July 18, 1930, the Federal District Court of Missouri had before it a situation which is of interest to the Bureau of Reclamation, particularly as concerns the Federal power to acquire by purchase or condemnation property held by one of the States and devoted to a public use. In many respects, as will be seen, the facts are similar to those connected with the Boulder Canyon project development.

The following is taken from the opinion of the court dismissing the complainant's bill, which was brought by the State of Missouri seeking to enjoin the construction of a project under the Federal water power act:

This is an action to enjoin the construction of a dam across the Osage River, near Bagnell, in Miller County, Mo. It is alleged by complainants that the object of said construction is to secure power for a hydroelectric plant, and that said plant is to be operated by the defendant Union Electric Light & Power Co. solely for the purpose of generating electricity for profit. Although complainants assert that the Osage River and many of its tributaries are navigable in fact and in law, yet they say that the construction of said dam would not serve to promote navigation thereon, but would impede same; that the size of said dam, as now contemplated, would inevitably create an immense reservoir and cause the inundation of vast tracts and bodies of land, the submergence of many public highways and school districts, and the permanent overflow of the village of Linn Creek in Camden County, which is now the county seat of said county; and that the courthouse and other public property situated in said Linn Creek would be flooded and rendered useless.

It is further alleged that said dam is not intended as a public improvement and in fact would not be for the public interest, but is wholly designed as a private enterprise for the generation of electricity to be disposed of commercially, and on account of the lake formed thereby a condition deleterious to the public health would be created.

The defendants, on their part, admit the proposed and intended construction of said dam. They assert, however, that it would be an aid and benefit to navigation. The defendants, and particularly the Union Electric Light & Power Co., plead the legal right to construct said dam, which, it says, is vested by virtue of Federal license project 459, Missouri, granted by the Federal Power Commission, pursuant to the provisions of the Federal water power act of June 10, 1920, being chapter 12, title 16 of the United States Code (16 U. S. C. A. secs. 791–823). The authority of the Federal Power Commission, it is asserted, arises from clause 3, section 8, of article 1 of the Constitution of the United States, whereby power is vested in the Congress, "to regulate commerce with foreign nations, and among the several States."

The defendants, and particularly the Union Electric Light & Power Co., plead compliance with said water power act and assert the right not only to construct said dam but to acquire by condemnation, if necessary, all property of a private or public nature, situated within the proposed reservoir or in any manner affected by said project.

* * * * *

The evidence, on the part of the complainants, tended to show that navigation on the Osage River and its tributaries had been carried on uninterruptedly for many years, but that the volume of business had been so far reduced that it was practically negligible at the present time. Such navigation was seasonal and dependent in a large measure upon the stage of the rivers affected, which in turn were largely dependent upon uncertain rainfalls.

The evidence was undisputed that the dam, as proposed by the defendant Union Electric Light & Power Co., would have the effect to accumulate a vast body of water in a huge reservoir, and that the entire region within the valley of the Osage River and the valleys of its tributaries, for a distance of more than 100 miles, would be overflowed. This would result in submerging both public and private property, including the courthouse and jail in the village of Linn Creek, a large number of school districts, and at sundry points inundate the public highways. It was undisputed that Camden County would be divided in three parts by the lake to be formed, and that each part would be rendered inaccessible to the other parts.

It further appeared beyond question that a large portion of the more fertile bodies of land in Camden County, lying along and in close proximity to the Osage River and its tributaries would be inundated, so that the county, so far as agriculture is concerned, would be permenently deprived of its most valuable productive areas. There was evidence as to the necessary withdrawal of such lands from State and local taxation and the serious effect that would follow upon the revenues of Camden County. There was evidence that insanitary conditions would be created by the exposure of large areas covered with mud and bog due to the recessions of the lake.

The evidence on the part of the defendants showed that navigation on the Osage and its tributaries had been so greatly reduced in recent years that it was now negligible. It was admitted that valuable properties, both public and private, would be inundated. The testimony of the defendants, however, showed that no unhealthy conditions would result from the construction of said dam and reservoir, but that, on the contrary, the areas covered by mud and bog would be greatly reduced by reason of said construction.

The Osage River and its tributaries are subject to frequent and extensive overflow in their natural state. Much of the area to be taken as part of the proposed reservoir is now subject to overflow. Following such overflows, deposits are left similar to that which would follow the withdrawal of waters in the reservoir and are far more extensive.

The evidence, on the part of the defendants, tended to show that navigation would be materially benefited by the construction of said dam; that the Osage River would be rendered navigable for heavy draft boats between Warsaw in Benton County and Bagnell in Miller County; and that this would comprehend a distance of approximately 100 miles and would connect with railroad carriers at both of these points.

The evidence was that for many years there has not been continuous navigation, but that freight was ordinarily taken from the river at Bagnell and thereafter carried by railroad. There was much evidence that the release of water from the reservoir would much more evenly distribute the flow on the Osage River below the dam, and that navigation would experience a dependable and adequate flow of water. Moreover, the Missouri River would be affected somewhat favorably for navigation at periods of low water.

* * * * *

1. At the outset the court is concerned with the fundamental and jurisdictional question as to whether the project is one of Federal judicial cognizance. As a postulate to a further consideration of the case, it must be acknowledged, and the parties so concede, that the National Government, under the power "to regulate commerce with foreign nations and among the several States," has full and complete jurisdiction over all matters affecting navigation. (Addyston Pipe & Steel Co. *v.* United States, 175 U. S. 211,

20 S. Ct. 96, 44 L. Ed. 136; Gibbons *v.* Ogden, 9 Wheat. 1, loc. cit. 229, 6 L. Ed. 23; Alabama Power Co. *v.* Gulf Power Co. (D. C.) 283 F. 606, loc. cit. 613.) Moreover, this power and authority extends just as fully and completely to navigation upon the navigable waters wholly within a State.

In Sewell *v.* Arundel Corporation, 20 F. (2d) 503 loc. cit. 504, the Court of Appeals for the Fifth Circuit, said: "It is well settled that Congress has complete dominion over the navigable waters of the United States, whether wholly within the boundaries of a State or otherwise, and has authority to undertake and prosecute such work as may be thought necessary to improve their navigability. This authority includes the power to obstruct, and when Congress gives consent to the creation of an obstruction to navigation it ceases to be a nuisance and the courts are powerless to interfere. (Wisconsin *v.* Duluth, 96 U. S. 379, 24 L. Ed. 668; Pennsylvania *v.* Wheeling & Belmont Bridge Co., 18 How. 421, 15 L. Ed. 435.)"

* * * * *

Complainants are correct in their contention that, if the construction and maintenance of the dam is for the prime and sole purpose of generating electricity for commercial purposes, and not for its influence upon navigation, then the subject matter would not be within the power of the Congress or within the jurisdiction of this court. (Addyston Pipe & Steel Co. *v.* United States, supra.)

* * * * *

8. By section 21 of the water power act (16 U. S. C. A. sec. 814) it is expressly provided that: "When any licensee can not acquire by contract or pledges an unimproved dam site or the right to use or damage the lands or property of others necessary to the construction, maintenance, or operation of any dam, reservoir, diversion structure, or the works appurtenant or accessory thereto, in conjunction with an improvement which in the judgment of the commission is desirable and justified in the public interest for the purpose of improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, it may acquire the same by the exercise of the right of eminent domain in the district court of the United States for the district in which such land or other property may be located, or in the State courts."

The licensee has been granted the power to acquire property by the exercise of eminent domain in express terms. Concededly this right may be exercised as against private property.

"Public lands," as used in the act, refers only to lands owned by the United States. The only question, therefore, that is here presented is whether the right of eminent domain may be exercised against property already dedicated to a public use when situated within the proposed reservoir and to be affected by the improvement.

9. While it is well settled that the legislature may authorize the taking of property already devoted to a public use, it is equally well established that a general delegation of the power of eminent domain does not authorize the taking of property already devoted to a public use, "*unless it can clearly be inferred from the nature of the improvements authorized or from the impracticability of constructing them without encroaching upon such property that the legislature intended to authorize such a taking.*" (10 R. C. L., sec. 169; Western Union Telegraph Co. *v.* Pennsylvania R. R. Co. et al, 195 U. S. 540, 25 S. Ct. 133, 49 L. Ed. 312, 1 Ann. Cas. 517.) In this connection it can not be questioned but that Congress had the power to confer the right of eminent domain upon the defendant Union Electric Light & Power Co. (10 R. C. L. sec. 167.)

In the instant case the Congress must have contemplated this identical situation; hence the requirement of notice. Moreover, the proposed improvements could not be accomplished except through the exercise, if necessary, of eminent domain against property already dedicated to public use. To deny the right of eminent domain as against this public property would not only defeat the functions of the National Government, but would run contrary to the obvious intent of the Congress as expressed in the water power act. (Stockton, Attorney General,

WATER SUPPLY CONDITIONS

December was characterized by slightly subnormal temperatures and a marked deficiency in precipitation. In many localities only a negligible amount occurred during the month.

While it is yet early for predictions concerning the 1931 water supply, with most of the runoff producing snowfall normally occurring after December 31, the present extremely low snow cover on the watersheds indicates small runoffs for the ensuing year.

For reservoirs with concurrent records available, the storage contents on December 31, 1930, were 3,819,000 acre-feet, compared with 4,531,000 acre-feet for the same date in 1929.

v. Baltimore & New York R. R. Co. (C. C.) 32 F. 9; 20 C. J. sec. 90, P. 602; Vermont Hydro-Electric Corporation *v.* Dunn et al., 95 Vt. 144, 112 A. 223, 12 A. L. R. 1495; Imperial Irrigation Co. *v.* Jayne, 104 Tex. 395, 138 S. W. 575, Ann. Cas. 1914B, 322.)

* * * * *

12. This court can take no cognizance of the enforced removal of the county seat of Camden County. The Congress acting under its power to regulate commerce is supreme, and its authority must be upheld and executed, even though it involves the removal of the county seat of Camden County. Even a county seat could not endure as an obstruction and barrier to the free exercise of governmental authority.

* * * * *

NOTE.—The States can not condemn Federal property. (Utah Power & Light Co. *v.* United States, 243 U. S. 389), but in Nahant *v.* United States (136 Fed. 273), and Bedford *v.* United States (23 Fed. (2d) 453) the Federal condemnation of State property has been permitted. The foregoing case is in line with the Nahant and Bedford cases.

Recently Enacted Legislation

CHINOOK DIVISION MILK RIVER PROJECT

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act of May 25, 1926 (Forty-fourth Statutes at Large, page 636), be and the same is hereby, amended by adding after section 20 of said act sections 20–A and 20–B, as follows:

"SEC. 20–A. There shall be deducted from the total cost chargeable to the Chinook division of this project the following sum:

"(1) Twenty-one thousand six hundred and eighty-four dollars and fifty-eight cents, or such amount as represents the construction cost as found by the Secretary of the Interior against the following lands:

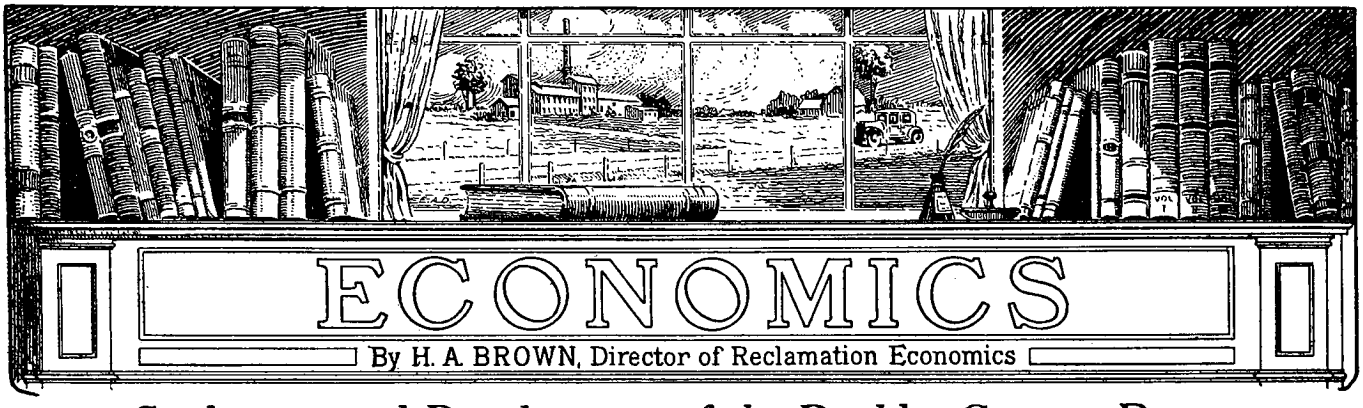
"(a) One thousand seven hundred and seventy and seventeen one-hundredths acres permanently unproductive because of nonagricultural character.

"SEC. 20–B. All payments upon construction charges shall be suspended against the following lands in the Chinook division:

"(a) Twelve thousand six hundred and seventeen and sixty-four one-hundredths acres temporarily unproductive because of heavy soil and seepage; (b) eleven thousand three hundred and seven acres for which no canal system has been constructed, all as shown by the land classification of the Chinook division made under the direction of the Secretary of the Interior and approved by him under date of January —, 1930. The Secretary of the Interior, as a condition precedent to the allowance of the benefits offered under sections 20–A and 20–B, shall require each irrigation district within the Chinook division to execute a contract providing for repayment of the construction charges as hereby adjusted within forty years and upon a schedule satisfactory to said Secretary; and no water from the Saint Mary River watershed shall be furnished for the irrigation of lands within any district after the irrigation season of 1930 until the required contract has been duly executed."

SEC. 2. All contracts with the Government touching the project shall be uniform as to time of payment and charge for the construction of the Saint Mary diversion.

Approved, July 3, 1930.



Settlement and Development of the Boulder Canyon Project

FOR the benefit of those who see in the Boulder Canyon project only another large area of land to be brought into cultivation in the near future for the production of crops to compete with agricultural products of the East and Middle West, let it be said at the outset that, as has been the case with other statements, it is perfectly all right except that in the first place there will be little or no such competition, and in the second place it will be seven or eight years before water will be available for growing crops on the withdrawn public land.

What our economic condition may be at that time no one can foretell with any degree of accuracy. It seems reasonably safe to assume, however, that what has been true in the past concerning the local absorption of the products of Federal irrigated agriculture will be equally true of the agricultural development under the Boulder Canyon project, and that these future products of Federal irrigation will be readily absorbed by the growing demands of the Southwest whose population and industrial development are confidently expected to respond in a marked degree to the stimulus of the construction of Hoover Dam.

The anticipated influx of capital and population to this region as a result of the vast power development at the dam and the assurance to Los Angeles and a score of smaller cities of an adequate supply of water for domestic purposes, thus insuring their continued phenomenal growth, must be met by an increased food supply. The arid areas irrigable from Hoover Dam will help to supply this need.

SETTLEMENT OPPORTUNITIES ON COMPLETION OF WORKS

At present all public land susceptible of irrigation from Hoover Dam has been withdrawn from entry and will not be opened to settlement until water for irrigation is available. That means not until after the Hoover Dam is completed and canals and laterals constructed to bring the water to the land, or from seven to eight years hence.

When water is available for irrigation and the land is opened to entry, ex-service men will have a preference right of three months to enter such land before citizens without a military or naval background are allowed to make application. The land will doubtless be opened in units of a few thousand acres at a time as water becomes available for a particular area and in order that there may not be too great a lag between completion of construction and full settlement.

TITLES TO ILLUSTRATIONS ON OPPOSITE PAGE

Upper: Commencement of construction of Hoover Dam. Left to right: Senator Key Pittman of Nevada; Governor Fred B. Balzar of Nevada; Carl R. Gray, president of Union Pacific System; Hon. Ray Lyman Wilbur, Secretary of the Interior; Senator Tasker L. Oddie of Nevada.

Lower: Government engineers in charge of construction. Left to right: Dr. Elwood Mead, Commissioner of Reclamation; Raymond F. Walter, chief engineer; Walker R. Young, construction engineer; John C. Page, office engineer; Ralph Lowry, assistant construction engineer.

CROPS ADAPTED TO PROJECT

It is not anticipated that much, if any, difficulty will be experienced in settling these lands as they become available. This region has been aptly called America's Valley of the Nile, where a potentially fertile soil and abundant sunshine, coupled with an adequate water supply and intelligent farming methods, will work wonders in transforming an arid waste into a garden spot. Here will be duplicated the crops of the Salt River Valley and the Yuma project in Arizona, and those of the Imperial Valley in California. A wide variety of crops is possible, including alfalfa, cotton, winter vegetables, cantaloupes, lettuce, pecans, citrus fruits, figs, dates, and many other crops normally grown in the temperate and subtropical zones.

It is believed that, as in the case with land opened to entry on the Tule Lake division of the Klamath project, Oregon-California, the demand for these Boulder Canyon project lands will exceed the supply, and that as a result a miniature agricultural empire will in time be gradually developed here to meet the needs of population increase and industrial expansion in the nearby cities and towns of the Southwest.

Every effort will be made by the Bureau of Reclamation to see to it that the land opened to entry is economically feasible of producing crops of a character and in sufficient quantities to provide a living for the farmers and repay the charges to the Government. Careful land classifications and soil analyses will be made to determine this essential factor. In addition the men who take up the public land will be required to demonstrate to an examining board that they have the necessary qualifications for success, particularly experience in farming and a reasonable amount of capital. The combination of the right man with adequate capital, a fertile soil, an adequate water supply, and nearby markets should eliminate most of the hazards of changing raw land into producing farms. Every means will be used by the bureau to bring about this happy combination in the settlement and development of the Boulder Canyon project.

AT the end of the month a milk producers' association was in process of organization on the Klamath project. Thirty to 35 dairymen are expected to join the association, the members of which will be under contract to market their products through the Klamath Dairymen's Association.

Government Plans Model Town at Boulder City, Nevada

ON December 18 Secretary Wilbur approved the plans for Boulder City, Nev., the new town to be constructed by the Government on the Boulder Canyon project, about 6 miles west of the site of the Hoover Dam. For several months S. R. De Boer, city planner and landscape architect, of Denver, Colo., has been at work on plans for this town, which has resulted in a layout that will probably serve as a model in town planning for years to come. The employees of the Government and of the contractors, together with those who wish to engage in business, or to follow their trades or practice their professions, will find in Boulder City all the conveniences and comforts which the Government is able to provide. In southern Nevada there is an annual temperature range from 20° to 120°, with a mean temperature in December of 52° and of 94° in July. The summers are hot and dry, while the winter climate is quite agreeable. Trees, green grass, and flowers are missing in the vicinity of the town site, and instead are found sandy soil, bare rocks, and occasional desert shrubs. But a transformation will be worked in this particular instance, and here the "desert will blossom like a rose." Boulder City will truly be an oasis in the desert, a resting place for the weary traveler. The workers on the project who live in this "model town" will have comfortable living quarters specially designed for the prevailing climatic conditions, and the town will lack nothing to be found in the average progressive community elsewhere in the country.

There will be expended by the Bureau of Reclamation in the construction of Boulder City about $2,000,000, and it is expected that about 3,000 people will have residence there during the construction period. The size of the population after the dam and power plant are completed is problematical, but it seems very likely that it will be a sizable tourist town. With a main transcontinental highway as projected from Kingman, Ariz., on the east, and crossing over the top of the dam, thousands of tourists will use this route on their way to the Pacific coast. The 730-foot dam and 115-mile lake will compete with the National Parks as scenic attractions. A maintenance force will also be needed at the dam and power plant.

GENERAL PLANS FOR CITY

The city plan contemplates that the construction contractor's camp, the Government camp, and various business establishments to care for the needs of these people will be assembled in the city under Government administration. The streets, business section, residence section, and parks will be laid out as shown on the accompanying plan. Streets will be graded and oil surfaced, concrete curbings and sidewalks constructed, and street lighting system installed. The Government will construct a town hall, school, garage, dormitory and guest house, auditorium, administration building, and 75 cottages for its employees comprising five 6-room, nineteen 5-room, twenty-six 4-room, and twenty-five 3-room cottages; also 50 small garages, a swimming pool, and playground. About $600,000 will be expended on these features.

The proposed water system will have sufficient capacity for the needs of 3,000 people, together with incidental city uses. The water will first be pumped from the Colorado River to a mechanical presedimentation plant and then pumped in two lifts to a chemical treating plant, sand filter, and storage system at the city, with a total lift of about 2,000 feet. Sufficient distribution system is to be installed by the Government to make water available to each lot. The water system will cost upwards of $400,000. A sewage system to cost about $150,000 will also be constructed, to consist of city distribution, with service connections to Government buildings and a disposal plant located about three-fourths mile from the city.

A transmission line from the substation of the Southern Sierras Power Co. at the dam site, substations at the water-supply pumping plant and at the city, and the city distribution and lighting system, are included in the bureau's construction plans. Sufficient capacity will be installed to handle all cooking and refrigeration uses as well as other requirements, making Boulder City an electric community. An ornamental street-lighting system is planned for the business section. Landscaping is also provided for in the Government estimates.

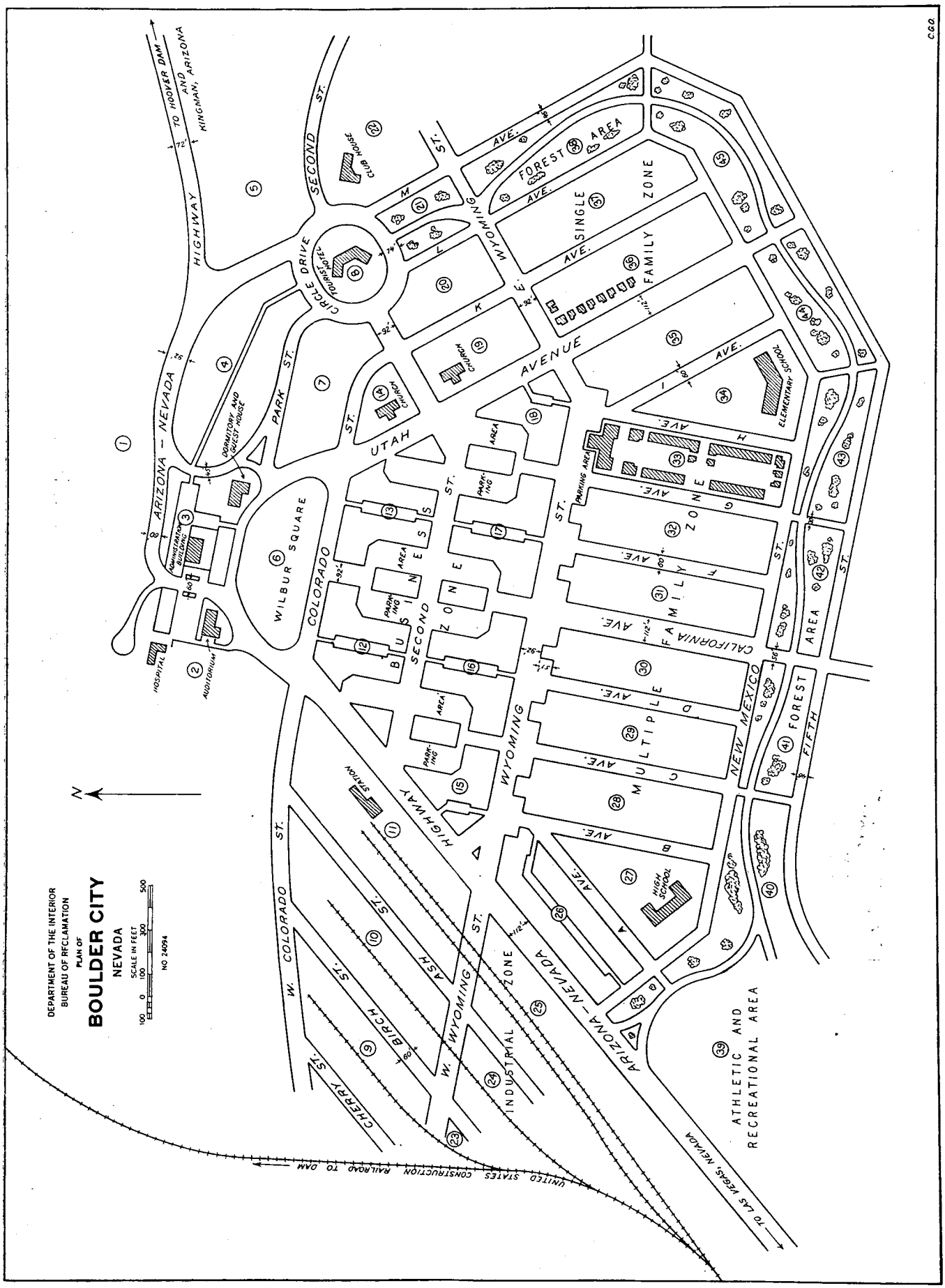
TOWN GOVERNMENT

The administration of the town government will be in the hands of a commission of three, one of whom will probably be a representative of the contractor for the dam. A city manager will have direct charge under supervision of the commission, with United States deputy marshals appointed as police officers. All operation and maintenance of water, sewer, and electric systems, streets, parks (with a combined area of about 10 acres), and other municipal works will be under the direction of the city manager. The duties of police judge will be taken care of by a United States commissioner and there will be a superintendent of public works with the usual city maintenance force.

The contractor for the Hoover Dam, power plant, and appurtenant works will have a section of the town set aside for his construction camp, in which he may erect an office building, warehouses, garages, commissary, hospital, dormitories, boarding houses, homes for employees, and other necessary buildings. These buildings are required to have a neat attractive appearance and the plans for same are subject to the approval of the Government. For the use of the land set aside for the contractor, and for the municipal services and facilities made available, he will be charged $5,000 per month during the construction period, together with additional charges for water and electricity. After acceptance by the Government of the dam, power plant, and related works, the contractor will have the right to lease the land occupied by his camp at the regular established rates. The specifications covering construction work at the dam site include a provision requiring the contractor to house not less than 80 per cent of his employees in Boulder City. There will necessarily be a few isolated camps, at places such as the Arizona gravel pits, and also boarding and lodging facilities which will be needed at the dam site.

SUMMIT SITE SELECTED

Due to the inaccessibility of the work, the magnitude of the operations, and the severe weather conditions during the hot summer months, and having in mind the health, comfort, and general welfare of those engaged on the work, the town has been located at the "summit" on a saddle of the divide between the river area and Las Vegas. The elevation is 2,500 feet, which is about 1,000 feet higher than the top of the canyon at the dam site. The location is about 6 miles west of the dam site and 23 miles southeast of Las Vegas, Nev., on a branch line (now under construction) of the Los Angeles & Salt Lake Railroad, a part of the Union Pacific system. A main highway will connect Boulder City with Las Vegas and the dam, and will probably join with a highway from Kingman, Ariz., and the east, in the near future. This summit site has an average temperature 6° lower than that of any of the other sites under consideration. It is at the top of the divide with a rather steep descent to the north, and a uniform 3 per cent slope to the south, with hills both to the east and west. There is an unusually beautiful view to the north overlooking the proposed 145,000-acre


DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PLAN OF
BOULDER CITY
NEVADA
SCALE IN FEET
NO 24094
N
TO HOOVER DAM — 72 — KINGMAN, ARIZONA AND ARIZONA
HIGHWAY
SECOND ST.
CIRCLE DRIVE
TOURIST CAMP
CLUB HOUSE
WYOMING AVE.
FOREST AREA
SINGLE FAMILY ZONE
ARIZONA — NEVADA
DORMITORY AND GUEST HOUSE
PARK ST.
UTAH AVENUE
CHURCH
ELEMENTARY SCHOOL
ADMINISTRATION BUILDING
WILBUR SQUARE
COLORADO ST.
BUSINESS ZONE
PARKING AREA
HOSPITAL
AUDITORIUM
CALIFORNIA AVE.
MULTIPLE FAMILY ZONE
NEW MEXICO AVE.
FOREST AREA
FIFTH ST.
HIGHWAY
STATION
W. COLORADO ST.
W. WYOMING ST.
ASH ST.
BIRCH ST.
CHERRY ST.
INDUSTRIAL ZONE
HIGH SCHOOL
ARIZONA — NEVADA
ATHLETIC AND RECREATIONAL AREA
TO LAS VEGAS, NEVADA
UNITED STATES CONSTRUCTION RAILROAD TO DAM

33646—31——2

reservoir 4 miles away. This lake will have an area 20 per cent larger than Lake Tahoe in California-Nevada.

The main axis of the town has been placed at a slight variation with the compass to give a more equal exposure of sunlight for all building walls. There will be no automobile parking allowed on streets, but provision will be made for parking on specially created open plazas in the downtown business blocks. In the business district the blocks have been provided with alleys, the interior part of which will be 46 feet in width, thus providing a loading and unloading space for trucks. Main through-arteries will be separate from business and residential streets. Street widths contemplated are as follows: Main highways 112 feet, roadway 56 feet, with possible extension to 76 feet; business streets 92 feet, roadway 56 feet; residential streets 60 feet, roadway 30 feet. All buildings in the town will be in harmony as to design. Different types of stores and business establishments will be given definite locations. Residential blocks have great length in the more densely populated districts, as much as 900 feet, with an average width of about 260 feet. In the design of these residential blocks provision has been made for open plazas in the block interiors to provide small parks and playground facilities.

STREET LAYOUT

Three main arterial highways are the basis of the street plan, the center one of the three being the axis of the city, and all three highways centering on the Government administration building located on a saddle overlooking the reservoir to the north. The west boulevard (Arizona-Nevada Highway) connects with the highway to Las Vegas and passes the railroad station, following the railroad on the west side of the city. The central boulevard (California Avenue) will pass through the center of the business district, with the administration building facing squarely on it, at the upper end of the street grade. The third arterial boulevard (Utah Avenue) on the east is of residential character.

At right angles to the arterial boulevards is the main business street (Second Street) with the railroad station at the west end. All the other streets connecting the radial boulevards are to be parallel to this main street. Residential streets are all planned to parallel the three radial boulevards and generally run in a southerly direction. The blocks south of the business district will have the greatest density of population, while the eastern part of the city has been set aside as a residential district of a more open character and less density. The higher part of this residential district to the north and directly east of the Government group of buildings is proposed for residences of the Government employees.

PRINCIPAL BUILDINGS

The office building of the Bureau of Reclamation has been made the central feature of the city. It will front on a central park (Wilbur Square) and have auto parking areas on both sides. To the southeast and close by will be the dormitory and guest house, while the auditorium and garage will be located in block 2 adjoining on the west.

The business section (blocks 12, 13, 15, 16, 17, and 18) has been designed around open plazas partly closed on the ends, with the central one the most important. With the provision of parking space in the plazas, and the elimination of parking in the streets, the business frontage is shifted from street to plaza. These plazas, with grass plots and trees through the center to provide open vistas, have parking space for over 1,400 automobiles and trucks. This capacity is independent of parking facilities provided for Government buildings, railroad station, and other public buildings. It is planned to design all stores with arcades over the sidewalks.

The city hall and post office are to be located in the two end buildings on the north end of the central business plaza. It is proposed to group together the stores that logically belong together and assign definite types of buildings to the various plazas. Stores for wearing apparel, notions, books, etc., would be located in the south half of the plaza with grocery, hardware, and furniture stores in the north half. Directly on the main street on the four corners of the intersection of the main street with the plaza would be the drug stores. Hotels and lodging houses will be in the business district fronting on Wilbur Square, while a large tourist hotel is proposed at the east end of the main street (Second Street) on a small hill, where a 4-acre tract is set aside for this purpose.

RESIDENTIAL SECTION

Sites for apartment houses are located just south of the business section, and in this area there are small parking spaces at every corner. These apartment houses will face on the open courts of the residential blocks to the south, giving an unusual amount of air and light. Several blocks south of the apartment house area (blocks 26, 28, 29, 30, 31, 32, 33, and 35) are designed for multiple dwellings, with interior courts 100 feet in width, in which will be playground apparatus, and the remainder will be made into lawn. Between the buildings and court is a space from 20 to 30 feet wide set aside for private yards. These dwellings will be set back from the curb about 20 feet, with garages in pairs made a part of the building design instead of being independent structures.

In the eastern part of the city a district (blocks 36 and 37) has been set aside for single family dwellings, with more space allowed for individual gardens and less community space. The Government residential area in the northeast section will have probably the most desirable location in Boulder City. Parks and playgrounds are plentifully provided in the proposed plans. The central park facing the Government administration building will serve as a civic center. North of the Government buildings the ground drops away rapidly and there is a valley between some small hills which can be used advantageously for a swimming pool. An industrial zone is planned to the southwest of the railroad station. On the Arizona-Nevada Highway entering the city from Las Vegas will be placed garages, filling stations, repair shops and business establishments of a similar nature. A forest belt will encircle the southern and eastern part of the city as a protective shelter from the desert beyond. In this belt can be located play areas such as football fields and tennis courts, the larger part of block 39 being planned for an athletic and recreational area. Facing the forest area in block 27 is a site for a high-school building. A driveway, bridle path, and walking path can be placed through the trees. In the eastern section of the forest area (block 8) will be located the tourist hotel with a golf course. A second forest belt farther out from the town is designed for a future time, in which will be located a municipal airport and municipal golf course. There will also be a district set aside for truck gardening and orchards, for which the second forest belt will provide a protection

PLAYGROUNDS AND PARKS

With the creation of courts in the residential blocks, there will be a small playground in the interior of every block which can be equipped with apparatus for the small children and also croquet lawn and horseshoe pitching court for elderly people. With these playgrounds it will not be necessary to have play facilities for small children in schoolgrounds and parks, but the latter can be used rather for older boys and girls, young men and women, and be equipped with football and baseball fields, tennis courts, etc. Two triangular blocks (27 and 34) are set aside for school grounds. These blocks are away from the main traffic lines, but still conveniently located, and face the forest area. Grouping of church buildings is proposed at the east end of Second Street in blocks 14, 19, 7, and 20. In the naming of streets, the names of States in the Colorado River Basin are used for the main thoroughfares. A careful study is

(Continued on p. 41)

Diversified Farming on Riverton Project

By A. G. Keys, Pavillion, Wyo.

The December issue of the ERA carried an article on the production and marketing of irrigated crops in the lower Yakima Valley which is of interest to settlers in other irrigated sections and has called forth the following statement from a farmer on the Riverton project, Wyoming:

Although the crops adapted to the Yakima Valley would bring poor returns on the Riverton project, the diversified plan could be carried out with the idea of producing the maximum amount of forage from new land, in addition to two or three cash crops which would allow the farmer to meet his water charges, taxes, payments on implements, and provide for his family with the surplus.

In the absence of cheap transportation Riverton is handicapped in the production of bulky crops which must be trucked to the railroad. At the present time it takes about 25 per cent of the crop to cover this charge. To overcome this disadvantage many farmers have seeded their places down to alfalfa and sweet clover to be fed to livestock so that the finished product can be marketed with reduced transportation charges.

This year's crops proved beyond a doubt that exceptional returns may be expected from Riverton soil, but more thought should be given to the individual who must succeed from the start if the project is to go forward. With the experience gained on older projects a program covering a 10-year period might be worked out that would serve as a guide to a man who is not familiar with local conditions. Too many men depend on oats or wheat for the first year's crop, with disappointing results as a rule. Others seed their land to alfalfa and sweet clover when they have no prospect of getting the money to fence the clover off for pasture or of supplying winter feeding for their sheep or cattle. They pass up the sidelines of chickens, turkeys, and a good truck patch which would mean a living for their familes.

With a small amount of commercial fertilizer there is an increased yield in potatoes, corn, beans, millet, and small grains. Raw land will produce potatoes for seed, flax, cabbage, stock carrots, tomatoes, and other vegetables which would find a ready sale in an outside market. The man who wishes to specialize in dairy stock, beef cattle, sheep, hogs, or poultry can not be bound by any set rule, but these men will be in the minority and any program should fit the needs of the fellow who depends on the soil alone to get his start.

A suggested program is given in the accompanying sketch. After the settler has arranged his fields according to the lay of the land and the location of head ditches he will probably have a good idea of the crops to be grown. This will enable the county agent to advise him intelligently, but without a definite plan ahead and little knowledge of what can be expected from any particular crop the new settler, as well as some of the older ones, is bound to fail if he is depending on hay or grain alone to carry him along.

Examples of the success of men who practice diversified farming should be hammered home at every opportunity in order that their experiences may prove profitable to new settlers.

SUGGESTED ROTATION PROGRAM FOR 80-ACRE FARM UNIT

RIVERTON PROJECT, WYOMING

1ST. YEAR		2ND. YEAR		3RD. YEAR		4TH. YEAR		5TH. YEAR	
BLDGS. AND GARDEN	OATS OR RYE WITH SWEET CLOVER FOR PASTURE OR HAY	BLDGS. AND GARDEN	HARROW IN BROME, ORCHARD, AND BLUE GRASSES FOR PERMANENT PASTURE	BLDGS. AND GARDEN	PASTURE	BLDGS. AND GARDEN	PASTURE	BLDGS. AND GARDEN	PASTURE
OATS WITH ALFALFA	BEANS, CORN, POTATOES	ALFALFA	OATS WITH ALFALFA	ALFALFA	ALFALFA	BEETS, POTATOES, CORN, OR PEAS	ALFALFA	BEETS, BEANS, BARLEY, OR PEAS	POTATOES OR CORN
BEANS AND FLAX OR FALLOW	FALL PLOW	BEANS, CORN, POTATOES	FLAX OR WHEAT WITH CLOVER	GRAIN WITH ALFALFA	BEANS OR CORN AND POTATOES	ALFALFA	OATS WITH CLOVER	ALFALFA	BEANS OR PEAS

6TH. YEAR		7TH. YEAR		8TH. YEAR		9TH. YEAR		10TH. YEAR	
BLDGS. AND GARDEN	BEETS, POTATOES, CORN, OR PEAS	BLDGS. AND GARDEN	BEETS, PEAS, BEANS, OR CORN	BLDGS. AND GARDEN	OATS WITH SWEET CLOVER	BLDGS. AND GARDEN	PASTURE MIXTURE IN CLOVER	BLDGS. AND GARDEN	PASTURE
OATS OR RYE WITH SWEET CLOVER FOR PASTURE	BEETS OR BEANS	PASTURE	BEETS OR BARLEY	PASTURE	OATS WITH ALFALFA	POTATOES OR CORN	ALFALFA	BEETS	ALFALFA
ALFALFA	GRAIN WITH ALFALFA	POTATOES OR CORN	ALFALFA	BEETS, BARLEY, OR BEANS	ALFALFA	BEETS OR BEANS	ALFALFA	GRAINS WITH CLOVER OR ALFALFA	POTATOES OR CORN

1ST. YEAR-50 HENS-1 COW-1 SOW-6 TURKEY HENS AND 1 GOBLER.
2ND. YEAR-100 HENS-2 COWS-1 SOW-15 EWES OR SOME "BUM" LAMBS-10 TURKEY HENS.
3RD. YEAR-INCREASE POULTRY AND LIVESTOCK AS FINANCES WILL PERMIT.
PLANT A FEW NATIVE TREES AND SHRUBS EACH YEAR AND FILL IN WITH NURSERY STOCK LATER. START A FEW STRAWBERRIES AND RASPBERRIES FIRST YEAR IF POSSIBLE.
EXCHANGE WORK AND FARM TOOLS WITH YOUR NEIGHBOR. SAVE YOUR MONEY TO INVEST IN POULTRY AND LIVESTOCK. PLANT A GOOD GARDEN EACH YEAR. SUBSTITUTE SEED CROPS ON NEW LAND AS LOCAL MARKET DEVELOPS.

ENGINEERING

By C. A. BISSELL, Chief, Engineering Division

Specifications and Plans Available for Work at Hoover Dam

THE most important construction job ever undertaken by the Bureau of Reclamation, and the largest Government project since the Panama Canal is now being advertised, and bids are to be publicly opened at the Denver, Colo., office at 10 o'clock a. m. on March 4, 1931. In one contract there will be included the Hoover Dam, power plant, and appurtenant works estimated to cost about $108,000,000, which amount includes both labor and materials. Specifications and plans have been printed and were available for distribution on January 10 at the Washington, Denver, and Las Vegas offices. The specifications contain about 100 pages of text and 76 drawings and sell for $5 a copy. A bid bond in the amount of $2,000,000 must be submitted with each bid, and the successful bidder who is awarded the contract will be required to furnish a performance bond of $5,000,000. The Colorado River board of engineers and geologists, of which Maj. Gen. William H. Sibert is chairman, has approved the designs for the diversion works and other features which must be completed during the early stages of construction. Final approval of plans for the section of the dam and spillways is deferred, awaiting the results of further analyses and of tests on models of these features.

DIVERSION WORKS

The works for diversion of the river during construction, which will be built first, consist of upper and lower cofferdams and four tunnels, and are described in the specifications as follows: The upstream cofferdam will be of the earth and rock-fill type, the upstream earth-fill slope being protected by a 3-foot rock blanket covered with 6 inches of reinforced concrete paving. Steel sheet piling will be driven in a trench at the upstream toe to form a water-tight cut-off wall in the river bed. The downstream cofferdam will also be of the earth and rock-fill type, the downstream slope being protected from eddy action by a rock barrier. This rock barrier will be placed downstream from the downstream cofferdam and will consist of a massive embankment of 127,000 cubic yards of dumped rock. These cofferdams are sizable structures in themselves, the upper dam being about 80 feet in height with a top width of 70 feet. In the two cofferdams will be placed 798,000 cubic yards of earth and 227,000 cubic yards of rock.

There will be four diversion tunnels, two on each side of the river, circular in section, lined with a minimum of 2 feet of concrete and measuring 50 feet in diameter inside of the lining. In length the four tunnels average about 4,000 feet. They will require 1,563,000 cubic yards of tunnel excavation, as well as an additional 400,000 cubic yards of open-cut rock excavation, and the placing of 337,000 cubic yards of concrete in the inlet and outlet structures and linings. Plugs in the tunnels will require 121,000 cubic yards of concrete.

After the downstream cofferdam and rock barrier have served their purpose they will be removed from the river channel by the contractor.

HOOVER DAM

The dam will be of the massive concrete arch-gravity type. It will be about 1,180 feet long on the crest and about 730 feet in height above the lowest point of foundation bedrock. The radius of curvature of the axis will be about 500 feet. About 3,400,000 cubic yards of concrete will be placed in the dam out of a 4,400,000 total for all the works. A cut-off trench will be excavated in the foundation rock along the upstream toe. The foundation and abutment rock are to be drilled and pressure grouted, the holes being located at 5-foot intervals in one line in the trench. Grout holes will vary in depth up to a maximum of about 150 feet. The dam will contain a very complete drainage system, with a main drainage gallery parallel to the axis of the dam, connecting with radial drainage conduits discharging at the downstream toe of the dam. To provide for expansion and contraction the concrete will be built up in sections or columns. The setting heat of the concrete will be dissipated by means of a refrigeration plant supplying and forcing cooled water through pipes imbedded in the concrete. In addition to the drainage galleries there will be a number of inspection galleries. Two elevator shafts will connect the two wings of the power house with the top of the dam. The contractor must take out 857,000 cubic yards of common excavation for foundations of dam, power house, and cofferdams; and 400,000 cubic yards of rock for the dam foundation.

SPILLWAYS

Two spillways will be constructed, one on each side of the river. Each of these will consist, in downstream order, of a 50-foot by 50-foot Stoney gate, a concrete ogee overflow crest about 700 feet long, a reinforced concrete-lined open channel, a 50-foot diameter concrete-lined inclined tunnel, through which the water will pass into the outer diversion tunnel. This outer tunnel, after having served its purpose as a diversion tunnel, will be plugged with concrete immediately upstream from its junction with the inclined spillway tunnel, and the downstream portion will then become a part of the spillway system. It is estimated that the spillways will require 1,012,000 cubic yards of open-cut excavation and 144,000 cubic yards of excavation in the inclined tunnels.

OUTLET WORKS

The outlet works on each side of the river will consist of two separate systems, each being regulated by a cylinder gate in the bottom of an intake tower, the two towers being about 185 feet apart in a direction parallel with the river. The system regulated from the upstream intake tower will consist, in downstream order, of the tower with a cylinder gate 31 feet in diameter, discharging into a 30-foot diameter inclined tunnel connecting with the inner diversion tunnel; the upstream tunnel plug in the diversion tunnel with temporary slide gates; the inner diversion tunnel below the upstream tunnel plug; the downstream lower and upper canyon-wall outlet gates and needle valves; the downstream tunnel plug with outlet gates and needle valves installed therein; and the 50-foot by 50-foot Stoney gates at the outlet end of the inner diversion tunnels.

The system regulated from the downstream intake tower will consist of the

tower with its cylinder gate 31 feet in diameter discharging into a 30-foot diameter horizontal penstock tunnel, leading to the upstream lower and upper canyon-wall outlet gates and needle valves. Power penstocks divert from each system. The lower and upper canyon-wall outlet gates and needle valves on each side of the river are housed in separate buildings, and in each of the four buildings there will be eight 72-inch needle valves for discharge control. The canyon-wall valve houses will require 255,000 cubic yards of excavation, and the placing of 51,000 cubic yards of concrete, while 108,000 cubic yards of concrete are specified for the intake towers, foundations, and superstructures.

POWER PLANT

The power plant will be located immediately downstream from the dam. It will be a U-shaped structure of concrete and structural steel with one wing on each side of the river, with the connection portion constructed across the downstream toe of the dam. Each wing of the building will be built sufficiently large to accommodate at least six, and possibly eight, main power generating units, together with transformers, switching and control equipment, and auxiliary apparatus. The length of the river face of each wing will be about 500 feet, the depth to the excavated canyon wall about 66 feet, and the height from the generator floor to the top of the roof will be about 85 feet. Construction of the power house is covered by the specifications, but the hydraulic and electrical machinery, equipment, and wiring will be installed by the Government. The power house will require the placing of 143,000 cubic yards of concrete.

INCLINED FREIGHT ELEVATOR

The inclined freight elevator guide structure will be located on the slope of the canyon wall immediately downstream from the power house on the Nevada side of the river. The top of the structure will be about elevation 1,261 and the bottom elevation about 667. It will consist of a channel excavated in the rock wall and lined with concrete, in which track rails, structural guides and other metal work will be installed to guide the elevator car. This guide structure will be connected to the power house by a spur track constructed in a concrete foundation. After the construction of the dam, power plant, and appurtenant works is completed, the inclined freight elevator and spur track will be used by the Government for general operation and maintenance purposes. The distance between upper and lower landings will be 594 feet, the speed of the transfer car 60 feet per minute, and the size of the car platform 12 feet by 50 feet. The elevator may be used by the contractor during the construction period for transporting labor, materials, equipment, and supplies. If the contractor desires this, the Government will, upon request, proceed with the purchase and installation of the elevator equipment. The elevator would then be operated and maintained by the contractor during the construction period.

PREFERENCE IN EMPLOYMENT

The contractor and his subcontractors will be required to give preference at the time of employment, so far as practicable; first, to qualified ex-service men, and second, to qualified citizens of the United States. Preference for ex-service men is a requirement of the Boulder Canyon project act, and the citizens' preference was recommended by Secretary Wilbur and approved by President Hoover on December 17, 1930.

CONSTRUCTION PROGRAM

It is expected that the successful contractor will receive notice to proceed about April 15, 1931, and will begin work within 30 days after that date. The program outlined calls for completion of the four diversion tunnels by October 1, 1933, and the cofferdams by May 1, 1934. It is thought that placing of mass concrete in the dam will start not later than December 1, 1934. The program contemplates that all concrete, the construction of all necessary features for the beginning of storage of water by June 15, 1936, and of all other necessary features for the generation of power by September 1, 1936, with the storage of water to elevation 935, will be completed by the required dates.

All that portion of the two wings of the power house sufficient to permit installation of the six upstream power units on each side of the river; the portion of the building connecting the two wings; the substructure of the power house, for installation of two additional power units on each side of the river immediately downstream from the other power units, up to elevation 660; and all other portions of the power plant and other works which must be completed before the necessary power machinery and other equipment to be installed by the Government for the operation of power units N1, N3, N5, A1, A3, and A5 can be placed, are to be completed within 1,600 calendar days (about October 1, 1935).

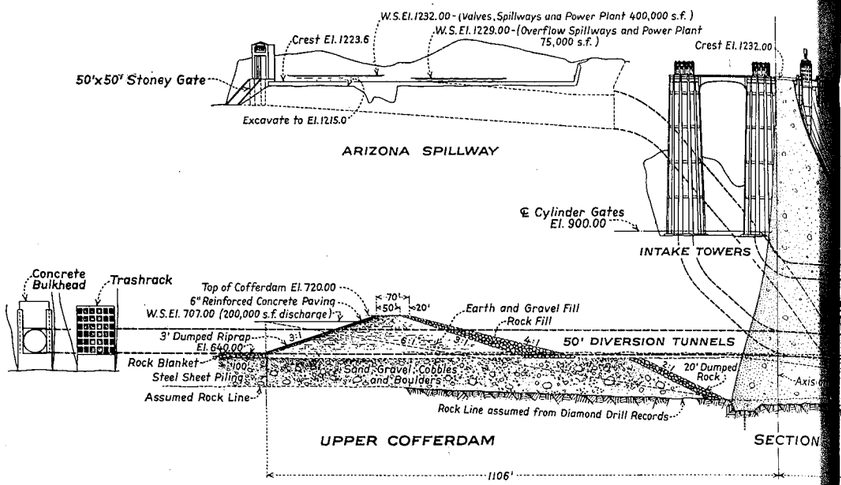
All other portions of the dam, power plant, and appurtenant works which will permit, without damage to any part of the required works, the permanent storage of water up to a maximum elevation of 935, and the operation of power units N1, N3, N5, A1, A3, and A5, are to be completed within 1,965 calendar days (about October 1, 1936). All of the remainder of the work under the schedule, including completion of the power house and power plant for six power units on each side of the river, must be completed within 2,565 days, or 7 years (about May 1, 1938). If the Government gives the contractor notice within 1,600 days that seven or eight power units will be required on each side of the river, instead of six, this additional work must also be completed within the 2,565-day period.

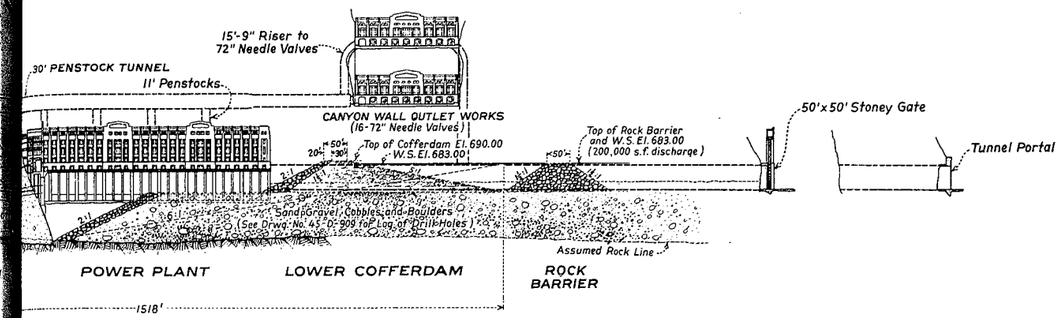
If any part of the work is not completed on or before the date fixed for its completion by the terms of the contract, the contractor shall pay to the Government as fixed, agreed, and liquidated damages the sum of $3,000 per day for each calendar day's delay for each part of the work, as described in the two previous paragraphs.

MATERIALS FURNISHED

As a general rule the Government will furnish to the contractor all materials which are to enter into the completed work. These include the more important items of cement, reinforcement steel, pipe and fittings, plate-steel conduit linings, gates and hoists, needle valves, power-house machinery, and structural steel. These materials will be purchased by the Government from time to time during the construction period, as they are needed. The contractor must furnish sand, broken rock or gravel and cobbles for concrete, form materials, and lumber. Sand, gravel, and cobbles will be obtained by the contractor from deposits on Government property, on the Arizona side of the river about 8 miles upstream from the dam site.

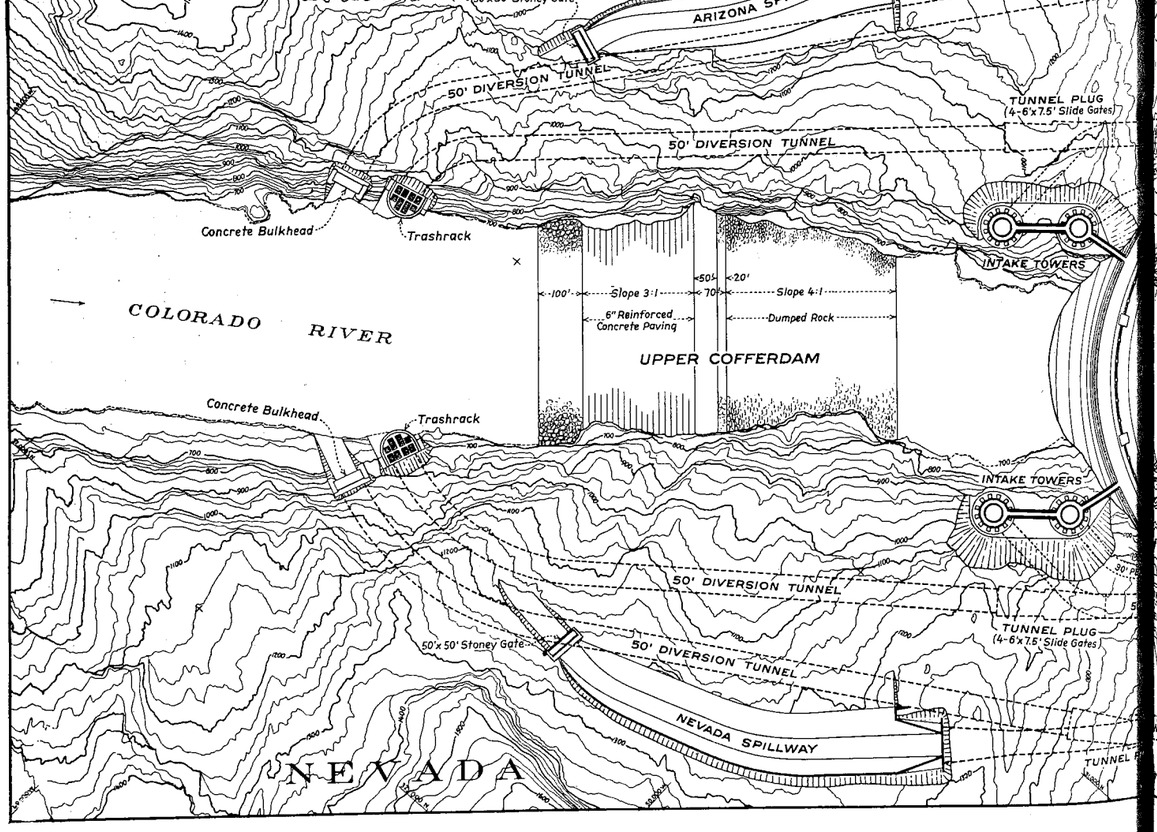
Open-cut excavation	*1,800,000 cubic yards.*
Tunnel and shaft excavation	*1,900,000 cubic yards.*
Earth and rock fill in cofferdams and river channel protection	*1,200,000 cubic yards.*
Concrete	*4,400,000 cubic yards.*
Grout	*228,000 cubic feet.*
Drilling grout and drainage holes	*290,000 linear feet.*
Installing reinforcement bars	*5,500,000 pounds.*
Installing small metal pipe and fittings	*1,900,000 pounds.*
Installing large metal conduits	*32,500,000 pounds.*
Installing structural steel	*10,600,000 pounds.*
Installing gates, hoists, and other metal work	*20,000,000 pounds.*





SECTIONAL ELEVATION ALONG LINE OF RIVER

24123-A



NOTE
The 30' and 50' Penstock Tunnels, the 11' Penstocks and the 91" Conduits are Pressure Tunnels.

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BOULDER CANYON PROJECT
HOOVER DAM
DAM AND APPURTENANT WORKS
GENERAL LAYOUT

DRAWN: C.A.M. SUBMITTED:
TRACED: W.L.S. C.B.S. RECOMMENDED:
CHECKED: P.B. O.L.R. APPROVED:

24122 | DENVER, COLO., DEC. 1, 1930 | 45-D-922

HIGHWAY AND RAILROAD

A highway will connect with the end of the 7-mile construction highway from Boulder City to the dam site, and descend to the crest of the dam on the Nevada side of the river. After crossing over the canyon to the Arizona side on the roadway along the crest of the dam, the highway grade will rise to a terminus above the canyon rim, where it can connect with a contemplated State highway from Kingman. There will be constructed by the contractor about 4,000 feet of highway on the Nevada side and 1,400 feet on the Arizona side.

The construction railroad from Bracken Junction on the Los Angeles & Salt Lake Railroad of the Union Pacific system to the dam site will be completed about September 1, 1931. The United States section of 10¼ miles from the summit, near Boulder City, to the dam site will be turned over to the contractor for the dam, power plant, and appurtenant works, to be operated and maintained by him during the construction period.

ACCEPTANCE OF COFFERDAMS BY GOVERNMENT

After the upstream cofferdam, rock blanket in the river channel, the downstream cofferdam and rock barrier and adjacent rock protection have been completed, in accordance with the specifications, they will be accepted by the Government, provided that the four diversion tunnels have been completed and the river satisfactorily diverted through them. After this acceptance the Government will assume liability for any damage to the accepted works, due to flood or other causes not the fault of the contractor, and for damage resulting thereby to other features of required construction.

EARLY DEVELOPMENT OF POWER

It is expected that four units of the power plant will be placed in operation about 1 year and 8 months prior to the completion of the dam, and two additional units about 1 year later, all of these units to be operated by the downstream in-take towers. In this connection the Government reserves the right to commence the generation of power at any time after water has been stored to elevation 900.

WALLS ALONG CANYON RIM

It will be necessary to construct rubble masonry walls along the canyon rim above the power plant and in-take towers and below the highway on both sides of the canyon, for protection of the permanent works from injury by falling rocks.

GROUT AND DRAINAGE SYSTEM

The contractor will be required to drill 258,000 linear feet of grout holes in tunnels, adits, shafts, and foundations for dam and spillway crests; also 34,000 linear feet of drainage holes in the foundation for the dam. There will be 422,000 cubic feet of pressure grouting required, of which 376,000 cubic feet will be placed in tunnels, adits, and shafts. Grout holes in the foundations will be drilled to varying depths up to a maximum of 150 feet. In the upstream cut-off trench of the dam the grout holes will be drilled at about 5-foot intervals.

CONTRACTION JOINTS IN DAM

Contraction joints in the concrete of the dam will be provided for convenience in construction and to take care of expansion and contraction of the concrete in horizontal directions. These contraction joints will divide the dam into sections. Horizontal keys are to be built into the circumferential joints and vertical keys into the other contraction joints.

CONCRETE

With about 4,400,000 cubic yards of concrete to be placed in the dam, power plant, and appurtenant structures, strict precautions will govern in the mixing and placing of concrete. In general, the proportions shall be such as to produce concrete having an ultimate compressive strength at the age of 28 days, varying from not less than 2,500 pounds per square inch for the mass concrete of the dam, to not less than 3,500 pounds per square inch for slabs, beams, and other thin reinforced members. The accuracy of the weighing equipment shall conform to the requirements of the United States Bureau of Standards. Placing of concrete in the dam must, in general, be done by means of bottom-dump buckets or other methods whereby each complete mixer batch or combination of mixer batches is conveyed in one mass to its location in the dam. The rate of placing concrete in any panel or column of the dam shall be such that not more than 5 feet in depth shall be placed in 72 hours, and not more than 35 feet in depth in 30 days. Methods of conveying concrete to any of the structures, by which the mixed batch or combination of batches is progressively loaded into chutes, belts, or conveyors, or other similar equipment and carried in a thin continuous flow to the forms, will not be permitted, except by permission of the contracting officer, for very limited, isolated sections of the work. The continuous flow methods of conveyance are excluded under the specifications.

COOLING CONCRETE IN DAM

After any portion of the concrete in the dam and tunnel plugs has set for a minimum period of six days it shall be cooled by removing the excess heat above 72° F. The temperature is to be reduced by running cooled water through pipes placed in the concrete. The contractor shall furnish, install, and operate a complete refrigeration plant for removing the excess heat. This plant is to be a 3-unit plant, interconnected so that the units may be used in combination as well as separately, and the plant must have a capacity sufficient to reduce the temperature of a flow of 2,100 gallons of water per minute from 40° to 47°. The average temperature rise due to setting of concrete is approximately 40° F. above placing temperature; and the amount of heat to be removed is approximately 700 B. t. u. per degree per cubic yard of concrete. In the month of July with a mean monthly temperature of 93.8° and the maximum temperature of the concrete 133.8°, it is estimated that cooling water must be applied for 2.4 months to reduce the temperature of the concrete to 71.7°, the average of the mean monthly temperature for the year. It is contemplated that 2-inch standard pipe and fittings, or boiler tubing, will be used and that there will be required the installation of about 800,000 linear feet or 150 miles of pipe, in lines 10 feet apart, and involving the use of 16,000 couplings.

STEEL REQUIREMENTS

The contractor will be required to install 6,435,000 pounds of plate-steel conduit linings for the outlet works and 13,915,000 pounds for the power penstocks. A portion of the metal conduit linings in the upper and lower canyon-wall outlet works, and in the tunnel-plug outlets will be plate-steel pipes embedded in concrete. These linings will have an inside diameter of 7 feet 7 inches, with the plate thickness varying from 1¼ inches to ¾ inch, with welded longitudinal seams and bolted flanged joints.

Power penstocks connecting the turbines with the 30-foot diameter penstock tunnels and the inner 50-foot diameter diversion tunnels will be lined with plate steel varying in thickness from 1½ to 2 inches, and embedded solidly in concrete. The inside diameter of these power penstocks will be 11 feet with the lining varying from ¾ inch to 2 inches. There will also be 9,570,000 pounds of conduit lining castings installed.

In the dam, power plant, and appurtenant works will be placed 35,000,000 pounds of reinforcement bars and rails. There will be required the installation of 6,600,000 pounds of standard steel and cast-iron pipe, fittings and valves. Another item in the schedule calls for installing 17,875,000 pounds of structural steel. The contractor will furnish and erect 3,170,000 pounds of steel ribs, liner plates, and arch ring segmental bars in tunnels, adits, and shafts.

(Continued on p. 38)

Aqueduct 265 Miles Long to Cost $200,000,000

THE Parker route for the proposed 265-mile aqueduct, which will carry water from the Colorado River to the cities and towns of southern California, was approved on December 19, 1930, by the board of review comprising Andrew J. Wiley, Richard E. Lyman, and Thaddeus Merriman. This aqueduct is planned to provide an adequate future domestic supply for Los Angeles and vicinity, and the estimate of cost is $200,000,000. A recommendation in favor of this route had previously been made to the board by Frank E. Weymouth, chief engineer of the Metropolitan Water District of Southern California, formed to build and operate the aqueduct. To provide funds for this construction, it will now be necessary for the district to vote bonds, and it is reported that a proposition to authorize their issuance will be submitted to the voters within the next few months.

Diversion from the Colorado River is planned at a point a few miles above Parker, Ariz., about 150 miles below the Hoover Dam, and a pump lift of 1,523 feet will be required. The route of the aqueduct is via Rice to Hayfield Reservoir; then to Shavers Summit, Whitewater, Portero, Moreno, Perris, and the Puddingstone Reservoir near Pomona. The annual maximum cost of maintaining and operating the aqueduct and delivering 1,500 cubic feet of water per second is estimated by the board at $6,106,000 per annum; but this annual cost does not include either interest on the original investment or annual payments on amortization of bonds. The total carrying charges, including interest, will be $15,606,000, but this maximum will not be reached until about the twentieth year after beginning of construction.

ADVANTAGES OF PARKER ROUTE

Among the reasons given by the board of review for selecting the Parker route in preference to the Bridge Canyon, Black Canyon, Bull's Head, Picacho or All-American routes, are the following: From the viewpoint of geology, it passes through the best terrain; no unusually large tunnels are involved, construction hazards are the smallest, and safety against earthquake damage is the greatest. The route is less expensive in first cost than all others, and comparative estimates show a smaller operating cost because of a lower pump lift. The quantity of power required for pumping, over and above that produced by drops in the aqueduct line itself, is less than on either the Picacho or All-American route. At the Hayfield Reservoir site intermediate storage is available, an advantage not found on any of the other routes. The Parker route for its entire length is in the State of California, thus avoiding the question of taxes or assessments in any other State.

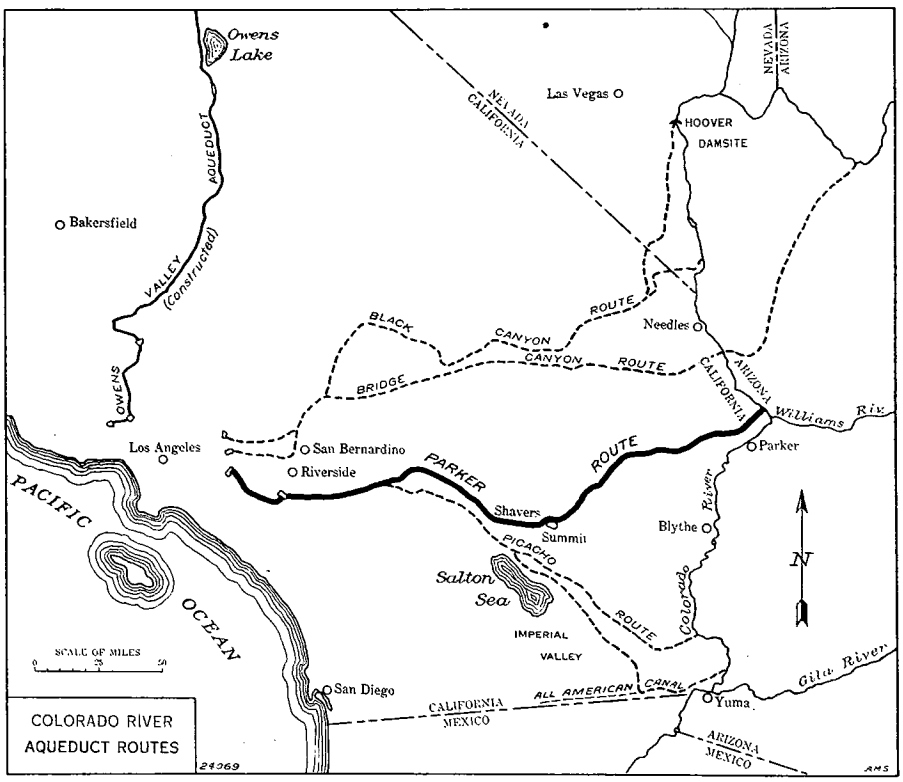
BUILDING OF PARKER DAM TO BE DEFERRED

The board is of the opinion that it is desirable to defer construction of the Parker Dam on the Colorado River for several years after the completion of the Hoover Reservoir. This reservoir will remove silt from the river, and the clear water below will then pick up and remove silt now present in the bed and along the banks, and change and modify the regimen of the stream. Until this readjustment has taken place, the consulting engineers believe that it is best to defer building the Parker Dam. A combined diversion and power dam may later be constructed and it is estimated that enough power can be produced at the site to pay the cost of the dam. Prior to construction of the dam, diversion may be made by pumping directly from the stream, with clarification of the water by basins and mechanical apparatus.

The average diversion from the river will be 1,500 second-feet, and about 10 per cent will be lost by seepage and evaporation. Four pumping plants will be required, with a total lift of 1,523 feet. Electric power required for pumping amounts to 291,040 kilowatts, or about 390,000 horsepower. At the point of diversion 29,100 kilowatts can be produced, and with a power drop beyond the divide at Colton of 406 feet, an additional 38,430 kilowatts will be available. The remainder of the power required will be purchased from the power plant at Hoover Dam. There will be 74.1 miles of open canal (lined or unlined), 80.3 miles of closed surface conduit, 92.6 miles of tunnels, and 18.4 miles of pipe lines. The longest tunnel will be 13 miles, with a 9.7-mile tunnel the next in length.

An initial pump lift of 539 feet is proposed at the river and the aqueduct then enters the 13-mile tunnel through the Whipple Mountains. Near Shavers Summit three pumping plants are required to lift the water to the summit elevation of 1,817 feet. At the base of the last pumping plant is a natural reservoir site (Hayfield) of large capacity. The line west of Shavers Summit is to be principally in tunnel along the face of the San Bernardino Mountains. Crossing the upper end of the Coachella Valley the line will be in open conduit and the San Jacinto Mountains are to be tunneled.

According to the report of the board, six routes for the aqueduct were surveyed and carefully studied, all but one requiring pumping the water over the intervening mountains with total lift ranging from 1,523 feet on the Parker route to 2,051 feet on the Bull's Head route. In length the five pumping routes vary from 234 to 299 miles, while the gravity route from



Bridge Canyon is 315 miles long. The All-American Canal route would have been the cheapest, but would involve joint use of the canal which is planned for irrigation of the Imperial and Coachella Valleys, and the board of review did not believe this to be either desirable or practicable. The Bridge Canyon gravity line would cost $468,000,000 and require two very long tunnels, one 89 miles and the other 75 miles. With a gravity aqueduct it is estimated that the cost per acre-foot of water delivered at terminal reservoirs over a 40-year period would be $51.23, as compared with $26.56 for the adopted Parker route.

The Metropolitan Water District is composed at the present time of 12 cities and towns—Anaheim, Beverly Hills, Burbank, Colton, Glendale, Los Angeles, Ontario, Pasadena, San Bernardino, San Marino, Santa Ana, and Santa Monica. These have a combined population of about 1,500,000. A number of other cities and towns have indicated an interest in the plan to obtain a supplemental water supply from the Colorado River, but have not yet made final decision through special elections. A contract has already been made with the United States which provides for the delivery to the district each year from the Boulder Canyon Reservoir, up to and not to exceed 1,050,000 acre-feet of water, which corresponds to an average flow throughout the year of 1,500 cubic feet per second. The district will be charged 25 cents per acre-foot for Boulder Canyon Reservoir water during the project 50-year repayment period. This will mean an annual payment to the Government of about $250,000.

Specifications and Plans Hoover Dam

(Continued from p. 36)

GATES AND OTHER MACHINERY

Four structural steel Stoney gates with their hoists, counterweights, structural steel guides, and other appurtenances, weighing 2,600,000 pounds, will be required. One of these gates will be installed in the upstream end of each spillway structure, and the other two gates at the downstream end of the inner diversion tunnels. Each gate will be 50 feet in height by 54 feet 7½ inches in width, made up of structural-steel plate girders approximately 72 inches in depth, and mounted on caterpillar roller trains, running on heavy structural H-beams attached to the concrete structure.

The hydraulically operated high-pressure gates, 56 in number and weighing 10,340,000 pounds, include emergency gates in the upper and lower canyon-wall outlet works and the slide gates in the upper concrete plugs in the inner diversion tunnels. In each of the 30-foot diameter intake towers a 31-foot diameter by 10-foot cylinder gate will be installed, each gate with hoist weighing about 570 tons. Twelve 8-foot by 10-foot metal shutter gates will be provided for each tower, to be used for closing the water passages for repairs to the cylinder gates. Forty 72-inch needle valves weighing 4,070,000 pounds will be installed, 32 of which are to be in the 4 canyon-wall buildings. Fourteen traveling cranes will be furnished by the Government for use in installing and maintaining gates, hoists, and valves. The 4 cranes in the intake towers will be 15-ton capacity; 36-foot span; in the canyon-wall outlets there will be 4 cranes of 30-ton capacity and 36.5-foot span.

Contractors Request Hoover Dam Specifications

The following contracting firms (not necessarily prospective bidders) have requested plans and specifications for the Hoover Dam from the Washington office: The Arundel Corporation, Baltimore, Md.; Mason-Hanger Co., New York City; Underpinning & Foundation Co. (Inc.), New York City; R. S. Morrow & Son, Omaha, Nebr.; Joseph Miele Construction Co., Maplewood, N. J.; Ward Engineering Co., San Francisco, Calif.; A. Phelps & Sons, Detroit, Mich.; Spencer, White & Prentis (Inc.), New York City; Booth & Flinn Co., Pittsburgh, Pa.; Parker & Graham (Inc.), Slatington, Pa.; The Carleton Co. (Inc.), New York City; Harrison-Wright Co., Charlotte, N. C.; The American Foundation (Inc.), Cincinnati, Ohio; Robert E. McKee, El Paso, Tex.; States Corporation, Chicago, Ill.; Paul J. Moranti (Inc.), New York City; Allied Engineers (Inc.), New York City; W. S. Lee Engineering Corporation, Charlotte, N. C.; Mark R. Hanna Co., Detroit, Mich.; Gauger-Korsmo Construction Co., Memphis, Tenn.; A. Guthrie & Co. (Inc.), Chicago, Ill.; The Hunkin-Conkey Construction Co., Cleveland, Ohio; White & Dart, New York City; M. P. Smith Construction Co., Chattanooga, Tenn.

New Map Available

A new map of the Boise irrigation project, Idaho, has just been received from the lithographer. Four printings have been used to show topography, reservoirs, principal canals, and irrigable areas of the Boise and adjacent projects.

The map is numbered 23900, the scale is 8 miles to an inch, the size is 10½ by 13½ inches, and the price is 10 cents per copy.

Colorado River Commissions and Boards

Colorado River Compact Commission.—The members of the original Colorado River Compact Commission who signed the Colorado River compact Nov. 24, 1922, which was approved for the United States by Hon. Herbert Hoover, then Secretary of Commerce were: W. S. Norvel, of Arizona; W. F. McClure, of California; Delph E. Carpenter, of Colorado; J. G. Scrugham, of Nevada; Stephen B. Davis, jr., of New Mexico; R. E. Caldwell, of Utah; Frank C. Emerson, of Wyoming; and Herbert Hoover, chairman.

The Colorado River compact provides that the chief official of each State charged with the administration of water rights, together with the commissioner of Bureau of Reclamation, and Director of Geological Survey shall cooperate along certain lines. The organization contemplated by the compact has not yet assembled.

Upper basin compact commission.—The upper basin States have organized a compact commission consisting of the following: Delph E. Carpenter, Colorado River commissioner, Colorado; Francis C. Wilson, Colorado River commissioner, New Mexico; W. W. Ray, attorney, member Colorado River Commission, Utah; and John A. Whiting, State engineer, Wyoming.

Colorado River Board.—Under Public Resolution No. 65, dated May 29, 1928, Seventieth Congress, the Secretary of the Interior, on July 6, 1928, appointed a board of engineers and geologists to consider plans and specifications for the Boulder Canyon project comprising Maj. Gen. William L. Sibert, Mobile, Ala., chairman; Prof. Charles P. Berkey, Columbia University, New York; Prof. Daniel W. Mead, University of Wisconsin; Robert Ridgway, 49 Lafayette Street, New York; and Prof. Warren J. Mead, University of Wisconsin, Madison, Wis.

This board has made three reports as follows:

(1) November 24, 1928, House Document 446, Seventieth Congress, Second session, 15 pages. (Summary in Reclamation Era. January 1929, pp. 2–3.)

(2) April 16, 1930, raising height of dam 25 feet, and other matters. (Summary in Reclamation Era, June, 1930, p. 113.)

(3) December 6, 1930, approval given to the designs for diversion works and other features which must be completed during the early stages of construction.

(Continued on p. 41)

Secretary Orders Separate Contract For American Canal

EL CENTRO, Oct. 28 (Special) —Secretary of the Interior Ray Lyman Wilbur has ordered a separate contract between the government and Imperial valley irrigation district for the construction of the All-American canal, removing the conditions requiring the inclusion of Coachella lands.

Provision is to be made for Coachella to join Imperial district within a reasonable but limited period, according to a telegram received at district headquarters here yesterday.

This brings to a successful conclusion seveal months of insistence on the part of the district that Coachella has had sufficient time to bring about inclusion and that development should not be delayed further.

Charles L. Childers, chief counsel, and M. J. Dowd, chief engineer, will leave for Los Angeles tomorrow for a conference with Richard J. Coffey, district counsel of the bureau of reclamation, as to the necessary amendments for a separate contract between the district and the government. Discussion of various ways for proceeding with the contract also will take place at the conferences.

Wilbur explained in his telegram to the district that "it is manifest those who have insisted upon scrapping the plan approved by the department for a single contract between the beneficiaries of the All-American canal and United States have not solved the problem which I have repeatedly stated is the first prerequisite for any separate contract. That is, the securing of an adequate water right by negotiating with Imperial Irrigation district. It is further appaent that no such agreement can be obtained."

District officials said today that every energy would be directed toward an immediate completion of the necessary amendments to the contract which was accepted by voters at a special election February 11.

ENDS LONG WAIT

The order from Wilbur brings to an end months of waiting for Coachella Valley to iron out internal differences. Opposition to the contract in the meantime has instituted recall proceedings to all members of the board of the Coachella Water Users association who favor inclusion in Imperial district under the All-American canal. The recall election will take place Oct. 28.

It was explained that Coachella may present her petitions for inclusion since the secretary of interior has definitely said there is no hope for them to obtain a separate contract with the government. In that case, proceedings would have to go forward on the original set up outlined in the All-American canal contract as it is at present.

At this time it is not known whether, in the event a separate contract is the course of action taken, the entire amended contract will be presented the voters of the district or just the amendments.

The telegram from Wilbur was read at a mass meeting held last night in Coachella Valley when a discussion of inclusion was the main topic of the evening.

W. P. Britton, secretary-manager of the Coachella Water Users association, received concussion of the brain in an automobile accident last night as he was taking residents to the meeting. He is well known in Imperial valley as he at one time was secretary of Water company No. 3.

Yuma Pecans Exhibit At State Fair Attracts Crowd

By CLYDE EARL ELY

Yuma county pecans today at the Arizona State fair took six out of eight first places, besides some second money, sweepstakes and most complete exhibit.

Another first place on Ray Farmers Schleys was lost because the judges couldn't decide which was the best and made an adverse award abitrarily. Apparently Yuma was getting too much.

"Knock 'em Dead" Heineman was the nut hero. Most of the first places went to his entries The score was:

Millican, 1st,	A. R. Heineman
Binkett, 1st,	A. R. Heineman
Kincaid, 1st,	A. R Heineman
Kincaid, 2nd,	F. W. Creswell
Hubert, 2nd,	F. W. Creswell
Western Schley, 1st,	Heineman
Western Schley, 2nd,	Creswell
Success, 1st,	Heineman
Success, 2nd	Creswell
Souverign, 1st,	Creswell
Soverign, 2nd	Heineman

Sweepstakes, Heineman with Success.

Best and most complete exhibit by one exhibitor, Heineman.

Ray Farmer took a third place in Schley.

Yuma's mass display of pecans laid out so artistically by Bill Linder is the main attraction of the Agricultural building.

Weather

For 24 hours endiny 3 p. m. toady
Data furnished by U. S. Weather Bureau

Highest temperature	86
Lowest temperature	51
Average highest this date	84
Average lowest this date	54
Deficiency for day	1
Deficiency for month	12
Excess since Jan 1	70
Rainfall last 24 hours	0
Rainfall for month	3.39
Rainfall since Jan 1	5.83
Excess for month	3.15
Excess since Jan 1	3.20
Sunshine, percent of possible	100

RELATIVE HUMIDITY

6 p. m.	32
6 a. m.	66
Noon	25

Three Planes Crash In Fog Off San Diego

Sudden Fog Catches 22 Planes in Navy Day Feat Over Bay

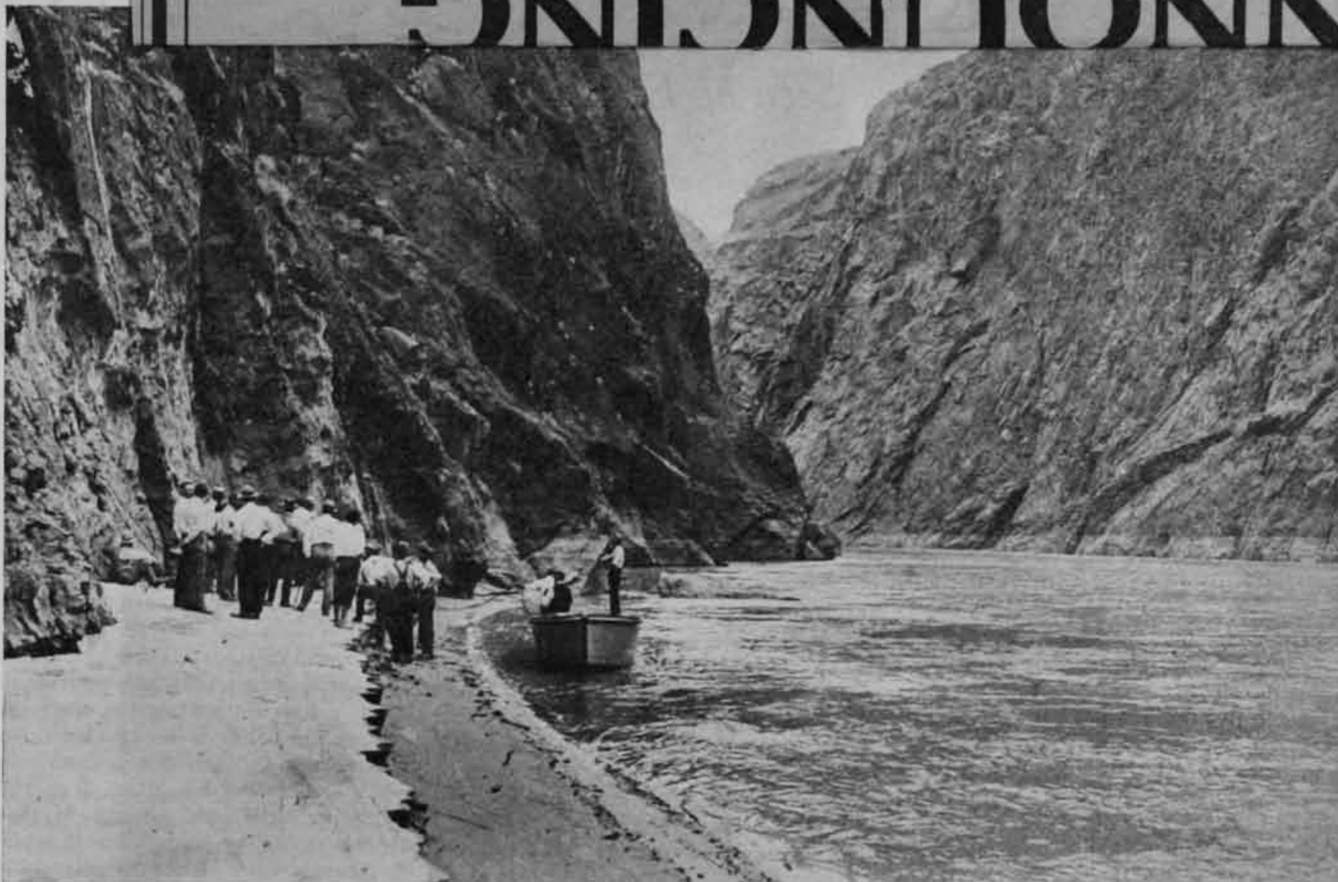
By Associated Press

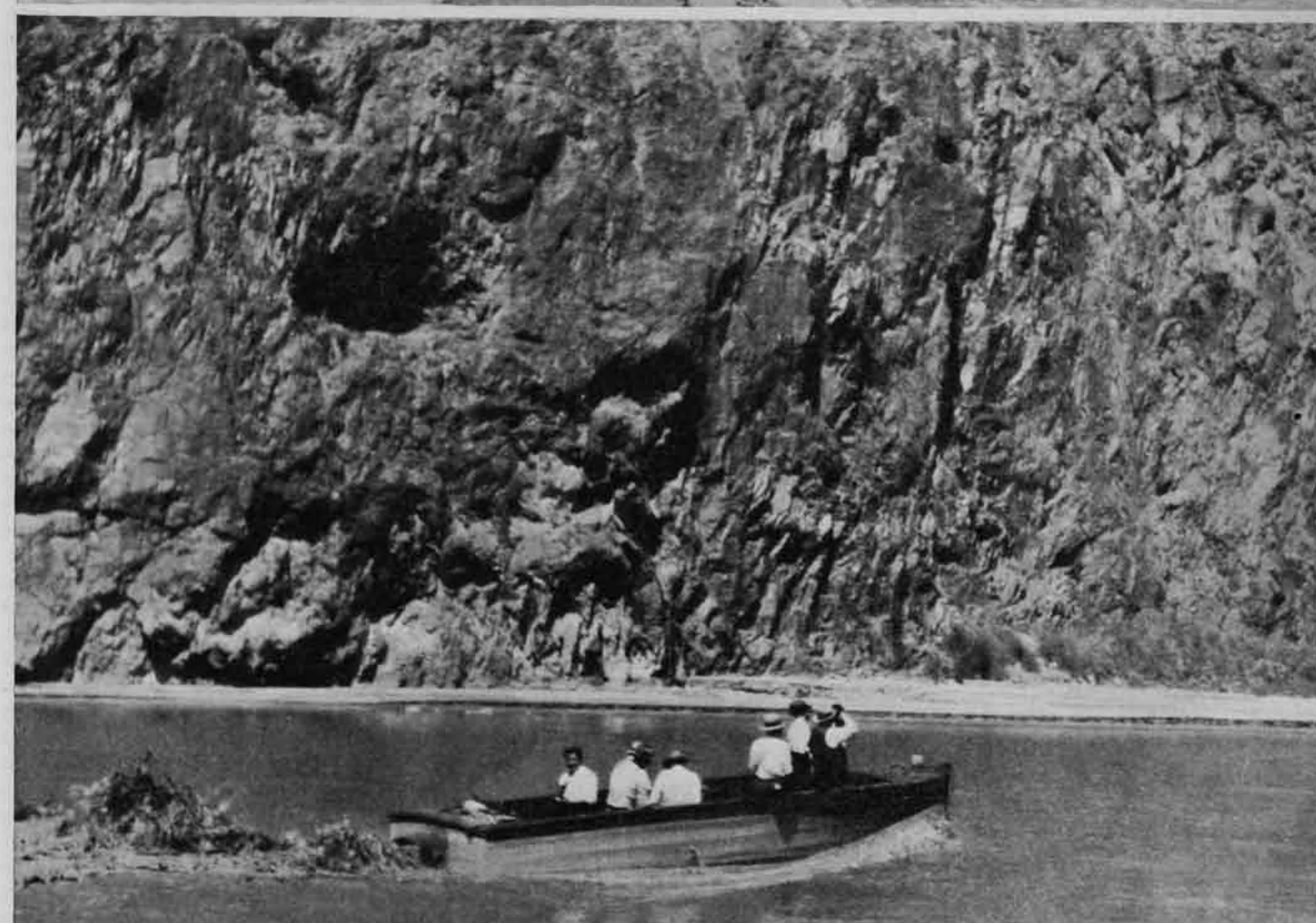
SAN DIEGO, Oct. 28— Three navy planes crashed here last night as 14 taking part in Navy Day celebration were trapped in a sudden fog. There were 22 planes in the air as the fog swept in.

Eight of the planes raced for landing fields and made it. Nine others dived through the fog and landed safely, but three crashed. The only injury to pilots was a sprained finger for one.

The W. C. T. U. will meet at 2:30 Tuesday afternoon at the home of Mrs. W. W. Sturgess on 10th street.

The delegates who attended the convention at Phoenix this week are expected home and will make a report at this meeting.





GOVERNMENT OFFICIALS AND ENGINEERS INSPECTING BLACK CANYON ON THE COLORADO RIVER, THE SITE OF HOOVER DAM

Hoover Dam as Seen by Engineering News-Record

HERETOFORE the Boulder Canyon Dam, or Hoover Dam, to use the name given it by prenatal christening, has been thought of as excelling chiefly in size. Even the description given in our pages last February seemed to convey little more. Now the bidding plans and specifications reveal it as the most advanced, the boldest and most thoroughly studied hydraulic enterprise in engineering history.

That it proved possible through special effort to put the call for bids ahead six months, and thereby help to bring earlier relief to our lagging productive activities, entitles the engineers and officials of the Reclamation Bureau to thanks and congratulations. But they deserve even greater commendation for the quality of their work. The plans and specifications are of rare perfection. Not only are the arrangement and details of the structure worked out with high originality and painstaking care but the specification of desired results approaches measurably near to that ideal at which the engineer's arbitrary judgment is eliminated. Such preparation goes far toward assuring successful and satisfactory construction.

Hoover Dam is to be nearly twice as high as any dam yet built. But this single fact gives only a fragmentary view of the dimensions of the tasks involved. With 5,000,000 cubic yards of concrete, 30,000 tons of structural steel, and over 70 miles of grouting holes, with rock tunnels ranging from 50 to 70 feet in diameter and 2,000 tons of needle valves, the structure that is to be set in the path of the turbulent Colorado in a sheer-walled narrow gorge at the bottom of an inaccessible desert canyon, in the remotest region of the United States, constitutes a work ranking with the greatest ever attempted by human hands. Size and remoteness aside, however, the project gave rise to broader and more fundamental study of the strength and action of dams than engineering science until now has known. It will doubtless become a new datum point in the record of dam and hydraulic construction.

Two years ago a review board of engineers and geologists answered various doubts about the safety of the projected dam by indorsing the general scheme, with a conservative recommendation as to foundation loads—30 in place of 40 tons per square foot. The same board was then charged with the responsibility of approving the final design before construction. It has done so, and only details remain to be considered—certain construction features of the dam and the discharge works. As now presented to bidders the project is substantially final, and no engineering problems stand in the way of early beginning of work or its successful prosecution through the seven years of construction.

CONTRACTUAL PROBLEMS OVERCOME

Very recently it had been feared that difficulities would arise in the contractual relations between the bidder and the Government because of the size of the work, the risk of loss by floods and the possibility of unforeseeable changes in labor and material costs during the long time involved. Some people believed that the contractor would need to be protected by a special contract to relieve him of undue risk, while others asked that local labor be given a preference, that a prevailing-wage requirement be included, and the like. In short, the contractual relation appeared to be a serious problem. It is highly fortunate, we believe, that a simple and normal contract is now proposed to bidders. Only three unusual clauses appear: (1) The bid bond and the construction surety are set at fixed and moderate amounts ($2,000,000 and $5,000,000 respectively); (2) the Government, after once accepting the cofferdams built to its design, assumes the risk of flood damage to all property except contractor's plant; (3) qualified veterans and citizens have a preference right to employment. These provisions give such protection as is needed and are not likely to cause delay or to limit the contractor's freedom in his effort to get efficient and economical results. It may be noted also that the Government will supply all main materials, except concrete aggregates, but this is not without precedent and should not bear on satisfactory construction relations.

INTENSIVE STUDY OF DAM

Of the structures of the project, the great dam itself commands interest far overshadowing that of the accessories. It was early recognized as presenting a critical problem in respect to determining the stress action, especially because the arched form (suited to the gorge location and the hard rock walls) made it inevitable that much load would be borne laterally by arch action. Intensive study was therefore given to mathematical analysis of the structure in order to determine the precise nature of the interaction between the horizontal arch elements and the vertical beam elements of the dam. As a result, a high degree of certainty has been attained in determining how the dam will resist water pressure. Model tests are to be made in confirmation, but perhaps after all a model 3 or 4 feet high will not be able to bring out as much truth as does the mathematical study. The dead-load stresses and those stresses which exist in the unloaded mass are of course unknown; the construction methods are planned to set limits to these stresses as far as possible.

A more critical question was that of building the dam so as to obtain an integral mass and avoid cracking, which, outside of foundation uncertainties, is the most serious defect in modern concrete dam construction. Both shrinkage (due to moisture change) and thermal action (due to heating of the concrete while it is setting and to subsequent cooling and contraction) are factors here. Shrinkage is dealt with in Hoover Dam by building the structure in blocks or vertical columnar prisms 50 feet square, the joints between which are to be grouted under pressure later on, thereby creating a solid arch. The heating difficulty is dealt with by placing within the concrete a close network of cooling pipes, through which refrigerated water is to be circulated during the setting of the concrete to keep it cool and draw out the heat generated by the chemical action of set. The ideas embodied in these two expedients are closely in harmony with those entertained by leading workers in the field of dams for some time past, but they have never been translated so definitely into practical form. Block construction has been adopted in many dams ever since Schussler's Crystal Springs dam of 40 or more years ago; but as now used, with bitumen-painted sides fully keyed, and subsequent grouting, it is unmistakably a new departure. Far more radical an innovation, however, is the cooling-pipe system, an expedient which perhaps is due in part to the hot summer climate at the site. Its virtues are untried, but on the other hand it can not harm the dam. It is preeminently the most original feature of the dam.

Dry mixtures are to be used in all the concrete work, to obtain high strength and density, and accordingly bucket placing is specified. But it is timely to remark here that many questions relating to the concrete work are still to be considered in detail. A special committee of concrete experts outside the Reclamation Bureau has been appointed for this purpose; its sessions early in January are expected to place the questions of cement and concrete on a final basis. They will contribute to making Hoover Dam a significant milestone in the progress of dam science and construction.

In view of these remarkable studies and design developments, the exceptional site, the deep foundation work, and the thorough grouting of the foundation rock that is proposed, the magnitude and complexity of the associated structures, it is in no way extravagant to conclude that that Boulder Canyon project has been given an engineering stature fully proportionate to its position as a surpassing contribution to the development of the Southwest, and indeed its security. Full appraisal of the service that the control of the Colorado will render to that region must be left to the future, but at the most moderate estimate the service constitutes a challenge to the engineering profession that it support the project with the highest performance within its power. The engineers responsible for the project have done their part.

Colorado River Commissions and Boards

(Continued from p. 38)

Hoover Dam consulting board.—The following board of engineers and geologists has been appointed by Commissioner Elwood Mead as a consulting board on Hoover Dam: Prof. W. F. Durand, Leland Stanford University, Calif.; D. C. Henny, Portland, Oreg.; L. C. Hill, Los Angeles, Calif.; F. L. Ransome, Riverside, Calif.; and A. J. Wiley, Boise, Idaho.

Board of consultant specialists on concrete.—The following have been appointed by the Bureau of Reclamation to consider problems regarding cement and concrete for the Hoover Dam: F. R. McMillan, director of research, Portland Cement Association, Chicago, Ill.; Prof. William K. Hatt, school of civil engineering, Purdue University, Lafayette, Ind.; Prof. Raymond E. Davis, department of civil engineering, University of California; Prof. H. J. Gilkey, University of Colorado, Boulder, Colo.; Dr. P. H. Bates, chief, cement division, Bureau of Standards, Washington, D. C.

Colorado River Planning Commission.—A planning commission (the membership is not quite yet complete) includes the following: Porter J. Preston, for the United States; M. C. Hinderlider, for Colorado; H. W. Yeo, for New Mexico; W. D. Beers and George M. Bacon, for Utah; and John A. Whiting, for Wyoming. Representatives for the other States are to be requested on the commencement of the investigations in those States.

STATE COMMISSIONS

Arizona.—Colorado River Commission includes Governor George W. Hunt, ex officio; Charles B. Ward, chairman; John M. Ross, secretary.

California.—Colorado River Commission includes John M. Bacon, chairman, W. B. Matthews, Earl C. Pound, and F. H. McIver, secretary.

Colorado.—Colorado River Commission, Delph E. Carpenter, commissioner, and the Colorado River Planning Commission; M. C. Hinderlider, State engineer.

Nevada. — Colorado River Development Commission: Governor F. B. Balzar, chairman; George W. Malone, State engineer; and Ed. W. Clark.

New Mexico.—Interstate Water Commissioner Francis C. Wilson; Colorado River Planning Commission, H. W. Yeo, State Engineer.

Utah.—Colorado River Planning Commission, W. R. Wallace, chairman, W. W. Ray and W. D. Beers, Colorado River Planning Commission; W. D. Beers and George M. Bacon, State engineer; Utah Water Storage Commission, William R. Wallace, chairman, George M. Bacon, secretary, Richard R. Lyman, A. F. Doremus, A. P. Bigelow, W. W. Armstrong, William Paterson, J. R. Murdock, John G. M. Barnes, W. O. Creer, Wilford Van Wagenen, S. M. Nielson, and B. O. Colton.

Wyoming.—State Engineer John A. Whiting is representative on all State organizations having to do with interstate stream problems.

Model Town Planned at Boulder City

(Continued from p. 30)

to be made of the planting of trees along the streets as well as in the parks. Along residential streets tree planting will be in groups, thus admitting sunlight and giving shade alternately. In the business blocks at setbacks in the buildings individual trees can be placed.—*P. I. Taylor, Engineer, Bureau of Reclamation.*

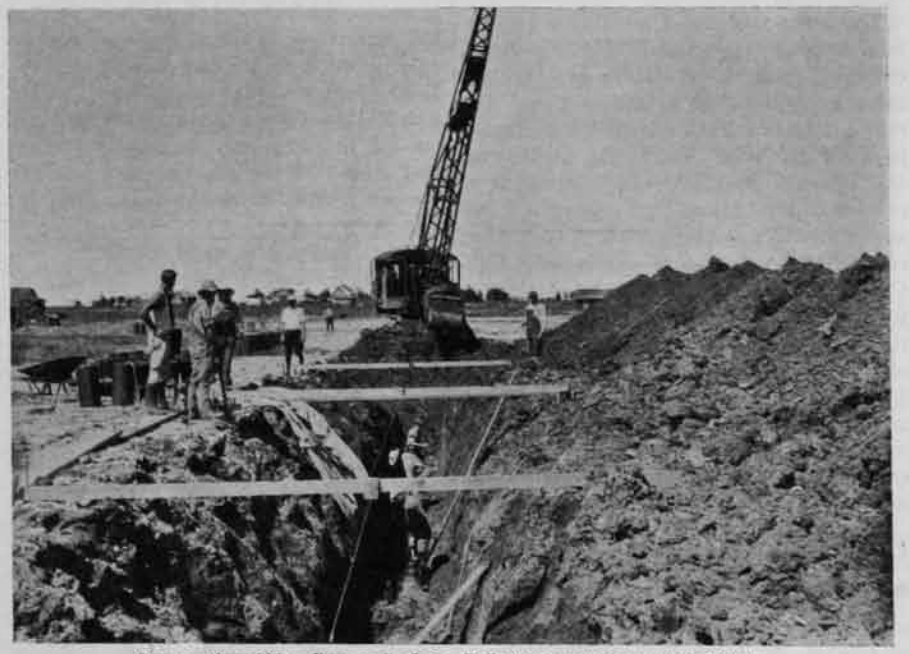
Representative Arentz's Name Omitted

The January issue of the NEW RECLAMATION ERA carried on page 10 an excerpt from the speech of Hon. Ray Lyman Wilbur, Secretary of the Interior, at the celebration in connection with the commencement of construction of the Boulder Canyon project, as quoted from a recent press release by the Department of the Interior.

In the original speech Secretary Wilbur gave credit to Hon. Samuel S. Arentz, Member of Congress from Nevada, for participation in the enactment of the Boulder Canyon Project legislation, along with Senators Johnson, Pittman, and Oddie, and Representative Swing, but through an inadvertence Representative Arentz's name was omitted in the news release. The ERA regrets this omission and hastens to make the correction.

In the Imperial Valley of Southern California the silt content of the irrigation water from the Colorado River was 3.55 per cent by volume in the year 1929, as compared with 1.94 per cent in 1928.

The Owyhee Dam on the Owyhee project, Oregon, is 51 per cent completed, and the General Construction Co. is very little behind schedule with the work. Concrete operations slowed down in December, and suspension of this feature was looked for in January. Cold weather necessitated keeping up fires and protecting fresh concrete with canvas as soon as poured. Aggregates and water were heated at the mixer, so that no concrete reached the forms at a temperature lower than 50° F. At this temperature the concrete was protected for 72 hours.



Construction of Newell town-site drain, Belle Fourche project, South Dakota

Boulder Canyon Project and Its Effect on Future Development

Address by Miss Mae A. Schnurr, assistant to the Commissioner, Bureau of Reclamation, at the annual meeting, land reclamation division American Society of Agricultural Engineers, San Francisco, Calif., January 6 and 7, 1931

THE Boulder Canyon project has been in the public eye for many years, and magazines, newspapers, and lecturers have featured this project until it might be thought there would be no phase of its development which had not been covered, but when one tackles the subject of this project's effect on future development it offers an opportunity to discuss evident benefits and stirs the imagination as to probable ones.

The interest of the United States in the Boulder Canyon project is now largely centered upon it as a colossal feat in engineering. This dam will be nearly twice as high as any hitherto attempted, the lake fourteen times the size of the lake at Assuan in Egypt and ten times the size of any existing artificial reservoir for irrigation purposes in the United States. It is a wonderful engineering undertaking to place this huge wedge of concrete in a canyon nearly 2,000 feet deep and where man will have to work under a summer temperature of over 100°.

AFFECTS WATER LAW

The greatest significance is to be found, however, in the social and economic changes which the building of a single structure is destined to bring about. Already it has wrought a significant change in our water laws. California, wedded to the riparian doctrine, will experience a revolutionary change by building a huge aqueduct 265 miles long to carry the Colorado River into another watershed. The Colorado River compact, which dedicates to particular States a perpetual share in this water supply, modified both the riparian doctrine and that of appropriations which have heretofore controlled. But the great change is in the increase in wealth and the improvement in living conditions over a wide area of the Southwest.

REMOVES MENACE TO IMPERIAL VALLEY

The original reason for enlisting the aid of the Federal Government was the plight of the people living in Imperial Valley. Before the water of the Colorado was brought into this basin, it was a hideous desert, but supplied with water it became a center of production that has been benefiting the whole Nation. The thousands of carloads of lettuce which every spring go out of the Imperial Valley to every large eastern city, have changed the diet on their tables, and the thousands of carloads of Imperial Valley cantaloupes have made this a better world to live in from one ocean to the other. But the people who have wrought this transformation have had to do it under a continuous menace, because where the river crosses the boundary into Mexico, it is 100 feet above where their irrigation canal crosses the international boundary, and the lower part of the valley is 300 feet below the river. It is kept out of the valley by a levee 70 miles long and that levee is menaced by every flood. The only way to remove that menace, and give permanence to the lives and fortunes of the 100,000 people in Imperial Valley is by means of a reservoir large enough to hold all the water in times of emergency, and large enough to regulate its flow so that the disastrous floods of the past will be only a memory. That is why Hoover Dam was first thought of. That is why it was designed to have a reservoir large enough to completely regulate the river, and why the one planned will hold all the water that comes down the river for two years.

When this matter was brought to Congress 10 years ago it was seen that without some modification of existing water laws, it would be a menace to the development of the upper section of the stream. It took years to inspire Congress with courage enough to sanction a dam that broke all precedents, and in that time the Southwest was growing as no one had ever dreamed it would grow. Los Angeles, San Diego, and other California cities more than doubled in population while Congress was deliberating on Hoover Dam, and all through this meagerly watered section of the Southwest, more people, more orchards, more factories were creating a demand for water which could not be supplied locally.

When Los Angeles went 250 miles to the Owens River to reinforce its water supply, everyone drew a breath of relief. They said "Now that question is settled. We have water for all time. Not only water enough for the city but enough to irrigate the San Fernando Valley." Secure in that conviction, little attention was paid by the people of that city to what was proposed on the Colorado, but before Congress had passed the act, Los Angeles had become a city of over a million people, and had begun to dream about being the largest city on the continent. To insure that, an adequate supply of pure water had to be provided, as no city can expand larger than its water supply, and the only source was the Colorado, so that now Los Angeles is planning the largest and longest aqueduct in the world, a fit counterpart in its engineering features to the Hoover Dam and the great lake above it.

Public opinion would never have sanctioned approval of the Boulder Canyon Project Act if it could not be shown that the project would pay for itself. It was thus that the development of hydroelectric power entered into the deliberations of Congress and was finally accepted as the instrument to finance this project.

Hoover Dam power means lightening the burden of settlers, the establishment of industries, and the economic development of natural resources. The dam will be located in a mineralized section; as a result its latent resources will very probably be developed.

SCENIC ATTRACTIONS

As water begins to gather behind the dam, forming a huge lake 110 miles long, we will see in the making what is destined to be a wonderful scenic attraction. Hoover Dam will be a connecting link between Arizona and Nevada, and the combination of the dam and the lake will undoubtedly create a Mecca for tourists.

We are planning a model city for 5,000 people, 7 miles from the damsite to be

known as Boulder City. It is reasonable to expect that with natural attractions and good accommodations, tourists may be expected to come in great numbers. Denver is now largely supported by tourist travel to the Rocky Mountains, having formerly depended on its smelters. It is a phase not to be overlooked. Chambers of Commerce recognize its possibilities to foster further development.

In the case of the Boulder Canyon project tourist travel would maintain certain enterprises started during the 7-year period of construction by employees.

I have touched on some of the effects of the Boulder Canyon project on future development; there must be many others.

I appreciate the opportunity to address you. The fact that I was sent to this meeting from Washington indicates an interest in your society and the things you are trying to accomplish. We have a wholesome respect for your organization and the way you go about matters that the society interests itself in. The magazine of the society, The Agricultural Engineer, is an aristocrat in its field.

You will always find us ready and willing to cooperate in any way we can.

Imperial Valley Has 424,000 Acres in Crops

The annual report of the Imperial Irrigation District of California, just received in the Washington office, contains much interesting data concerning this area which is to be greatly benefited by the construction of the Boulder Canyon project. The district includes 605,000 acres (the largest irrigation district in the United States) of which 515,000 acres are irrigable. In this valley situated below sea level there is a population of 60,000 persons. The annual diversion from the Colorado River for the year 1929 amounted to 3,423,511 acre-feet or 20 per cent of the river's discharge at Yuma, Ariz., of which 615,934 acre-feet or 18 per cent were delivered to water users in Mexico. Of this amount 1,173,390 acre-feet were wasted or lost, and the remaining 2,250,121 acre-feet were delivered to the farms, or 3.95 acre-feet to each acre. The net area cropped was 424,145 acres, and the grand area in crops was 675,843 acres, which includes 251,698 acres counted twice. Among the principal crops and their acreages are, alfalfa, 245,775; barley, 117,793; corn, 29,251; cotton, 20,431; lettuce, 77,654; cantaloupes, 64,773; melons, 24,530. In Mexico the principal crops with acreages and percentages were, cotton, 145,452, 88.1 per cent; alfalfa, 16,893, 10.3 per cent; grain, 2,185, 1.3 per cent.

Yakima Project Holds Third Annual Dairy Show

By Maurice D. Scroggs, Irrigation Manager, Sunnyside Division, Yakima Project

The Third Annual Sunnyside Dairy Show was held October 3 and 4, 1930, at which there were 168 entries of registered and grade dairy cattle of the Jersey, Guernsey, and Holstein breeds. Over 60 exhibitors entered and several hundred project men and women attended the 2-day show.

The success of the Sunnyside Dairy Show, which was initiated in 1928 by the Sunnyside Commercial Club, has been made possible by the financial and administrative support of the business men of Sunnyside and the active interest and participation of the farmers of the Sunnyside division.

The purpose of the show is to encourage and stimulate the dairy-cow owner, especially the small farmer with grade cows, for whom, the sponsors of the show realized, success in the dairy industry rested primarily upon production. Although prizes are offered for registered cattle, the larger share of the premiums go to the exhibitors of grade cattle. Every effort is made by special production classes and otherwise to place the emphasis upon breeding and building for production. The scrub bull is taboo and the purebred sire of proven worth encouraged.

One of the most gratifying phases of the show is the participation of the youth of the farm, especially those enrolled in 4-H clubs. This interest has grown each year and it is planned to foster it in every way possible.

The committee for the Sunnyside Commercial Club this year was: A. G. Fleming, chairman; Fred H. Langford, secretary; George R. Gochnour, superintendent; S. H. Harrison, John Heffron, and Maurice D. Scroggs, directors. These had the very active assistance of the Washington State College, the county 4-H leader, the State supervisor of livestock, and the Yakima Dairy Development League; as well as many farmers and business men throughout the Yakima Valley.

The budget for the Dairy Show has approximated $2,000 each year. The chief item of expenditure has been for premiums. The permanent building for housing the exhibits was constructed in 1929 and another is planned for the near future. Permanent grounds near the center of the business district of Sunnyside have been acquired and adequate arrangements have been provided for the watering, care, and exhibiting of the stock. The Sunnyside Dairy Show seems to be on a permanent basis. With the unquestioned possibilities and indeed necessity for dairying in the Yakima Valley, this annual event should be increasingly effective in contributing to the growth and success of the industry. While some prophesy greater things, the sponsors of the Dairy Show are planning conservatively, well content with that all too rare an accomplishment—a community enterprise in which so many are enthusiastically and constructively cooperating.

Yakima

Oh, Yakima we praise thee,
All glory to thy name,
The God of genius' ideas
Made possible thy fame.

There once the coyote traveled,
A seeming worthless plain,
Burned by the sun of summer
And destitute of rain.

'Twas man's imagination,
The work of many years,
That brought about your progress
By skillful engineers.

The water in abundance
Comes from the mountain stream
To decorate your acres,
All with a lovely green.

Your beauty and your grandeur,
Your majesty supreme,
Would mock the boasting artist
Beyond his thought or dream.

There stand the great snow mountains,
Their lofty peaks soar high,
To bless the fields and hamlets
When all is parched and dry.

Your people all are happy,
Contented to remain;
'Tis proof that many blessings
With Reclamation came.

—John S. Gabbard,
R. F. D. 6, Yakima, Wash.

WORK has been started by the State Highway Department of California on the paving of 6 miles of the Los Angeles and San Diego Highway starting at the Colorado River bridge at Yuma. This work includes a relocation of a portion of the highway, erection of several bridges over washes, making of a number of grade changes, and the laying of 6 miles of 20-foot bitulithic paving. The building of this highway, the completion of which is anticipated by June, is expected to relieve to a considerable extent the local unemployment situation.

Notes For Contractors

Boulder Canyon project.—Bids were opened on January 7, 1931, for the construction of the highway between Boulder City and the Hoover Dam (specifications No. 517). Sixteen bids were received, the low bid being that of the General Construction Co. of Seattle, Wash., whose bid on the basis of a 30-foot oiled surface highway was $388,207 and on the basis of a 22-foot oiled surface was $329,916.

On January 12, 1931, bids under specifications No. 518 were opened at Las Vegas, Nev., for constructing about 10¼ miles of the United States construction railroad from the summit to the Hoover Dam site. The low bidder was the Lewis Construction Co. of Los Angeles, Calif., with a bid of $455,510.

Specifications No. 519 covering construction of the Hoover Dam, power plant and appurtenant works are now available at the Denver, Las Vegas, and Washington offices. The price of the plans and specifications is $5 a copy. Bids for this work will be opened at the Denver office at 10 o'clock a. m., March 4, 1931.

Plans and specifications for the various features of the construction of Boulder City are being prepared as rapidly as possible. Bids were opened on January 15 for furnishing two riveted plate-steel tanks for the water-supply system. On January 26 bids were opened at the Denver office, under specifications No. 501–D, for furnishing three deep well pumps, each having a capacity of 550 gallons per minute, when operating under a total effective head of 110 feet; six horizontal, centrifugal pumps, each having a capacity of 450 gallons per minute, when operating under a total effective head of 1,200 feet; and three horizontal, centrifugal pumps, each having a capacity of 550 gallons per minute, when operating under a total effective head of 170 feet. These pumps are for installation in the water-supply system for Boulder City. Specifications have also been issued which cover the construction of twelve 3 and 4 room houses for Government employees.

Other specifications which are being prepared and which will be issued as fast as completed, include the purchase of materials for the water-supply pipe line from the river to the city, construction of the pipe line, purchase of materials for the city water-supply system and the sewer system, including a sewerage disposal plant, the construction of the sewer and water system, purchase of electrical apparatus for transmission lines and substation for the city electrical system, construction of the electrical system, grading streets, construction of sidewalks and curbs, construction of an administration building and garage, and the construction of additional houses.

Vale project.—Bids were opened on December 19, 1930, for earthwork and structures on the Vale main canal between stations 2060+58 and 2450 and the Bully Creek east bench lateral system, under specifications No. 515. The low bidder for schedules Nos. 1, 3, 4, 5, and 6, which included the canal work and lateral excavation, was W. H. Puckett Co., of Boise, Idaho, at $75,323.50. The low bidder for schedule No. 2 was Henry C. Boyer, of Ontario, Oreg., at $5,080 and for schedules 7 to 11, inclusive, covering the construction of lateral structures, Gabbey & McNeil, of Boise, Idaho, were low with a bid of $32,630.45.

Owyhee project.—On December 23, 1930, bids were opened at Denver, Colo., under specifications No. 516, for furnishing three 48-inch internal differential needle valves for the Owyhee Dam. The American Locomotive Co., of Schenectady, N. Y., was low bidder, with net price f. o. b. cars at Dunkirk, N. Y., of $18,831, and delivered cost $19,986.61. The award of contract was approved on January 5.

Bids were opened at the Denver office December 18, 1930, under invitation No. 16205–A for 5,000 barrels of cement in sacks, and 200,000 barrels of bulk cement for the Owyhee project, and proposals were received from five companies. The low bid for the bulk cement was submitted by the Utah-Idaho Cement Co., of Ogden, Utah, for 40,000 barrels of cement only at a price of $1.31 per barrel, which, with the addition of the freight item, would amount to $2.438 per barrel. It is proposed at this time to make an award for only 40,000 barrels and later to make recommendations with respect to the 5,000 barrels of sack cement and the remaining 160,000 barrels of bulk cement.

Low River at Yuma

The discharge of the Colorado River at Yuma, Ariz., on December 1, was 5,500 cubic feet per second. During the greater part of the month the flow was stationary at 3,300 to 3,800 cubic feet per second. The last few days of the month the discharge fell off and on the 31st was 2,350 cubic feet per second. Run-off for the month of December was the lowest of record, being only 45 per cent of normal. The run-off for the calendar year 1930 of 10,629,000 acre-feet was the lowest for 26 years, 1904 being the only year of record with a lower run-off. This low river is a convincing argument for the need of storage in the reservoir behind the Hoover Dam, and the resulting regulation of river flow. (LATER.—On January 7 the discharge was 1,740 cubic feet per second.)

DURING the fall months approximately 1,000 acres were planted to new alfalfa on the Vale project.

Columbia Basin Project Yields Abundant Fruit

During Commissioner Mead's visit to the Columbia Basin project last fall he was driven through a 157-acre apple orchard which had produced several varieties of apples, setting a record for a place of that size. The owner of this orchard, Charles Simpson, packed for shipment during the season the following boxes: Jonathans 55,757, Delicious 54,304, Winesaps 25,571, Stayman Winesaps 22,484, Spitzenburg 14, a total of 158,130, or 1,007 boxes per acre.

In another section of the Columbia Basin project—Neppel, Moses Lake—where irrigation is done by pumping, 450 carloads of apples, pears, and other fruit were shipped out during the season. The Milwaukee Railroad, which considers this the brightest spot on its line, received $300,000 in freight from these shipments. The Schnuerlie orchard in this section packed over 1,000 boxes of apples to the acre during the season.

Hauling apples from orchard to packing house, Columbia Basin project, Washington

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Echo Dam, illus. Professional Engineer, December, 1930, vol. 15, pp. 16–17 and 32.

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Hoover Dam, illus. Tech. Engineering News, January, 1931.

Deadwood Dam:
Large dam (Deadwood) constructed 70 miles from a railroad, illus. Union Pacific Magazine, January, 1931, p. 23.

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Balance sheet and statement of revenues and expenses to Sept. 30, 1930. Arizona Producer, Jan. 1, 1930, vol. 9, p. 6.

Conservation Committee Holds Final Meeting

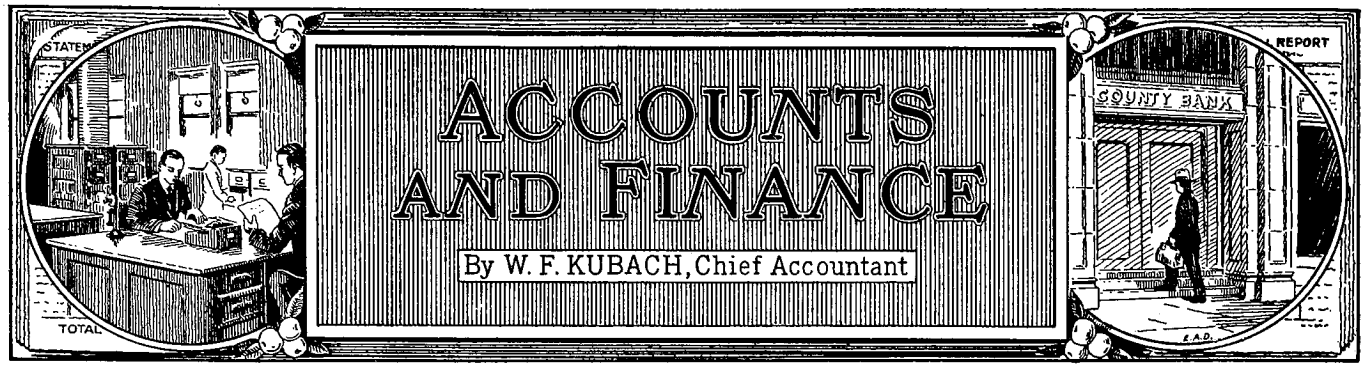
On January 12, 1931, Chairman James R. Garfield opened the third and final meeting of the members of the Committee on the Conservation and Administration of the Public Domain, at the conclusion of which the report was signed and transmitted to the President.

The act authorizing the appointment of the committee was approved on April 10, 1930, and funds were made available on May 14. The first meeting of the committee, under the enabling act, was held early in June, and the second in November, when a tentative draft of the report was prepared. The January meeting was called by Chairman Garfield for consideration of this tentative draft and such changes as had been suggested by the various members.

The members attending the meeting were as follows: James R. Garfield, chairman; I. M. Brandjord, H. O. Bursum, James P. Goodrich, Perry W. Jenkins, Rudolph Kuchler, George H. Lorimer, George W. Malone, Elwood Mead, Charles J. Moynihan, I. H. Nash, William Peterson, Mrs. Mary Roberts Rinehart, Huntley N. Spaulding, R. K. Tiffany, Wallace Townsend, and Francis C. Wilson. Pressure of other business prevented the attendance of Gardner Cowles, E. C. Van Petten, and W. B. Greeley, but the committee had the benefit of their written expressions of opinion.

The contents of the report had not been released as the ERA goes to press. The general and special recommendations and the text relating to reclamation will be printed in the magazine as soon as available.

Farm, buildings, and registered Holsteins of Vernon Herrigstadt, near Savage, Lower Yellowstone project, Montana-North Dakota



Appropriations for Boulder Canyon Project

Memorandum of Procedure Agreed to by Secretaries of Interior and Treasury

THE Boulder Canyon project act, approved December 21, 1928 (U. S. C., Supp. III, title 33, ch. 15A), authorizes the appropriation of $165,000,000 from the General Treasury. Pursuant to this act, $10,660,000 was appropriated by the second deficiency act, fiscal year 1930, approved July 3, 1930.

2. Section 2 (a) of the Boulder Canyon project act establishes a special fund to be known as the Colorado River dam fund, and directs that all revenues received in carrying out the provisions of the act shall be paid into and expenditures shall be made out of the fund, under direction of the Secretary of the Interior.

3. Section 2 (b) authorizes the Secretary of the Treasury to advance to the fund, from time to time and within the appropriations therefor, such amounts as the Secretary of the Interior deems necessary for carrying out the provisions of the act, * * * and that interest at the rate of 4 per cent accruing during the year upon the amounts advanced and remaining unpaid shall be paid annually out of the fund, except as otherwise provided.

4. Section 2 (d) provides that the Secretary of the Treasury shall charge the fund as of June 30 in each year with such amount as may be necessary for the payment of interest on advances made under subdivision (b) at the rate of 4 per cent per annum accrued during the year upon the amounts so advanced and remaining unpaid, except that if the fund is insufficient to meet the payment of interest the Secretary of the Treasury may, in his discretion, defer any part of such payment, and the amount deferred shall bear interest at the rate of 4 per cent until paid.

5. Whether the annual interest is paid out of funds advanced to the Colorado River dam fund, as provided by section 2 (b) or deferred as provided in section 2 (d), the interest charge practically amounts to interest compounded annually.

6. In view of the decision of the Attorney General of the United States that advances on account of the All-American Canal are not interest-bearing, it becomes necessary to account separately for advances on account of the Boulder Canyon project and the All-American Canal. The following accounts will be established on the books of the Treasury:

Appropriation symbol	Title of account
4X510	Advances to Colorado River dam fund, Boulder Canyon project (no year).
4X511	Advances to Colorado River dam fund, All-American Canal (no year).
4S512	Colorado River dam fund, Boulder Canyon project (no year).
4S513	Colorado River dam fund, All-American Canal (no year).

7. Appropriations made by Congress pursuant to the Boulder Canyon project act of December 21, 1928, supra, for advances to the Colorado River dam fund on account of the Boulder Canyon project, and the All-American Canal will be classified as general funds and will be established upon the books of the Treasury by appropriation warrants under the following appropriation symbols and titles:

Appropriation symbol	Title of account
4X510	Advances to Colorado River dam fund, Boulder Canyon project (no year).
4X511	Advances to Colorado River dam fund, All-American Canal (no year).

8. Upon request by letter from the Secretary of the Interior to the Secretary of the Treasury, transfer appropriation warrants will be issued in amounts requested therein, charging account 4X510 or account 4X511, as appropriate, with corresponding credits to account 4S512 or account 4S513. For the purpose of reporting expenditures in the daily statement of the United States Treasury, "expenditures, general fund—general," will be charged when transfer appropriation warrants are issued advancing money to the Colorado River dam fund under section 2, and "special fund expenditures—other," will be credited. Checks against the Colorado River dam fund will be issued under special fund symbol numbers assigned to the special fiscal agents.

9. Interest on advances from the appropriation "4X510—advances to Colorado River dam fund, Boulder Canyon project (no year)," will be computed from the date of appropriation transfer warrant. The actual-day method will be followed in computing interest chargeable on advances to the Colorado River dam fund. In case a greater sum has been advanced to the Colorado River dam fund (4S512 or 4S513) than is necessary to provide for current payments, the excess amount may be transferred back to the advances account (4X510 or 4X511) upon letter from the Secretary of the Interior to the Secretary of the Treasury requesting such action, and interest on the amounts so returned will cease on the date the transfer warrant is issued. Amounts returned to the advances account (4X510 or 4X511) under this procedure will not be considered "repayment of advances" under section 2 (e) of the act of December 21, 1928.

10. In case interest is deferred under section 2 (d) of the act, an appropriate certificate will be issued by the Secretary of the Treasury to the Secretary of the Interior. As there are no means of recording such indebtedness on the accounts of the Treasury relating to receipts, appropriations and expenditures, in order that the indebtedness for deferred interest may be readily reconciled with the accounts of the Interior Department, the Treasury Department will maintain a memorandum account to record the interest so deferred, and the interest on such deferred interest.

11. On June 30, of each year, unless interest is deferred under section 2 (d), a direct settlement will be made against the Colorado River dam fund (4S512) the proceeds of which will be deposited into the

Treasury as "miscellaneous receipts—interest on advances to Colorado River dam fund." In the event there are insufficient funds in the Colorado River dam fund to meet interest due on June 30 of any year the Secretary of the Treasury, upon request of the Secretary of the Interior, may advance to the Colorado River dam fund within the appropriation available therefor, an amount sufficient to cover such interest and such advance will bear interest at the rate of 4 per centum per annum as in the case of other advances made under section 2 (b) of the act. However, the Secretary of the Treasury may, in his discretion, defer any part of such interest under the provision of section 2 (d) of the act as explained in paragraphs 4 and 10 of this memorandum.

12. Advances will be made to fiscal agents of the Department of the Interior only from the Colorado River dam fund (4S512 and 4S513). Deposits by fiscal agents of unexpended balances will be made to the Colorado River dam fund for credit to the accounts 4S512 and 4S513, as appropriate.

13. Although section 2 (a) directs that all revenues received in carrying out the provisions of the act shall be paid into the fund under the direction of the Secretary of the Interior, in order to conform to the standard practice of the Treasury Department, collections by fiscal agents will be deposited temporarily to the credit of "4025—Miscellaneous receipts—revenues, Colorado River dam fund (Boulder Canyon project)" and "4026—Miscellaneous receipts—Revenues, Colorado River dam fund (All-American Canal)." Such collections will not be considered repayments of advances under section 2 (e), but will be transferred monthly by appropriation warrant and credited to the Colorado River dam fund, 4S512 or 4S513, as appropriate.

14. Upon certification of the Secretary of the Interior to the Secretary of the Treasury at the close of each fiscal year of the amount of money in the Colorado River dam funds (4S512 and 4S513) in excess of the funds required for construction, operation and maintenance, and payment of interest, settlement warrant will issue charging the Colorado River dam fund (4S512 or 4S513, as appropriate) and the amount will be deposited into the Treasury as "miscellaneous receipts—repayments of advances to the Colorado River dam fund."

All-American Canal Investigations

The report on the All-American Canal investigations is now being prepared in the Denver office, under the supervision of Homer J. Gault, engineer. This work is being done under a cooperative contract with the Coachella Valley County Water District and the Imperial Irrigation District, both of California. It is thought that the report will be available about the first of February.

The most important structure will be the diversion dam and desilting works at the head of the canal, the plans for which features are well advanced. Studies of this feature have been confined principally to the upper diversion site, but consideration is being given to the Laguna site, and also to a site 1½ miles above the Laguna Dam.

On account of the unusual magnitude of some of the features, the application of unit costs in the estimates becomes important, and especially with regard to excavation from the dam to the west side of the sand hills.

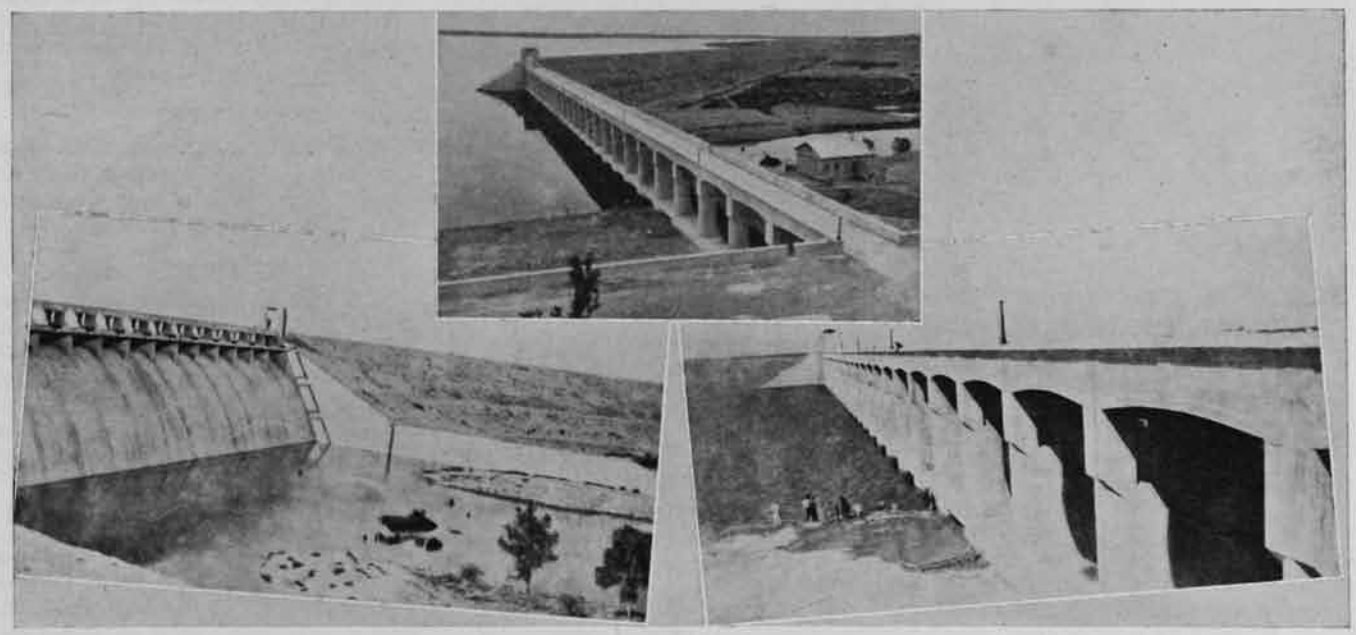
ERICKSON Brothers of Fruitdale, S. Dak., have constructed new pens at the Belle Fourche sugar factory for pulp feeding. This firm, which fattens about 7,000 lambs for market, is also wintering 4,000 ewes for breeding stock.

THE Black Hills sugar plant, South Dakota, closed on December 31 after a run of 94 days, during which 125,000 tons of beets were sliced bringing the contributing farmers $885,000 gross.

PLANTING of cantaloupes and watermelons on the Yuma project started in January, and with favorable spring conditions the crop will be ready to market in May or early June.

ON the Uncompahgre project efforts are still being made to effect a consolidation of the three poultry organizations on the Western Slope into one association.

ON the Yuma auxiliary project 18 cars of grapefruit and 3 cars of oranges were packed and shipped from local groves during December.



DON MARTIN DAM, SALADO RIVER, MEXICO

Upper, Dam and storage reservoir. Lower left, Downstream side of spillway. Lower right, Natives fishing in reservoir.

Reclamation Organization Activities and Project Visitors

Dr. Elwood Mead, commissioner, gave an illustrated lecture on Hoover Dam before the Massachusetts Institute of Technology at Cambridge, Mass., on January 9. This address was one of a series of Aldred lectures which were founded in 1923 at the institute by John E. Alfred, of New York City.

On January 21, Dr. Mead attended the annual meeting in New York City of the officers and directors of the American Society of Civil Engineers, and on January 22 left for California for a conference at Sacramento with the members of the Hoover-Young Commission on the report on water conservation in central California. While in the West Doctor Mead spoke on Hoover Dam before the Associated General Contractors of America, conferred at Los Angeles with the Imperial and Coachella Valley Irrigation districts relative to all-American canal matters, and visited Hoover dam site.

R. F. Walter, chief engineer in the Bureau of Reclamation, spent several days in the Washington office in connection with the financial situation of the bureau, returning to Denver on January 22.

Hugh A. Brown, who has been detailed for the past nine months as executive secretary of the Committee on the Conservation and Administration of the Public Domain, has resumed his duties in the Washington office as director of reclamation economics.

Early in the month J. R. W. Davis, chief engineer; Thomas Balmer, Colonel Mears, and C. B. Harding, officials of the Great Northern Railway, conferred with B. E. Hayden, superintendent of the Klamath project, regarding the changed location of the proposed Great Northern Railroad across project lands.

At Hoover dam site, January, 1931, showing excavation to determine character of abutment for dam. Left to right: Ralph Lowry, assistant construction engineer; Miss Mae A. Schnurr, assistant to Commissioner of Reclamation; Walker R. Young, construction engineer; D. L. Carmody, associate engineer.

J. G. Moody, California deputy real estate commissioner, was a caller at the Orland project during the month.

Miss Mae A. Schnurr, assistant to the commissioner, who was in the field the latter half of December and the first half of January, attending various reclamation meetings and visiting a number of the projects, returned to the Washington office on January 15. As usual, Miss Schnurr made a number of interesting and valuable contacts. Her address in San Francisco at the meeting of the land reclamation division of the American Society of Agricultural Engineers is printed in this issue of the ERA.

Miss Chloe D. Mantle, who has been a member of the Washington force of the Bureau of Reclamation since its organization in 1902, retired from active service on December 1. Miss Mantle will make her future home in Watertown, N. Y.

Miss Gertrude M. Athey, of the engineering division, has returned to Washington after an interesting trip to various points in Florida.

The headquarters of R. J. Coffey, district counsel, were changed from Berkeley to Los Angeles, Calif., effective January 14.

George O. Sanford, assistant director of reclamation economics in the Washington office, accompanied by Mrs. Sanford, motored to his old home in eastern Massachusetts and spent the Christmas holidays with relatives and friends.

On December 23 the Washington office force enjoyed its second Christmas party sponsored by Mrs. Margaret G. Young, supervisor of the stenographic section, and her several able assistants. Santa Claus made his appearance to the delight of the guests, and Miss Regina C. Watkins, of the chief clerk's division, gave an appropriate recitation. Mrs. P. I. Taylor, wife of a member of the engineering division, contributed a very important part by presenting the ladies with a delicious home-made devil's food cake, duplicating the one which she donated on the occasion of our first Christmas party a year ago.

J. L. Savage, chief designing engineer in the Denver office, was on leave several days during the month during which he served as a member of the Pine Canyon Dam Consulting Board. Mr. Savage later joined Chief Engineer Walter on his trip to Panama. They returned to Denver early in January.

Harold E. Rocker, of the mails and files section of the Washington office, was on leave for several days during the month of December, during which announcement was made of his marriage. The bride, Miss Doris Martin, is a native of England, but has been residing in Washington for several years.

Walker R. Young, construction engineer, Boulder Canyon project, spent one day in Denver en route from Washington to his headquarters at Las Vegas, Nev.

J. R. Iakisch, drainage engineer, was in the Denver office during the month preparing his report on the Saratoga investigations in Wyoming. Mr. Iakisch stopped at the Yuma project office the latter part of the month in order to secure data in connection with his studies of the drainage system on that project.

The Punjab, one of the most populous and prosperous regions of India, takes its name from the "five rivers" which irrigate the area, and is made up of the British Province of Punjab and 34 native States.

U. S. GOVERNMENT PRINTING OFFICE: 1931

ADMINISTRATIVE ORGANIZATION FOR THE BUREAU OF RECLAMATION

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E. K. Burlew, Administrative Assistant to the Secretary and Budget Officer
Northcutt Ely and **Charles A. Dobbel,** Executive Assistants

Washington, D. C.

Elwood Mead, Commissioner, Bureau of Reclamation

Miss M. A. Schnurr, Assistant to the Commissioner
W. F. Kubach, Chief Accountant

P. W. Dent, Assistant Commissioner
C. A. Bissell, Chief of Engineering Division
C. N. McCulloch, Chief Clerk

Hugh A. Brown, Director of Reclamation Economics
George O. Sanford, Assistant Director of Reclamation Economics

Denver Colo, Wilda Building

R. F. Walter, Chief. Eng; S. O. Harper, Gen. Supt. of Construction; J. L. Savage, Chief Designing Eng.; E. B. Debler, Hydrographic Eng.; L. N. McClellan, Electrical Eng.; C. M. Day, Mechanical Eng.; Armand Offutt, District Counsel; L. R. Smith, Chief Clerk; Harry Caden, Fiscal Agent; C. A. Lyman, Field Representative.

Projects under construction or operated in whole or part by the Bureau of Reclamation

Project	Office	Official in charge		Chief clerk	Fiscal agent	District counsel	
		Name	Title			Name	Address
Yuma	Yuma, Ariz	R. M. Priest	Superintendent	J. C. Thrailkill	E. M. Philebaum	R. J. Coffey	Los Angeles, Calif.
Boulder Canyon	Las Vegas, Nev	Walker R. Young	Constr. engr	E. R. Mills	Charles F. Weinkauf.	do	Las Vegas, Nev.
Orland	Orland, Calif	R. C. E. Weber	Superintendent	C. H. Lillingston	C. H. Lillingston	J. R. Alexander	Do.
Grand Valley	Grand Junction, Colo	W. J. Chiesman	do	E. A. Peek	E. A. Peek	R. J. Coffey	Los Angeles, Calif.
Uncompahgre	Montrose, Colo	L. J. Foster	do	G. H. Bolt	F. D. Helm	J. R. Alexander	Las Vegas, Nev.
Boise [1]	Boise, Idaho	R. J. Newell	do	W. L. Vernon	Denver office	do	Do.
Boise, Deadwood Dam	Cascade, Idaho	do	do	C. B. Funk	do	B. E. Stoutemyer	Portland, Oreg.
Minidoka [2]	Burley, Idaho	E. B. Darlington	do	G. C. Patterson	Miss A. J. Larson	do	Do.
Milk River [3]	Malta, Mont	H. H. Johnson	do	E. E. Chabot	E. E. Chabot	do	Do.
Sun River, Greenfields	Fairfield, Mont	A. W. Walker	do	H. W. Johnson	H. W. Johnson	Wm. J. Burke	Billings, Mont.
Lower Yellowstone	Savage, Mont	H. A. Parker	do	N. O. Anderson	Denver office	do	Do.
North Platte [4]	Guernsey, Wyo	C. F. Gleason	Supt. of power	A. T. Stimpfig [5]	A. T. Stimpfig	do	Do.
Carlsbad	Carlsbad, N. Mex	L. E. Foster	Superintendent	W. C. Berger	W. C. Berger	H. J. S. Devries	Do.
Rio Grande	El Paso, Tex	L. R. Fiock	do	H. H. Berryhill	H. H. Berryhill	do	El Paso, Tex.
Umatilla, McKay Dam	Pendleton, Oreg	C. L. Tice	Reserv. supt		Denver office	B. E. Stoutemyer	Do.
Vale	Vale, Oreg	Chas. C. Ketchum	Superintendent	C. M. Voyen	C. M. Voyen	do	Portland, Oreg.
Klamath [6]	Klamath Falls, Oreg	B. E. Hayden	do	N. G. Wheeler	J. C. Avery	do	Do.
Owyhee	Owyhee, Oreg	F. A. Banks	Constr. engr	H. N. Bickel	F. P. Greene	do	Do.
Belle Fourche	Newell, S. Dak	F. C. Youngblutt	Superintendent	J. P. Siebeneicher	J. P. Siebeneicher	Wm. J. Burke	Do.
Salt Lake Basin [7]	Coalville, Utah	F. F. Smith	Constr. engr	C. F. Williams	Denver office	J. R. Alexander	Billings, Mont.
Yakima [8]	Yakima, Wash	John S. Moore	Acting supt	R. K. Cunningham	C. J. Ralston	B. E. Stoutemyer	Las Vegas, Nev.
Yakima, Kittitas	Ellensburg, Wash	R. B. Williams	Constr. engr	Ronald E. Rudolph	do	do	Portland, Oreg.
Riverton	Riverton, Wyo	H. D. Comstock	Superintendent	R. B. Smith	Denver office	Wm. J. Burke	Do.
Shoshone [9]	Powell, Wyo	L. H. Mitchell	do	W. F. Sha	do	do	Billings, Mont.
							Do.

[1] Arrowrock Reservoir, Boise diversion dam, and Black Canyon power plant.
[2] Jackson Lake and American Falls Reservoirs, power system and Gooding division.
[3] Malta, Glasgow, and Storage divisions.
[4] Pathfinder and Guernsey Reservoirs, and power systems.
[5] Acting.
[6] Storage, main, and Tule Lake divisions.
[7] Echo Reservoir.
[8] Storage, Tieton, and Sunnyside divisions.
[9] Reservoir, power plant and Willwood division.

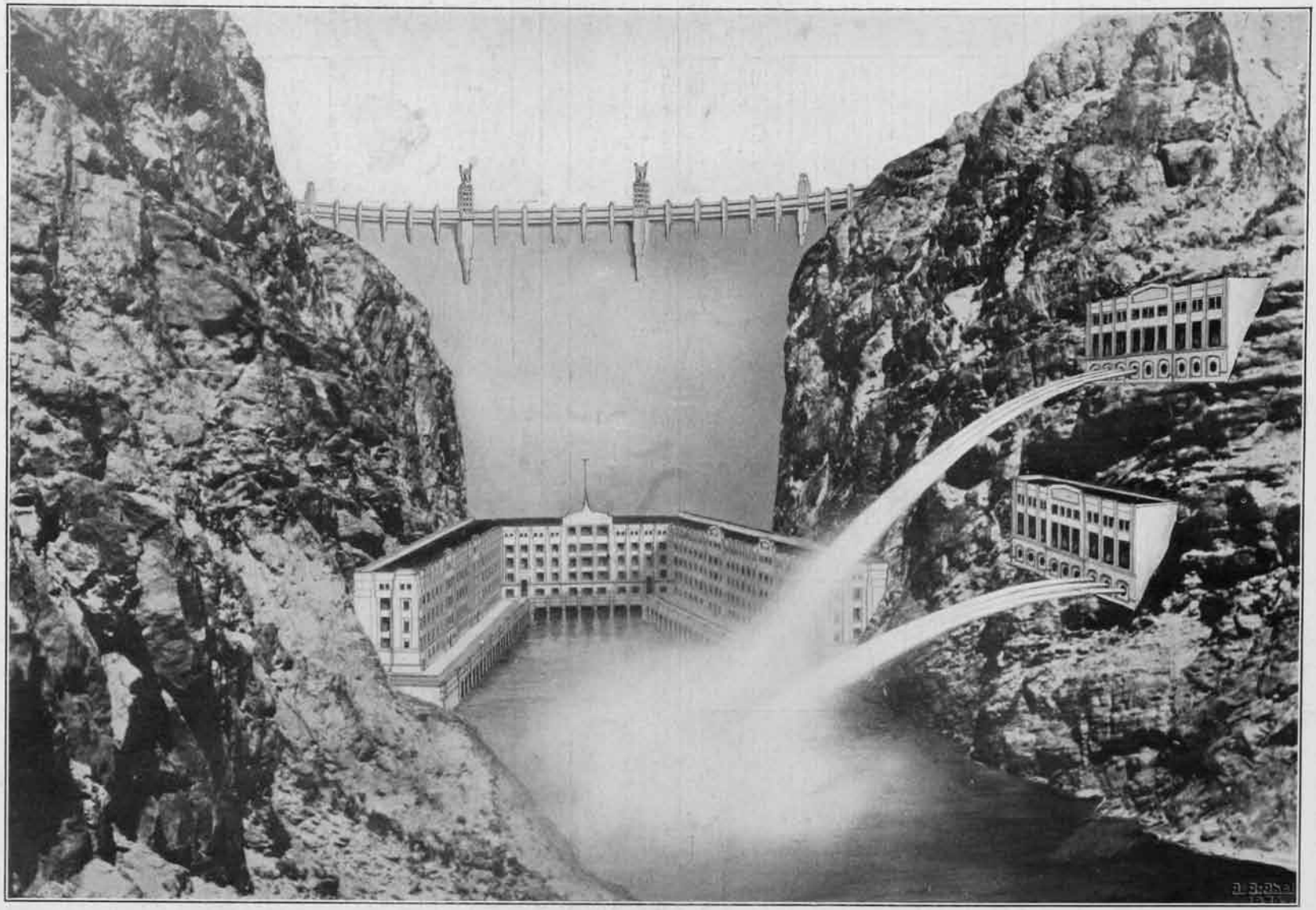
Completed projects or divisions constructed by the Bureau of Reclamation and operated by water-users' organizations

Project	Organization	Office	Operating official		Secretary	
			Name	Title	Name	Address
Salt River	Salt River Valley, W. U. A	Phoenix, Ariz	C. C. Cragin	Gen. supt. and chief engr.	F. C. Henshaw	Phoenix, Ariz.
Grand Valley, Orchard Mesa	Orchard Mesa irrig. district	Grand Junction	C. W. Tharpe	Superintendent	H. O. Lambeth	Grand Junction.
Boise [1]	Board of Control	Boise, Idaho	Wm. H. Tuller	Project manager	F. J. Hanagan	Boise, Idaho.
King Hill	King Hill irrigation district	King Hill, Idaho	F. L. Kinkade	Manager	Chas. Stout	Glenns Ferry.
Minidoka gravity	Minikoka irrigation district	Rupert, Idaho	R. L. Willis	do	W. C. Trathen	Rupert, Idaho.
Minidoka pumping	Burley irrigation district	Burley, Idaho	Hugh L. Crawford	do	Geo. W. Lyle	Burley, Idaho.
Huntley	Huntley irrigation district	Ballantine, Mont.	E. E. Lewis	Superintendent	H. S. Elliott	Ballantine, Mont.
Milk River, Chinook division	Alfalfa Valley irrig. district	Chinook, Mont.	A. L. Benton	President	R. H. Clarkson	Chinook, Mont.
Do	Fort Belknap irrig. district	do	H. B. Bonebright	do	L. V. Bogy	Do.
Do	Harlem irrigation district	Harlem, Mont.	Thos. M. Everett	do	Geo. H. Tout	Harlem, Mont.
Do	Paradise Valley irrig. district	Chinook, Mont.	R. E. Musgrove	do	J. F. Sharpless	Zurich, Mont.
Do	Zurich irrigation district	Zurich, Mont.	John W. Archer	do	H. M. Montgomery	Do.
Sun River, Fort Shaw division	Fort Shaw irrigation district	Fort Shaw, Mont.	H. W. Genger	Superintendent	H. W. Genger	Fort Shaw, Mont.
North Platte:						
Interstate division	Pathfinder irrigation district	Mitchell, Nebr.	T. W. Parry	Manager	Mary McKay Kinney.	Mitchell, Nebr.
Fort Laramie division	Gering-Fort Laramie irrig. dist.	Gering, Nebr	W. O. Fleenor	do	C. G. Klingman	Gering, Nebr.
Do	Goshen irrigation district	Torrington, Wyo.	B. L. Adams	do	Mrs. Nelle Armitage.	Torrington, Wyo.
Northport division	Northport irrigation district	Northport, Nebr.	D. R. Dean	do	Mrs. M. J. Thompson.	Bridgeport, Nebr.
Newlands	Truckee-Carson irrig. district	Fallon, Nev	D. S. Stuver	Project manager	L. V. Pinger	Fallon, Nev.
Umatilla:						
East division	Hermiston irrigation district	Hermiston, Oreg.	E. D. Martin	do	W. J. Warner	Hermiston, Oreg.
West division	West Extension irrig. district	Irrigon, Oreg	A. C. Houghton	Secretary and manager	A. C. Houghton	Irrigon, Oreg.
Klamath, Langell Valley	Langell Valley irrig. district	Bonanza, Oreg.	R. S. Hopkins	Manager	R. S. Hopkins	Bonanza, Oreg.
Do	Horsefly irrigation district	do			Wm. F. B. Chase	Do.
Strawberry Valley	Strawberry W. U. A	Provo, Utah	Lee R. Taylor	President and manager	E. G. Breeze	Payson, Utah.
Okanogan	Okanogan irrigation district	Okanogan, Wash.	J. C. Iddings	Superintendent	Nelson D. Thorp	Okanogan, Wash.
Shoshone:						
Garland division	Shoshone irrigation district	Powell, Wyo	Frank Roach	Irrigation superintendent	Geo. W. Atkins	Powell, Wyo.
Frannie division	Deaver irrigation district	Deaver, Wyo	Sydney I. Hooker	do	Edw. T. Hill	Deaver, Wyo.

[1] Boise, Kuna, Nampa Meridian, Wilder, New York, Big Bend, and Black Canyon irrigation districts.

Important investigations in progress

Project	Office	In charge of—	Cooperative agency
All-American Canal	Denver, Colo	H. J. Gault	Imperial and Coachella districts.
Central California water resources	Sacramento, Calif	W. R. Young and C. A. Bissell	State of California.
Salt Lake Basin	Salt Lake City, Utah	E. O. Larson	State of Utah.
Columbia Basin	Spokane, Wash	H. W. Bashore	



HOOVER DAM, POWER PLANT, AND ARIZONA OUTLET WORKS, BOULDER CANYON PROJECT
ARTIST'S CONCEPTION OF WORK UPON COMPLETION

NEW RECLAMATION ERA

VOL. 17 APRIL, 1926 NO. 4

TWO-YEAR OLD YUMA MESA GRAPEFRUIT TREE

CITRUS FRUIT GROWN ON THE FEDERAL IRRIGATION PROJECTS IN 1925 WAS VALUED AT NEARLY $1,000,000, OR $540.50 AN ACRE

FEDERAL RECLAMATION

WHILE just at this time reclamation is almost synonymous with irrigation of arid lands, we do not lose sight of the fact that that word and the policy of the Government include reclamation by drainage of swamp lands, by development of cut-over timberlands, and by fertilization of exhausted farm lands all through the eastern part of the United States. All will be needed in time. Our national necessities will compel us to go forward all along the productive line.

Reclamation is not only a matter of producing food for our people. The great thing is the transformation of the wilderness to civilization. It is the occupation and cultivation by the capital and labor of the settler of the unoccupied lands of this country. It is the creation of taxable wealth to help sustain the Government for all future times. It is the establishment of homes. It is the strength of manhood and womanhood contributing to the safety and defense of the Nation. It is the addition to our population of a splendid, enlightened, industrious citizenship which will enhance and enrich the security, the order, the welfare of our common country.

—From an address in the House of Representatives by Hon. Charles E. Winter, of Wyoming

NEW RECLAMATION ERA

Issued monthly by the Bureau of Reclamation, Department of the Interior, Washington, D. C.
Price, to others than project water users, 75 cents a year

HUBERT WORK
Secretary of the Interior

ELWOOD MEAD
Commissioner, Bureau of Reclamation

Vol. 17 APRIL, 1926 No. 4

High Lights on the Reclamation Projects

EARLY in April the bureau will open to entry 20 farm units on the Riverton project, Wyoming, under the new regulations providing for the selection of settlers on the basis of industry, experience, character, and capital. More details concerning the opening are given in another article in this issue.

THE farmers on the Fort Shaw division of the Sun River project recently shipped out 21 cars of alfalfa. It is to be regretted that an equivalent amount of stock was not shipped in to which this hay could have been fed.

THE work of placing the concrete lining of the diversion tunnel at Guernsey Dam, North Platte project, was completed on February 28. At the end of the month the dam was 39.9 per cent completed, based on contract earnings.

AT a recent public meeting of the dairy interests on the Newlands project the officials of the Mutual Creamery Co., owner of the local creamery, presented and explained a plan offering the plant and facilities of the company to the dairymen for operation under a cooperative arrangement. It is understood that the pledging of 2,500 cows under the plan will be necessary.

DURING the first two months of the year 190 cars of cotton and cottonseed were shipped from the Yuma project, valued at $633,000.

SETTLERS are now being selected on the basis of approved qualifications covering industry, experience, character, and capital. Among the first to qualify is a water user on the Sun River project and two on the Grand Valley project. In each case the entryman appears to be well qualified and should prove successful.

88534—26†

THE Grand Valley project reports that an increased spirit of optimism is apparent among most of the water users, and good results are anticipated. Development has been especially striking on the Orchard Mesa where one nursery has set out more than 30,000 peach trees. It is expected that approximately 2,000 acres of the east end of Orchard Mesa will be almost entirely set to peach orchards with excellent prospects of successful horticulture.

A PLOT of corn land, measuring 3.4 acres on the Sweitzer place on Garnet Mesa, Uncompahgre project, yielded 390 bushels of shelled corn, averaging 114 bushels per acre. This yield is believed to be the State record for 1925. The corn was well matured, uniform in type, and of a variety known as U. S. No. 133.

THE Ninth Annual Corn and Potato Show of the Uncompahgre project was held recently at Olathe, Colo. The display of exhibits was excellent, and many prizes of merchandise and other articles were presented by the various business firms of the three project towns. The show was particularly gratifying in view of the fact that approximately 800 people attended.

DURING February 424 cars of agricultural products were shipped from the Minidoka project, of which 250 were potatoes. Russets and Netted Gems were quoted at $2.65 and Rurals at $2.50 per hundredweight.

ON February 15 the Utah Construction Co. was notified to proceed with the construction of American Falls Dam to impound 1,700,000 acre-feet, within the limits of available funds. By the end of the month the foundation had been laid for nearly all of the structure that will be required to store 345,000 acre-feet this spring.

BIDS were opened on February 24 for the leasing of Tule Lake lands on the Klamath project. More than 300 bids were received, and 214 lots of 30,369 acres were leased for $29,012.90. After the contracts had been awarded those lots still open were offered at the minimum price of $40 a lot. At the end of the month 56 lots of 9,420 acres had been let for $2,240.

MASS meetings were held recently on the Okanogan project to consider the necessity and possibility of installing and operating a pumping plant to pump water from the Okanogan River into the project canals or to pay the Puget Sound Bridge & Dredge Co. for the pumping. The snowfall and precipitation during the first half of February, however, caused the water users to take an optimistic view of the water situation and they decided not to undertake either plan.

THERE has been a considerable increase in payments by the water users on the Yakima project over those of a year ago. On the Tieton division the collections for February were $17,547.08 compared with $11,202.78 for the same month in 1925.

DEEDS have been secured by the Kittitas reclamation district for practically all the right of way needed for the first four miles of the main canal, planned for immediate construction.

IN consequence of the minimum price of $8.50 a ton for sugar beets on the Shoshone project, which the sugar company is offering in its 1926 contract, there is considerable interest in the crop. About a dozen families of German-Russian beet farmers have moved to the Garland division and expect to contract for 500 acres. It is expected that 2,800 acres will be contracted compared with 1,700 in 1925.

The Economic Development of the Colorado River

A radio talk from Station NAA, the Naval Radio Station at Arlington, Va., on February 20, discussing the economic value of the project from a national standpoint, including irrigation, flood protection, and power development

By Dr. Elwood Mead, Commissioner of Reclamation

THE Colorado is one of the large and interesting rivers of the arid region. It is the only one where the valleys are all arid, and where permanent agriculture depends on ability to use water in irrigation. The river has therefore great economic value. Seven States are interested in its division and in works to make its water available. Two great cities. Denver in the Rocky Mountain area and Los Angeles on the Pacific coast, must go to this river for additional water needed for household and industrial uses. Both of these cities are outside the stream's drainage. It takes a long tunnel through the mountains to supply Denver and a 300-mile pipe line to carry it to Los Angeles. The river now irrigates 2,000,000 acres of land once desert. It can be made to irrigate 6,000,000 acres. It now generates electric energy to light a few towns and operate a few mines. It can be made to generate 6,000,000 horsepower.

A bill is now before Congress which, if it becomes a law, will provide $125,000,000 to build works to make available all the water of the lower third of the river. Under it the United States Bureau of Reclamation of the Interior Department would be given the task of building some of the greatest engineering structures of the world, needed to harness the stream. The Nation will secure thereby social and economic results that will mark it as one of the greatest constructive achievements of the century.

THE HUGE DAM

The plans for this development include three great structures. The first is a dam across the channel of the river, which from its foundation to its crest will be over 700 feet high, and it will raise the water surface of the river 550 feet. It will not only be the highest dam in the world, but will be more than twice as high as any dam ever built in any country. The highest dam now in existence is the Arrowrock in Idaho, built by the United States Reclamation Bureau, which is 349 feet high. The highest in any other country is the Camarasa Dam in Spain, which is 335 feet high. This dam will loom, therefore, among other dams as the Eiffel Tower does among structures of its class.

This dam will create a reservoir to regulate the flow of the river. The reservoir will be 86 miles long, and hold enough water to cover 26,000,000 acres of land a foot deep, or enough to cover the States of New Hampshire, Vermont, Massachusetts, Connecticut, New Jersey, and the District of Columbia to that depth.

The average flow of the river for a whole calendar year is about 16,000,000 acre-feet. This lake will hold, therefore, the entire discharge of the river for a year and a half. The great floods which now come down in the spring when the snows are melting will be caught here and held back, to be released later when water is needed to irrigate parched fields. No water will flow over the dam. All that goes down the stream will be let out through its regulating gates which will open into tunnels which pass around the end of the dam and will be cut through the towering cliffs between which the dam will be built.

THE ALL-AMERICAN CANAL

The second important feature of this development is what is called the All-American Canal. It would start at the western end of the Laguna Dam, a diversion dam in the Colorado, built about 20 years ago by the United States Reclamation Bureau. It is located about 30 miles from where the Colorado River crosses the international boundary into Mexico. The canal would follow the west bank of the river until it comes within a mile of the Mexican boundary; then it turns west through a deep cut, keeping north of the boundary and entirely in the United States, until it reaches the Imperial Valley. This requires a cut 60 feet deep, but it is the only means by which water can reach this valley without passing through Mexican territory.

THE POWER PLANT

The third feature of the development is a power house to be built just below the dam. When the reservoir is filled, water at the outlet gates will be under a pressure head of over 500 feet, and it will make possible the generation here of a million horsepower of electrical energy. A power house capable of this development is to be built.

The dam will cost $40,000,000, the All-American Canal $30,000,000, the power plant $35,000,000, or in all $105,000,000. It is proposed to finance this construction by a Government-bond issue, on which interest will have to be paid while construction is going on and until the revenue from power becomes available. This interest has been estimated at $20,000,000, making the total proposed bond issue $125,000,000.

No one questions that this great enterprise will be a financial success. Power revenues alone will pay interest on the development and create a sinking fund to to redeem the bonds in less than 50 years. Water sold for irrigation from the All-American Canal will return the entire cost of that structure and pay all its operating expenses, and, in addition, there will be revenue from water sold to cities and carried in great pipe lines, for which bonds have already been voted by the coast cities of California.

Comparisons serve to show the impressive magnitude of the engineering works needed to harness this river. The dam will be twice as high as any ever before built. The power house will generate twice the electric energy of any now in this country. The canal will cost more than any of the great works of India or Italy.

SOCIAL AND ECONOMIC NEEDS

About $2,000,000 has been spent studying the river and gathering information necessary to the selection of the site for this development and preparing plans. This would not have been done if the need for these mammoth structures were not urgent. It becomes interesting and important, therefore, to follow the regulated flow of the river from the dam down to the place of use, and to understand the needs which support this large expenditure in harnessing this stream and the social and economic conditions under which these great structures will perform their service.

Doing this discloses a situation so unique and remarkable as to seem unreal. Nearly all rivers flow through the troughs of valleys, but the Colorado, where it crosses the international boundary into Mexico, flows along the top of the rim of a great bowl or a basin which extends up into California for a distance of more than a hundred miles. This bowl was once an arm of the Pacific Ocean, into which the Colorado River

Imperial Valley shipping shed, where the famous cantaloupes are graded and loaded for shipment

emptied on its eastern side. It is one of the greatest carriers of silt and sand in the world. In time the continued discharge of its burden built a barrier entirely across this arm of the sea, lifted it above the level of the ocean, and evaporation in time created north of it a great basin with its deepest part 300 feet below sea level and with a silt deposit in places 700 feet thick.

THE RIVER MENACE

This river is kept out of this basin now by means of levees along its north bank, which turn it south into the Pacific Ocean, but water is carried from it by a canal which runs through Mexico into the Imperial Valley, where 400,000 acres are now irrigated and 700,000 acres can be irrigated. Sixty thousand people live on the irrigated lands of this valley, watered from the Colorado, with all of their homes below sea level and from 100 to 200 feet below the level of the river where it crosses the international boundary. Two cities, El Centro and Calexico, will vie with any cities of their size in the United States in their wealth and the architectural attractions of their buildings. Every year the extension of land in the valley intensively cultivated increases. Fifteen thousand carloads of lettuce are being shipped out of that valley this year, mainly to eastern cities. Last year 15,000 cars of cantaloupes, the largest and best in the country, supplied the homes of the outside world. Date palms, citrus orchards, table grapes of wide variety, long-staple cotton are among the contributions to the tables and economic wealth of this country, made possible by the rich soil and varying climate of this valley.

The valley has once been threatened by destruction through inundation. For a year the whole volume of the Colorado poured into this basin, flooding farms, washing away houses, and doing millions of dollars of damage. Now, with the growing use of water along tributary streams and the extension of its use in Mexico, further extension of irrigation is stopped and the farms of the valley are menaced by irreparable loss through drought. In September, 1924, less than a third of the water needed by irrigators came down the river. There had been dangerous floods a few months before, followed by this devastating drought, that in two weeks caused a loss of $6,000,000 to the farmers.

AN ECONOMIC NECESSITY

A great dam and reservoir will end this. It will enable the water to be turned out of the great lake it creates just as it is needed. It will enable Los Angeles to have its 1,500 cubic feet a second, without interfering with the rights of irrigators above or below. The power generation will enable farm homes to be lighted at less cost, more wheels of industry to be turned, more mines to be operated, and the industrial development now going on can be continued and thus supplement the increasing wealth of agriculture. More than half a million acres will be added to the irrigated area below this dam. The All-American Canal will give greater security to the irrigators and end the menace of international controversy with Mexico. The plight of the people now living in the Imperial Valley the great increase in wealth and population which will result, make this in the truest sense a national enterprise, entitled to the interest and support of all the people, no matter where they live.

THE Western Slope Creamery Association, which consists of eight creameries, including towns on the Uncompahgre project, is shipping a carload of butter every five days to the California markets. These cars run from 24,000 to 30,000 pounds. It is estimated that more than 70 per cent of the butter produced on the Western Slope is now going to California markets, and more money is being paid to the producer for butterfat, owing to the pooling of shares and the buying of supplies cooperatively by the creameries.

Special Joint Committee Proposed on Construction Program

Membership would consist of the chairmen of the Senate and House Committees on Irrigation and Reclamation, the chairmen of the Senate and House Committees on Appropriations, the Director of the Budget, and the Secretary of the Interior

IN ORDER that expenditures from the reclamation fund may be kept within safe limits of its annual income, Secretary Work has proposed the appointment of a special joint committee to work out a future construction program for new Federal irrigation projects covering the next 10 years.

The suggestion was made in a letter sent to Senator Charles L. McNary, chairman of the Senate Committee on Irrigation and Reclamation. Membership of the committee, it was proposed, would consist of the chairmen of the Senate and House Committees on Irrigation and Reclamation, the chairmen of the Committees on Appropriations of the Senate and House, the Director of the Bureau of the Budget, and the Secretary of the Interior.

Citing that old projects will require $60,000,000 to complete and new projects now pending before Congress will require $60,000,000, more or less, to build and that 15 additional projects have been urged on the Interior Department this winter costing about $40,000,000, the Secretary stated that this program of expenditure was considerably in excess of the probable income of the reclamation fund.

"The average annual receipts of the reclamation fund applied to construction," he continued, "for the past five years have been approximately $8,500,000. There is no prospect of the annual income being increased during the coming five years. Excluding moneys advanced by private interests to aid in the construction of the American Falls Reservoir in Idaho, the total for last year fell $2,500,000 below the previous year."

The Secretary pointed out that with this threatened diminution in the annual revenues every increase in the number of projects will mean reduction in the amount allotted to each individual project and that there is also the danger, unless a definite authoritative building program is soon adopted, that the funds will be distributed over so many localities that work will be prolonged, costs increased, and dissatisfaction engendered regarding delayed development in the localities to be benefited.

The proposed 10-year building program, if adopted, could be modified in detail from year to year, the Secretary concluded, and at the same time it would relieve the Bureau of Reclamation and the Bureau of the Budget from continued pressure for new projects, make their development more economical and efficient, and finally furnish valuable information to the public.

THE SECRETARY'S LETTER

The letter in full follows:

"There has been spent in Federal reclamation more than $200,000,000.

"There will be required some $60,000,000 under present plans to complete old projects, $25,000,000 of which is being spent now.

"New projects pending in Congress will require $60,000,000, more or less, to build; while 15 additional projects have been urged on the department this winter that contemplate an expenditure of about $40,000,000.

"The average annual receipts of the reclamation fund applied to construction for the past five years have been approximately $8,500,000. There is no prospect of the annual income being increased during the coming five years. Excluding moneys advanced by private interests to aid in the construction of the American Falls Reservoir in Idaho, the total for last year fell $2,500,000 below the previous year.

"To complete projects already begun and those being considered by Congress would require, therefore, more than the anticipated revenues for the next 10 years. There is now available in the reclamation fund to meet the demand of existing appropriations $6,500,000. Of this about $2,000,000 must be reserved for the construction of the American Falls Reservoir.

"In the annual report of the Bureau of Reclamation for 1924 there was incorporated, on pages 26 and 27, a tentative 10-year construction program, beginning in 1925. This program was intended to inform Congress and the public of the demands on reclamation funds for the completion of projects then unfinished, for projects for which appropriations had been made, or for proposed projects being considered by Congress.

"It is evident that this program involves an expenditure considerably in excess of the probable income. Unless some of these projects are to be displaced, the construction program will have to be largely extended and the rate of progress on particular projects made much slower than is desirable.

NEW PROJECTS URGED

"During the present Congress little or no consideration has been given to this financial situation. The bureau is being continually urged to recommend projects not included in the tentative program. The result is the total of these recommended new projects, which have been introduced in Congress, and for which estimates have been made, aggregates about $33,000,000. If others for which there are no estimates are included, the total will be somewhere between $35,000,000 and $40,000,000. A number of these projects have great merit and should be included in a construction program if there were sufficient funds. With a threatened diminution in the annual revenues, every increase in the number of projects means reducing the amount allotted to an individual one. And there is also danger, if a definite and authoritative program is not soon adopted, that the funds will be distributed over so many localities that the work will be greatly prolonged, its cost increased, and dissatisfaction engendered regarding slowness of development in the localities which are to be benefited.

SELECTION BASED ON FEASIBILITY

"There is a widespread belief that the selection of new projects is largely governed by personal considerations. It needs to be made clear that this is not true. In addition, there is much to be gained by a coordinated and carefully thought out program of development, the preparation of which would be participated in by Congress, this department, and the Bureau of the Budget. Such a program, when adopted, should be adhered to until changed by congressional authority.

"If such action impresses you as judicious, it is suggested that you communicate with the Senate and House and request that a special joint committee be appointed, consisting of the chairman of the Senate and House Committees on Irrigation and Reclamation, the chairman of the Committees on Appropriations of the Senate and House, the Director of the Bureau of the Budget, and the Secretary of the Interior, to work out a scheme of future construction for the purpose of keeping within safe limits the amount of expenditures for the next 10 years.

"Such a program, if adopted, could be modified in details from year to year, but it would furnish valuable information for the public, relieve this bureau from continued pressure, and make development more economical and efficient.

"Attached hereto is a copy of the Annual Report of the Bureau of Reclamation for 1924, above referred to, and a list of additional projects or divisions of projects for which appropriations have been solicited."

The following is the list of projects for which appropriations are asked, not included in the tentative program of future work in the Twenty-third Annual Report of the Bureau of Reclamation:

Project	Estimated cost
Trinity River, Tex	(1)
Red Bluff, Tex. (S. 2321)	$3,000,000
Alamogordo, N. Mex. (Carlsbad)	2,000,000
Rio Grande (Albuquerque)	(1)
Butte and Deer Creek, Calif.:	
Deer Creek	3,151,180
Butte	5,368,880
Orland (Stony Gorge)	1,485,000
Westland irrigation district, Oreg	600,000
Stanfield irrigation district, Oreg	300,000
Stanfield extension	300,000
Methew-Okanogan	4,400,000
Washington district	1,000,000
Gooding irrigation district	6,000,000
Casper-Alcova, Wyo	13,500,000
Saragoga, Wyo	2,560,000
Lonesome Prairie irrigation project, Mont	

[1] No estimate.

SENATOR McNARY'S REPLY

In a letter to Secretary Work, Senator Charles L. McNary, chairman of the Senate Committee on Irrigation and Reclamation, declined to accept the proposal of the Secretary on the ground that he did not deem the course of action wise because it would divide responsibility and would result in decentralizing authority in the selection of new projects when centralization of authority is needed to meet the excessive demands on the reclamation fund. The Senator's letter in full follows:

"Before me I have your recent letter stating that the demands upon the reclamation fund for the construction of new projects far exceed sums that will be available for a considerable period of time and suggesting that I 'communicate with the Senate and House and request that a special joint committee be appointed, consisting of the chairmen of the Senate and House Committees on Irrigation and Reclamation, the chairmen of the Committees on Appropriations of the Senate and House, the Director of the Bureau of the Budget, and the Secretary of the Interior, to work out a scheme of future construction for the purpose of keeping within safe limits the amount of expenditures for the next 10 years.'

"You ask me to take this action in the event it appears to be judicious. I regret, Mr. Secretary, to advise you that I do not believe this course of action wise. It would simply divide responsibility now wholly residing in you into as many human units as six is divisible by one, thereby passing the ultimate responsibility around in a circle without a beginning or an end. I feel that such a plan would work for decentralization when centralization of authority is greatly needed to meet the excessive demands on the reclamation fund, particularly when the only reservoir of information of the worthiness of the proposed projects is found in your department, the Bureau of Reclamation, and your chosen soil experts, engineers, and economists.

"The laws provide that you may examine into the merits of projects pressing for development and if convinced of their feasibility, transmit your approval with estimates of costs to the Director of the Bureau of the Budget, who, if satisfied the costs do not conflict with the economy program, will submit the estimates to the President. Meeting with the President's approval, the estimates are transmitted to Congress for appropriate action.

"The procedure here briefly sketched affords sufficient safeguards against wasting any portion of the reclamation fund on infeasible projects.

"The present plan and practice of committing to the Secretary of the Interior the responsibility of initiating the consideration of new projects and their construction, in my judgment, should not be substituted by your proposal, however hopeful you may be as to its excellence and desirability.

"In disapproving of your proposal, I must not be understood as being desirous of retreating from any responsibility placed upon me as chairman of the Senate Committee on Irrigation and Reclamation, as in such a capacity at all times you may be assured of my anxiety to cooperate with you in carrying out successfully this great work of development through reclamation."

Judging a Project's Feasibility

By R. E. Shepherd, manager, Twin Falls North Side Land & Water Co.

THERE are certain questions that must be satisfactorily answered before any project should be undertaken.

The order in which I shall present these questions does not signify their relative importance, as I believe if any project will not at the time stand up under all of them it should be let alone until such time as it will. It will be observed that some of these questions go to the very vitals of an irrigation project, while others relate to the time of the undertaking. Changed conditions may make desirable in the future that which would now be unprofitable. Satisfactory answers should be required and proof offered as to each of the following questions. If doubt exists as to any one, time should be taken to clear it up.

1. Is the land to be reclaimed sufficiently fertile and its soil structure such as to produce valuable crops for an indefinite period without resort to excessive cost for fertilization?

2. Is the surface of the land such as to permit of its irrigation without too great expense, having due regard to the class of major crops that it is adapted for?

3. Can the land be readily drained at reasonable cost, so as to prevent its becoming swampy or alkalied, after repeated irrigation?

4. Is there an adequate supply of water available within a reasonable distance and in the project with the amount sufficient at all times to supply all of the required to produce profitable crops?

5. Can this water be diverted for this purpose through a canal system that can not only be built within reasonable cost limits, but can thereafter be operated and maintained without excessive expense?

6. Is the project so located with reference to transportation and markets as to offer an incentive for its farm development?

7. Is there a present market demand for the products for which such land is naturally adapted, that under ordinary conditions would make the use of such land profitable to a farmer of ordinary ability and means?

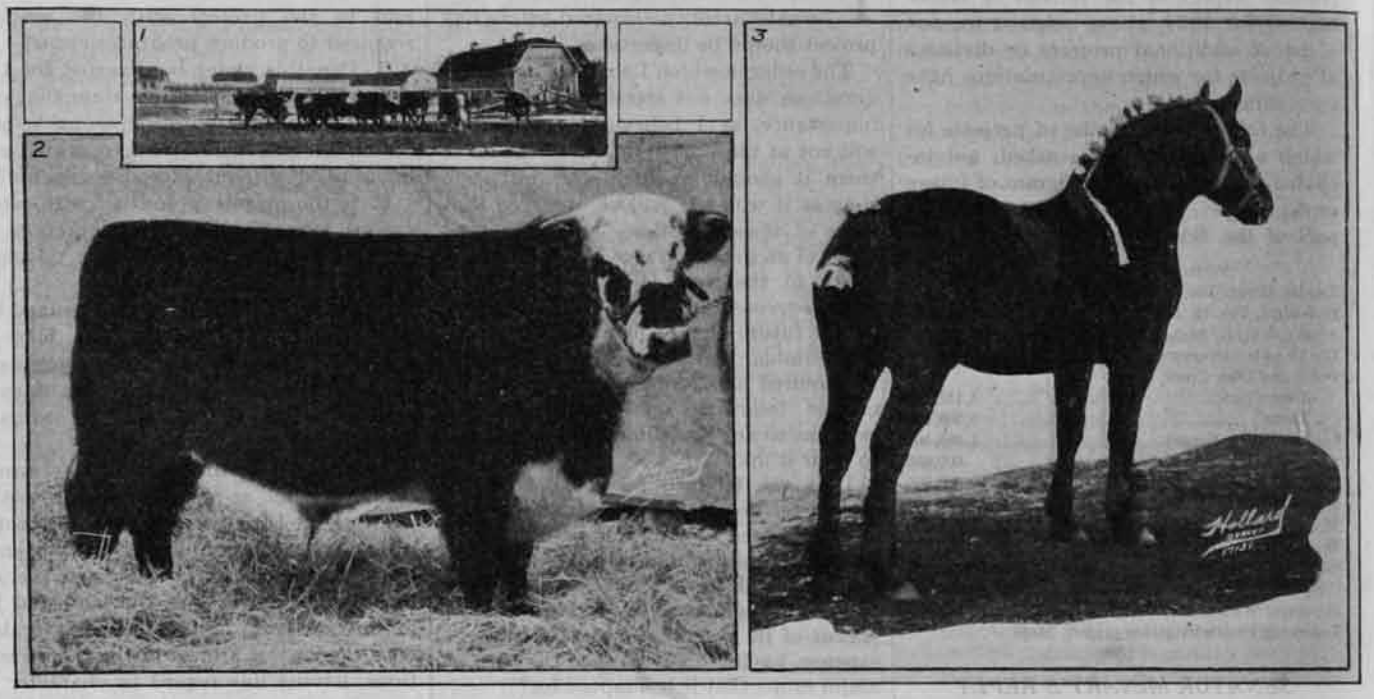
8. Will the entire cost of the work, including time required to secure settlement on the land, plus a reasonable profit, when spread over the entire area be such that the acre cost to the farmer, including the original cost of the land and its improvement by him, compare favorably with the cost of a farm in the humid sections, having due regard to character of crops, yield, and cost of production?

9. Is the project so financed as to the farmer that it will attract the man of limited means to locate thereon with assurance that he can succeed and meet his obligations promptly?

Livestock Improvement at University of Wyoming

The degree of improvement will depend upon the use of well-bred purebred sires; a rigid policy of culling females; and practicing approved and common-sense methods of feeding and care

By Prof. Fred S. Hultz, head of Animal Husbandry Department



1. The University of Wyoming Hereford herd. 2. Champion Shorthorn steer at the 1926 National Western Stock Show. He was bred, fed, and exhibited by the Univerity of Wyoming. 3. Grand champion Percheron mare at the 1926 National Western Stock Show. Owned and exhibited by the University of Wyoming

MUCH has been written about the importance of maintaining well-bred livestock on farms. Whether the farms are situated on a western reclamation project or are located in the heart of the Corn Belt, well-bred livestock will continue to play a most important rôle in their success. I purposely use the term "well bred" instead of "purebred." Purebred means just one thing—that a careful record of an animal's ancestry has been kept and recorded. Fortunately most purebreds are well bred, and most of our progress with domesticated animals has been with purebred stock. However, the fact of pure-bredness is not alone sufficient, because a high type of individual excellence should accompany every pedigree. The animal in question must be a good individual as well as have good ancestors.

It is not my purpose to belittle the purebred. Agricultural literature is full of proof that we must cling to the purebred for our livestock salvation. A known record of ancestry, commonly called a pedigree, should, and usually does, mean that careful thought has been given to the matings which appear in that pedigree. Each breed represents the ideal of a group of breeders, and the families in that breed represent the ideals of a smaller group of breeders. If the ideals of a certain breeder are known to be high, then that breeder's name on the pedigree means a great deal.

We know that offspring tend to resemble their parents; that is heredity. We also know of another force called variation, which causes offspring to resemble some of the ancestors further back in their family tree. It is variation which necessitates careful selection of all breeding stock, whether purebred or not. By selecting only good ones for breeding purposes we stand a better chance of getting good offspring.

The ability to recognize worth by examining an animal is called livestock judging. This ability is acquired tediously through long and varied experience, or more quickly by taking courses at the State agricultural colleges. It forms the very basis for success with livestock, as without the knowledge of what constitutes a good animal no one can intelligently buy, sell, feed, or breed animals.

THE THREE ESSENTIALS

A good pedigree, careful selection of the individual, and the right kind of care are the three essentials to livestock improvement. The best purebred will look like a scrub if not properly fed, and then no one can tell by his appearance if he is a good one or not. Heredity forms the skeleton, but the feed pail puts in the outlines. We can not spare the feed pail and hope to attain success in the development of the animal.

Dr. Mead has suggested that the readers of the RECLAMATION ERA might be interested in knowing what is being done toward livestock improvement at the University of Wyoming. Herds of Hereford, Shorthorn, Holstein, and Guernsey cattle, Percheron horses, Duroc-Jersey, Tamworth and Poland-China hogs, and flocks of Rambouillet, Hampshire, Corriedale, Lincoln, Oxford, and Southdown sheep are maintained at our farm, as well as several breeds of poultry. These animals are kept primarily for classroom instruction, but also one of the functions of an agricultural college is to assist stockmen in securing better livestock.

The quickest and cheapest way of accomplishing this is to produce good animals on our own State farm. We use only purebred, registered stock for breeding purposes, practice a rigid policy of selecting only the best for retention in the herds, and feed young stock adequately so as to be insured of their maximum growth and development. Many of these fine young animals have been sold out over the State to breeders, farmers, and ranchmen and have thus assisted in livestock improvement.

SPECIAL PROBLEMS OF THE STATE

Wyoming's system of animal production differs from that of most other States. Due to our climate, geographical location, wide variation in altitude, and distance from the great market centers, we are confronted with problems not common to other sections.

Many changes in production methods in recent years have presented an imperative need for experimental investigation. A few of the livestock projects now under way at the University of Wyoming are fattening beef calves, feeds for wintering range ewes, Wyoming feeds for producing pigs, dairy-cattle feeding, incubating chicks at high altitudes, and rations for egg production in Wyoming.

Any policy of improvement must look toward the future. There has never been a time when high-class meat animals received a higher premium for being high-class than now. It takes an exceptionally good steer to market as fat beef at 12 to 18 months of age, and a fine lamb to make a choice 40-pound carcass. Almost any fair steer can be made fat and marketable in two or three years, but the housewife is demanding handyweight cuts of meat and these come only from young beef and lamb. The reduced export demand is also a factor in making the market requirement what it is. We no longer have much demand from Europe for heavy beef carcasses. Occasionally a load of well-fatted 3-year-old steers will sell well on the market to go toward supplying the fancy hotel or restaurant trade, but this demand is comparatively limited. To secure a top price on the market, steers must class as baby beef. This class, as was pointed out above, can be produced only from well-bred, typey, early maturing calves of a highly improved sort.

FACTORS FOR SUCCESS

Regardless of whether your object is the production of feeder stock, finished meat, dairy products, or poultry, your success will depend upon the degree of improvement accomplished with your herds and flocks. I will say that the degree of your improvement depends upon:

1. The use of well-bred purebred sires, carefully selected as individuals.
2. A rigid policy of culling females for retention in the breeding herd.
3. Practicing approved and common-sense methods of feeding and care, particularly as regards adequate development of young stock.

Your State agricultural colleges are anxious to assist you in every way possible. Their doors are always open to boys and girls who wish to study the livestock industry and thereby become more proficient in livestock improvement

Land Opening on Riverton Project, Wyo.

The Wind River diversion dam on the Riverton project, Wyo.

EARLY in this month 20 irrigable farm units on the Riverton project, Wyoming, will be opened to entry under the new regulations providing for the selection of settlers on the basis of approved qualifications of industry, experience, character, and capital.

The irrigable area of the farms ranges from 35 to 108 acres, averaging about 75 acres. Water for their irrigation will be available during the coming season.

Until July 1, 1926, the farms will be open to entry only by ex-service men who served in the United States Army or Navy in the World War and have been honorably discharged or placed in the Regular Army or Naval Reserves, provided that they are qualified to make entry under the homestead laws. After that date any remaining farms may be filed on by any qualified person.

Applicants will be passed on by an examining board and will be selected in accordance with the regulations of the department. Each applicant must have had at least two years' experience in farming and must have $2,000 in money free of liability, or the equivalent in livestock, farming equipment, or other assets.

Irrigation water will be furnished the successful applicants during the seasons of 1926, 1927, and 1928 for a minimum advance payment charge of $1 per acre for 2 acre-feet, with additional water at the rate of 50 cents per acre-foot. As these lands were originally part of the Wind River, or Shoshone Indian Reservation, the entryman must pay, in addition to the reclamation charges, $1.50 per acre, of which 50 cents must be paid on the date of entry, and 25 cents per acre per year for each of four years thereafter. The construction charges on the land will be announced later.

Full information concerning the opening, together with the farm application blank which must be filed by each applicant, may be obtained from the superintendent of the Riverton project, Riverton, Wyo., from the Commissioner of Reclamation, Washington, D. C., or from the chief engineer, Bureau of Reclamation, Wilda Building, Denver, Colo.

Women on the Projects and Their Relation to Better Agriculture

The reclamation projects offer unusual opportunities for organized effort on the part of the women in coordinating all those activities which tend to the building up of the highest type of rural life

By Mae A. Schnurr, secretary to the Commissioner and Associate Editor, New Reclamation Era

THE old days are gone forever. Now when a man decides to take up a farm unit on a Federal irrigation project, he doesn't do all the questioning of the local officials of the Government. He is presented with a form of application which is designed to bring out the facts showing whether he possesses sufficient capital, experience, and is surrounded with other favorable conditions which have been found to be desirable.

Recognition of the importance of the woman's part in this great undertaking of establishing a home upon the land is mutely acknowledged in this question in the bureau's form of application:

"If married man, what experience has your wife had in farm life?"

Experience has proven that this factor is not to be underestimated, and that a farmer's ambition to become successful may be helped materially by marrying a girl brought up on the farm. Town-bred women are less likely to be contented.

In discussing the form of application and the above-quoted question in particular, the commissioner unwittingly formed the basis of this article when he said:

"That question is far more important than many others on our questionnaire. I knew four successful farmers on one project to quit their farms merely because they had married town girls."

The farmer's wife is responsible primarily for the well-being of the family, and as her main sphere, the management of the house. To this sometimes is added care of the poultry yard and garden. The woman's share in planning the farm work may sensibly increase the gross yield, and the net profit may also be larger in consequence of her excellent administration of her trust; and thus the economic basis of the family may be strengthened.

Economy versus Efficiency

Nine women out of ten believe themselves thrifty and economical when they "wear out" their old, run-down, misshapen shoes "round the house" where few notice what they have on, and many tasks inevitably dim the shine and spoil the appearance of any shoes. The tenth housekeeper perhaps realizes that when she wears comfortable, well-fitted shoes with broad, low heels and roomy toes, at her work, she can get through the day without a backache or tired feet, that she can stand straighter and for a longer time if necessary, and, in fact, be generally more efficient.

Miss Mae A. Schnurr, associate editor in charge of the women's section

In California the home demonstration agents have been conducting active campaigns in 12 counties during the past year to convince farm women of these facts, and to show them how to select their own and their children's shoes properly. Most of these rural mothers and housekeepers are keenly interested in scoring the shoes they happen to be wearing at the meeting where the subject is introduced, and in comparing their footwear with the types of good-health shoes exhibited by the extension worker who addresses them.

A report received by the United States Department of Agriculture states that as a result of these campaigns dealers are willingly cooperating with the home demonstration agents, lending models of approved shoes, instructing people in taking correct foot tracings and measurements, and providing more careful service in fitting shoes at the local stores.

Talks on foot hygiene are supplemented by such illustrated material as slides, X-ray pictures, photographs of good and bad choice of shoes, and the ills resulting from wearing the wrong kinds. Foot exercises for strengthening muscles and arches are demonstrated. It is also shown that stockings must be properly fitted and that garters should not restrict circulation.

Better Kitchens—A Woman's Delight

One of the first things the home maker thinks about in a better home is a well-arranged, well-equipped kitchen. That does not mean that she is kitchen-minded either. It means rather that she knows where convenience counts most in a house. In most family kitchens at least 1,000 meals are cooked during the course of every year. Surely for any job that comes as regularly and often as getting three meals a day, every step-saving, time-saving arrangement possible should be included in the plan and the equipment.

The points that make for convenience in the kitchen are as follows, according to the Bureau of Home Economics:

First, last, and all the time in planning and equipping a kitchen, says the bureau, think about the work to be done in it.

If building or remodeling a kitchen, make it oblong and with no more floor space than actually needed. A kitchen is a workroom. Spaciousness is paid for in miles of useless steps.

Study the relation of the kitchen to the rest of the house. Make a direct connection from kitchen to dining room in the common wall between them. See to it also that there is easy access to front and back doors, to the telephone, and to the stairs to the cellar and the second floor.

Arrange for adequate ventilation in all weathers and for good lighting at all work centers at night as well as during the day.

Screen windows and doors against household pests. Flies particularly are a menace to health.

Choose finishes for floor, walls, and woodwork that are durable, suitable in color, and can be kept clean easily.

Select furnishings that fit the wall and floor space and they will pay for themselves in usefulness. Weigh the pros and cons of built-in or movable pieces and compare prices carefully.

Make sure that there is an abundant supply of hot and cold running water and a sanitary drainage system.

Decide on the most comfortable height of working surfaces.

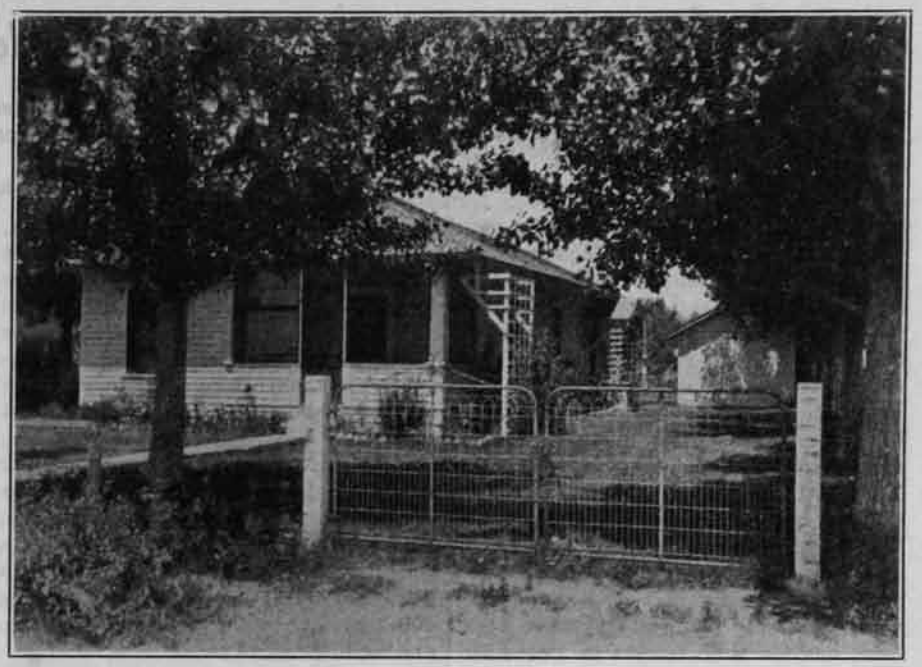
Group all equipment, large and small, into compact work centers for preparation of raw food, cooking, serving, clearing away and dishwashing, and any other activities done regularly and often in the kitchen.

The kitchen is above all else a place to prepare and serve food. Limit the kitchen to this use, if possible, and arrange for laundering and such work to be done in another place.

A breakfast alcove built in one end of the kitchen not only adds to the kitchen's appearance but saves the housewife many steps and keeps the work in one room for at least one meal.

Felt for Chair Legs

Felt glued on the ends of chair legs will prevent them from marring the polished floor. Also this simple device will do away with the scraping noise chairs generally make when moved about. There are rubber caps manufactured for this purpose, but the felt will be found easier to attach, as it can be cut to any size. Long strips also can be cut to fit the rockers of rocking chairs.



A home on the Minidoka project, Idaho

Rural Homes on the Minidoka Project

By Mrs. R. S. Moy, of Rupert, Idaho

THERE are about 2,500 farm homes within the boundaries of our Minidoka project, Idaho. Approximately 50 per cent of these homes are equipped with electricity and convenient water systems.

The greater proportion of these homes are substantial in structure, many of different new types of brick, some of cement, and many of first-quality weather lumber. Because all homes are comparatively new it is quite an attractive spectacle to visitors to see so many substantial, well-painted buildings erected in the short span of scarcely 20 years.

However, there are real vital factors in this environment that cause home making and settling to be very desirable, because of the natural advantages here for a home and for the family.

With the availability and small cost of electricity, the work of the housewife is lessened materially. Upon survey we find a large percentage of our home makers using electric milk separators, electric flatirons, electric washers, electric hot plates, electric curling irons, electric percolators, electric warming pads, electric water heaters, toasters, ranges, and waffle irons.

With the great development of poultry and dairy production which we have here, the housewife's work is made much easier with these mechanical aids because naturally poultry, milk, cream, and butter disposal can be handled by men of the household more readily if they have electric equipment to work with. This eliminates a great amount of work from the housewife's budget, allowing her more time for cultural privileges and the beautifying of her home to which, as a rule, the farmer's wife can give so little attention.

But this type of material development is not the only advantage. We find hand in hand with it the finest progress in those factors which build for future citizenship. The auxiliary agencies of schools, churches, and libraries are highly developed because of the very fine leadership available on a new project through helpful agencies. This has meant rapid, substantial, and well-founded development which easily parallels that on any older project in this or any other State.

Project Women Urged to Share Their Domestic Science Secrets

We will print in the ERA *all recipes, with credit to authors; also any good household hints.*

We will also be glad to print from time to time in the women's section accounts of personal experiences of our project women in their work of helping to make homes in the arid region.

Let us hear from you.

Try This

SUE'S FUDGE CAKE

½ cup butter or margarine.	2 squares chocolate melted over hot water.
1 cup sugar.	1 teaspoon salt.
2 cups pastry flour.	½ teaspoon soda.
1 cup buttermilk.	1 teaspoon baking powder.
1 well-beaten egg.	1 teaspoon vanilla.

Cream butter and sugar, add egg and chocolate. Add flour, baking powder, soda, and salt, sifted together—alternately with milk. Flavor with vanilla. Pour in greased pan and bake at 350° F. Frost.

Appreciation

Mrs. Moy has furnished the first article for the women's section, and I hope others will follow in sufficient numbers to publish one or more in each issue.

An account of the ideas, plans, and personal experiences of the women and children on the projects is bound to make interesting reading for others. In return for the contributions you make of material for this section I pledge to you hours of research every month into the things I believe will interest my readers. My compensation will be appreciation and the knowledge that what I present in this section is read by many.—*M. A. S.*

Uncompahgre Project Lamb and Cattle Feeding Tours

An interesting account of how farmers on the project are utilizing the by-products of the sugar-beet crop and of sugar manufacturing.—These tours should result in more finishing of stock and improved feeding methods

By H. A. Ireland, County Extension Agent, Montrose County, Colo.

FOLLOWING the introduction of sugar-beet growing on the Uncompahgre project, Colorado, came an interest in the feeding of lambs and cattle on the by-products of the crop and of sugar manufacture. With the rapid increase of this interest there was a need for more definite information, applicable to local conditions, regarding feeding methods, equipment, expected gains, costs of gains, etc. That men feeding or planning to feed cattle or lambs might be brought together for the discussion of these and other questions, and to review the results of experimental feeding of beet by-products, two tours were planned and have been held, one for lamb feeders in December and one for cattle feeders in February. Both were widely advertised through meetings, local papers, and circular letters addressed to all sugar-beet growers of Montrose and Delta Counties, and both were fairly well attended. The interest manifested by those on the tour and attending the meetings held in connection with the tours was very good.

WHAT THE LAMBS WERE FED

The lamb feeders' tour was held on December 15 and 16. Starting from Delta at 10 o'clock a. m. on the 15th visits were made to the feed yards of the following men: Alfred Smith, where 600 lambs from Utah were being fed on beet tops, pastured in the fields, and alfalfa. These averaged 70½ pounds at loading point and were received October 1.

W. P. Dale had elected to run a small band of 600 head of aged ewes, breeding them as early as he could after buying the ewes and getting them down from the range, with the idea of making an early market lamb and of feeding both ewes and lambs together. The ewes were on stubble fields with some alfalfa pasture and beet tops and were looking good. The demand for old ewes has been greater than the supply.

Mr. McConnell was feeding a small bunch of lambs in dry lots, on hay, beet tops hauled in, and squash, and apparently making a satisfactory gain in weight.

FEEDING BEET PULP

After a trip through the feed yards of the Holly Sugar Co. where several hundred cattle were being fattened on beet pulp and hay, and following a lunch provided by some of the larger-hearted lamb feeders of Delta, in the community rooms, the tour continued to the farm of Scott Bros., one of the larger operators, where another band was seen pasturing in the beet fields with hay fed in panels in the field. Across the road B. C. Marchbanks had 1,200 head on beet-tops pasture and was feeding hay in corrals at night with some beet pulp. M. H. Patnode, an old cattle feeder, had put in 2,100 lambs which had been fed tops and hay in large corrals till the tops were gone, when pulp had been substituted with a small amount of molasses and later a little barley. Ford Sayre was feeding 600, hauling beet tops from the field, and feeding hay in panels.

A meeting was held in connection with the Lions Club luncheon in Delta in the evening at which E. J. Maynard, in charge of feeding investigations of the Colorado Agricultural Experiment Station, Ralph Mahon, general livestock agent of the Denver & Rio Grande Western Railroad, and L. M. Pexton, traffic manager for the Denver Union Stock Yards, were present and discussed various problems with feeders and shippers.

The second day's tour was similar to that of the first, starting from Montrose and including stops at the farms of the Holly Sugar Corporation, where 120 head of steers were being fed in corrals as a test on hay and beet tops: N. E. Marchbanks, where 847 lambs were feeding on beet tops, hay, and ear corn: F. W. Vernon, who was feeding 1,500 lambs on alfalfa and stock beets grown for that purpose; C. W. McLaughlin, who had 2,000 head on tops in the field, and hay; and M. H. Patnode, who was visited the first day. A meeting was held in Olathe, at the high school at noon.

Some of the stock inspected was owned by the feeders, some was being fed on contract. No definite information could be gained at the time, but the purpose of the tour was to give feeders and prospective feeders an opportunity to note the rations used on different farms, compare the stock, and then in the meetings hear rations and feeding methods discussed by a man with wide experience in experimental feeding.

About 150 persons attended the two meetings held, most of these also going on the tour. Mr. Maynard states that the affair compared favorably in all respects with the annual tour held in the lamb-feeding section of northern Colorado.

VARIETIES OF CATTLE FEED

On February 10 a cattle feeders' tour similar in plan and purpose to the tours of January 15 and 16, was held on the project. Cattle feeding is less popular than lamb feeding at this particular time and it was necessary to include feeders of both counties in one tour to fill the day. The following is a statement of farms visited and stock and methods inspected:

Harry Hoover was feeding 111 head of yearling Herefords on corn, silage, and alfalfa; Elmer Smith had 50 head of short 2-year-old Hereford steers on silage, alfalfa hay, and cottonseed cake, to which he planned to add some beet molasses after seeing results of experiments with rations similar to the one he was using; John Boyden was feeding some calves and cows on silage, alfalfa, and molasses; Alfred Smith had 100 head of baby beeves on alfalfa, beet pulp, molasses, cottonseed cake, and a small amount of oats, which with the grain eliminated is considered the ideal ration for beet-growing sections from the standpoints of both efficiency and economy; E. J. Hatcher had 110 head of yearlings on alfalfa, pulp, and corn; Hallock Bros. had a somewhat mixed bunch of steers and heifers on alfalfa, pulp, and corn silage; and W. W. Newton was feeding a choice bunch of 28 2-year-olds on alfalfa and corn silage. B. W. Fairbanks, State livestock specialist, commented on the rations used at each stop, and at a meeting held in Delta in the evening led a general discussion of rations and feeding methods. A total of about 70 persons attended the tour, the greatest number present at any one farm being 55. Everyone present seemed to feel well repaid for the time spent.

More finishing of stock for market and a general improvement in rations and feeding methods are the results hoped for from the tours.

Revision of the Government's reclamation policy is expected to give a new impetus never before known to the reclaiming of arid and semiarid land.

The proposed Colorado River development will be one of the greatest engineering undertakings ever attempted by the Government.

Law Notes of Interest to the Irrigationist

Submitted by the district counsel and others

CONDEMNATION IN TEXAS

THE Government brought suit to condemn land for the Tornillo Canal in the Texas division of the Rio Grande Federal irrigation project. The defendant landowners asked that the suit be dismissed on the ground that the law extending Federal irrigation to Texas is unconstitutional, there never having been any public lands in that state. Delays in the suit caused the Bureau of Reclamation to change the course of the canal and utilize other lands. Those described in the suit being no longer needed, the United States moved to dismiss the case. The defendants contested this motion, alleging that the construction of the Tornillo Canal had damaged them to the extent of $20,000, and asking for judgment in that amount. The Government's motion being allowed, the defendants appealed to the circuit court of appeals. In Owen et al. *v.* United States (8 Fed. (2d) 992) the appellate court sustained the decision of the lower court, holding that the Government may dismiss a condemnation proceeding at any time before there is a taking of property which vests right to compensation, that the Government can not be sued without its consent, and that defendants cross-claim being in excess of $10,000 was not within the jurisdiction of the district court.—*O. H.*

WARREN ACT WATER RIGHTS TAXABLE

The Northside Canal Co. (Ltd.), an Idaho corporation, has a contract with the United States, authorized by the Warren Act of February 21, 1911 (36 Stat. 925), which provides for a water supply for that company from the Jackson Lake Reservoir of the Minidoka Federal irrigation project. The reservoir is in the State of Wyoming and the lands irrigated by the water are in Idaho. The taxing officials of Wyoming sought to tax the "equity or water rights in Jackson Lake Reservoir" held by the company, and suit was brought by the company in Federal court to enjoin the assessment and collection of such taxes. The United States intervened, asking the same relief. In Northside Canal Co. (Ltd.) *v.* State Board of Equalization et al. (8 Fed. (2d) 739) it was held that the rights of the plaintiff in the reservoir are taxable in Wyoming; that this is not the taxation of Federal property; that such taxes are not invalid on the ground that they tend to make Government contracts under the Warren Act less desirable; and that the fact that the legal title to the reservoir is in the United States is immaterial. An apeal has been taken and is now pending.—*O. H.*

FEDERAL VERSUS STATE WATER LAW

S. Clare Mower, a farmer on the Boise Federal irrigation project in Idaho, brought suit to enjoin J. B. Bond, the project superintendent, from cutting off his water supply because of delinquency for more than a calendar year in the payment of an operation and maintenance charge. The procedure proposed by the project superintendent was in accordance with Federal law but alleged to be contrary to State law, which the plaintiff contended should apply. This contention by the plaintiff was denied by the court in Mower *v.* Bond (8 Fed. (2d) 518).—*O. H.*

The Water Supply On the Projects

Water supply conditions on the projects at the end of February were as follows: Prospects for additional storage and natural flow were above average on the Belle Fourche, North Platte, and Orland projects; average on the Carlsbad, Strawberry Valley, and Umatilla projects; average for Minidoka, as to additional storage, and for Grand Valley and Uncompahgre as to natural flow. On the Boise, Klamath, Milk River, Minidoka (Jackson Lake), Newlands, Okanogan, Rio Grande, Sun River, and Yakima projects the prospects were below average, and on the Salt River project the prospects were very poor. The Huntley, King Hill, Lower Yellowstone, and Yuma projects, which are without storage, are assured of full water supply from natural sources. The Riverton and Shoshone projects, which have storage, are assured of full water supply for present development. Since January, conditions have improved on the Newlands, Okanogan, Orland, Strawberry Valley, and Umatilla projects, while the prospects are less favorable on the Milk River and Sun River projects.

FIRST DEFICIENCY ACT, 1926

(Extracts from.) An Act Making appropriations to supply urgent deficiencies in certain appropriations for the fiscal year ending June 30, 1926, and prior fiscal years, to provide urgent supplemental appropriations for the fiscal years ending June 30, 1926, and June 30, 1927, and for other purposes. (Approved March 3, 1926, 44 Stat. —.)

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums are appropriated, out of any money in the Treasury not otherwise appropriated, to supply urgent deficiencies in certain appropriations for the fiscal year ending June 30, 1926, and prior fiscal years, to provide urgent supplemental appropriations for the fiscal years ending June 30, 1926, and June 30, 1927, and for other purposes, namely: * * *

Bureau of Reclamation

North Platte project, Nebraska-Wyoming: For continuation of construction and incidental operations, including the general objects of expenditure enumerated in the second paragraph under the caption "Bureau of Reclamation," contained in the Interior Department appropriation act for the fiscal year 1926, $300,000, to remain available until June 30, 1927, and to be paid out of the "reclamation fund."

Yakima project (Kittitas division), Washington: For continuation of construction and incidental operations, including the general objects of expenditure enumerated in the second paragraph under the caption "Bureau of Reclamation," contained in the Interior Department appropriation act for the fiscal year 1926, $2,000,000, to remain available until June 30, 1927, and to be paid out of the "reclamation fund." * * *

Judgments of United States courts

For payment of judgment rendered against the United States by the United States District Court for the District of Wyoming, on September 2, 1925, in favor of the Bothwell Co., in condemnation proceedings under section 7 of the act of June 17, 1902 (32 Stat. 388), for the acquisition of lands for the Pathfinder Reservoir, $9,600, together with interest thereon at 8 per cent per annum from July 3, 1909, to and including February 19, 1923, and at 7 per cent per annum from February 20, 1923, until the date of payment, payable from the "reclamation fund" created by said act.

None of the judgments contained herein shall be paid until the right of appeal shall have expired. * * *

Washington Irrigation Institute Adopts Irrigation Resolutions

AT its annual meeting, held on February 11 and 12, the Washington Irrigation Institute adopted, among others, the following resolutions relating to irrigation:

Resolved, That reclamation by irrigation is an important factor in American agriculture with an increasing influence in the economic production of an adequate national food supply. Although some mistakes have been made in both national and private projects, these are now serving as a preventative of their repetition on future projects.

Resolved, That with the new era in the organization, selection, and administration of reclamation projects which include soil, adequate water supply, and a market for the products of the soil, the settler will have a reasonable opportunity for success; and the State being benefited greatly by the increase in property values, Washington Irrigation Institute favors a policy of cooperation between the Federal Government and the State or irrigation district or a local land-settlement corporation in procuring settlers for reclamation projects created by Federal appropriations.

Resolved, That we believe that the State of Washington is fundamentally interested in irrigation and reclamation and should adopt a reasonable State policy. The legislature has created a commission to investigate and report at its next session upon the whole question of State reclamation and upon a policy for future procedure. It is, therefore, recommended by Washington Irrigation Institute, that the president appoint a committee of three members to conduct an independent study and cooperate with such legislative commission, if deemed advisable, and report its findings to this institute prior to the next session of the State legislature.

Alkali Soil and Its Reclamation

By C. C. Wright, specialist in irrigation investigations, State College of Washington

CERTAIN areas on practically all irrigation projects have been damaged by the accumulation of alkali in the surface layers of the soil. The extent of these areas and damage, varies from a few acres where partial crop production is possible to large tracts thousands of acres in extent, where scarcely any crop plants can be grown. This accumulation of alkali in one place or another, usually in the lower lands of irrigated projects, seems almost inevitable under our present irrigation methods and practices. In the future it may look just as foolish to build an irrigation system without its accompanying drainage system as it would look now to put in a city water system without a sewer.

Hundreds of thousands of dollars are being spent in the Western States every year in the reclamation and attempted reclamation of alkali lands, while thousands of acres more are "going bad" each year. Hence the prevention of alkali land bears the same relationship to its reclamation as the prevention of diabetes or influenza bears to its treatment and cure. And there are just as many disappointments in trying to reclaim alkali land as there are in trying to cure diabetes or the flu.

Excessive accumulation of alkali salts in the soil is invariably associated or has been associated with inadequate drainage and a resulting high groundwater table of relatively salty water. The soil blanket above the water acts like a wick in that it absorbs the water with dissolved salt at its lower side and loses water by evaporation from its surface, the salts being deposited at the place of evaporation.

Most crop plants will not tolerate a concentration of salt in the soil solution much above 1.5 per cent. This means that in order to be safe for crop production the salt content of the soil should be rather less than 0.5 per cent. When the soil contains this amount of alkali the first consideration in its reclamation must be to in some way get rid of the excess salt. Little or nothing can be accomplished by trying to grow crops which are especially tolerant of alkali, such as sweet clover or some of the salt grasses which are used for pasture, until the excess salt has been removed. There is only one method known for the reclamation of alkali soil. That method is to reverse the process by which the salt has been deposited. The salt was brought into the soil by the upward movement of water to replace evaporation loss. If the soil is to be reclaimed that salt must be moved downward through the subsoil by heavy irrigation and carried away by drains.

The removal of this excess salt, however, is not always accomplished by simple drainage. Certain types of alkali soils will not become normal or productive by merely removing the soluble or "washable" salts which so often has been assumed in reclamation practice, but the replaceable sodium, which is held in combination with the soil or absorbed by it, must also be displaced. Experiments are now in progress on certain alkali lands in different parts of the country to determine the best methods of accomplishing this result. Present indications are that applications of gypsum or sulphur, either alone or with manure, will be a necessary part of the procedure.

But by properly sampling the soil of an alkali area and subjecting these samples to chemical analysis it is now possible to tell whether the area can be fully reclaimed by drainage alone or whether it will need special chemical treatment in addition. In case such special treatment is necessary it is not easy to tell what the cost will be or what will be the rate of reclamation. These, along with many others, are questions to be answered by future experiment.

Boards Appointed To Select Settlers

Additional boards of examiners to select settlers have been appointed on the following projects:

Sun River project, Montana.—G. O. Sanford, superintendent, Fairfield, R. L. Clarkson, Choteau; Henry Radcliffe, Fairfield.

North Platte project, Nebraska-Wyoming.—H. W. Bashore, superintendent; Mitchell, Nebr.; Henry M. Springer, Mitchell; Royce F. Tebbet, Torrington, Wyo.

Rio Grande project, New Mexico-Texas.—L. M. Lawson, superintendent, El Paso; F. J. Rigney, jr., Las Cruces, N. Mex.; H. L. Kent, State College, N. Mex.

Riverton, Wyo.—H. D. Comstock, superintendent, Riverton; J. J. Jewett, Riverton; P. B. Dykeman, Riverton.

In future relief will be granted only to individual farmers who furnish satisfactory proof of inability to meet charges.

Operation by the Water Users

From "The Gazette," Reno, Nev., February 11, 1926

THE sooner the settlers upon Federal irrigation projects take over their operation and maintenance, which is being seriously considered by those upon the Newlands project, the sooner they will bring their affairs to a proper business basis and remove themselves from the depressing influences which have attended prolonged Federal operation.

Not only Secretary Work and Commissioner Mead, but the Fact-Finding Commission which conducted extensive investigations two years ago, went far beyond immediate consideration of the Government's financial interests when they urged that such steps be taken. In reality they were primarily influenced by the welfare of the settlers themselves when they advised them to stand upon their own feet and become the actual and active owners and operators of the works which the Government had built for their benefit.

As excellent authorities upon reclamation have pointed out, it was never intended by Congress, when it enacted the reclamation law, that the Federal Government should remain the operator of any project for an extended length of time after bringing its lands to a productive basis. The entire theory of the act was that the Government would finance the construction of the works and then surrender them to the settlers who would repay the cost and operate them as their own property under restrictions which would insure proper maintenance. It was never meant that Government operators should remain forever upon the ground and that the settlers should be placed in the same category as Indians upon reservations.

It would be incorrect and ungrateful, however, to belittle the fostering efforts which have been put forward by the Government upon behalf of the settlers. In fact, it has been more than generous. True, it has made mistakes, costly ones, but on the other hand it stands ready to cancel the charges in all such instances. It has frequently postponed the collection of operation charges when no such postponements would have been allowed by a privately owned irrigation district or a banking corporation. And its leniency, it truthfully may be said, has not infrequently been abused by demands, which have been conceded, for wholesale moratoriums and large cancellations.

In every instance the best interests of both the Government and of the settlers will best be served by the latter taking over completely project operation and maintenance. Before this can be done, of course, there must be a clear definition of the repayment charges to be undertaken by the settlers, a clear limitation upon project areas, and an understanding that the Government will complete storage and other works not yet finished. To such a plan the Government is agreed.

The owners of the project farms will then be placed upon their own responsibility. They will manage their own works, make their own collections, and be practically independent of distant control from which the Government wishes to escape. It will be up to them to direct not only their farms but their irrigation systems, which they are fully competent to do if they will only attempt it.

Uncompahgre Man Breaks Corn Record

AN announcement was made at the Olathe Corn and Potato Show that Morgan Sweitzer, one of the Uncompahgre project farmers, had broken all State records in producing 114 bushels of corn to the acre during the 1925 season. The corn was grown on 3.4 acres of ground on Garnet Mesa and the total yield amounted to 390 bushels of shelled corn which averaged 114 bushels to the acre. The corn was grown on ground that had been in orchard during previous years.

The measurements were made by the Montrose and Delta county agents and are official. Ten pounds of selected seed were sown to the acre. The seed bed was in perfect condition and a perfect stand was obtained.

It was hoed at once, cultivated, and irrigated as necessary. The corn was well matured and uniform in type and of a variety known as U. S. No. 133.

The corn was planted on May 7 and was not irrigated until May 16. The methods used as announced by Mr. Sweitzer consisted of less irrigation and more irritation. The log of Mr. Sweitzer's activities was as follows:

April 16, 17, double disked.
April 18, 22, plowed, followed by harrow twice.
April 24, cross disked.
April 25, cross harrowed.
April 27, cross floated.
April 28, rolled.
April 28, 30, floated three times, diagonal each way and up and down.
May 3, rolled.
May 7, planted, 2-row planter, 10 pounds of seed per acre.
May 8, marked out.
May 16, irrigated.
May 27, harrowed diagonally.
June 1, irrigated.
June 8, cultivated with 5-tooth harrow cultivator.
June 12, cultivated.
June 17, cultivated.
June 22, marked out.
June 25, irrigated.
July 1, cultivated.
July 7, cultivated.
July 8, hoed weeds.
July 10, marked out and laid by.
July 18, irrigated.
August 2, irrigated.
August 21, irrigated.
September 15, corn fully matured.
September 22, slight frost.
October 15, killing frost.
November 19, December 11, harvested and stored in bin.

In referring to the success obtained by Mr. Sweitzer, Professor Olin, of the Denver and Rio Grande Western Railroad, stated that the secret of success lay in the cultivation of the soil and that big crops in all lines consisted of working the ground, working the ground again, and then working the ground some more.

Yakima Valley Crops Bring Good Returns

Crop movement in the Yakima Valley has been more satisfactory recently, and all crops probably will be marketed at remunerative prices before the new crop is available.

Shipments of apples have amounted to 10,773 cars, with 4,000 cars in storage.

About 700 cars of potatoes were shipped during February at prices running from $45 to $55 a ton for No. 1. Growers who held their crops in storage are having to sort, owing to some rotten ends, and will probably not get as much for their crop as if they had sold out of the field.

Hay is moving to market in a satisfactory manner.

The construction work now being conducted by the Bureau of Reclamation is stimulating to an inestimable degree business and industrial activities throughout the West.

The proposed Columbia Basin project in Washington will cost approximately $193,360,000. The amount of land available for irrigation is estimated at between 1,000,000 and 1,500,000 acres.

Agricultural Demonstration Program

THE agricultural demonstration work on the Minidoka project, Idaho, is handled through two agencies—the United States Department of Agriculture and the county agent. John T. Montgomery, associate agriculturist of the Department of Agriculture, devotes most of his time to animal husbandry, and J. W. Barber, county agent, to crop work, poultry management, marketing, etc. In addition, Miss Esther V. Kahle, under university extension auspices, gives valuable aid and advice in dietetics, prenatal care, clothing problems, and other phases of home economics. All these agencies work in harmony with the Minidoka project office. The following is the program of demonstration work on the project for 1926:

Crop work will embrace the following schedule: Crop clubs (boys and girls); grain standardization and certification, with variety tests, disease control, and weed control; clover-seed production and marketing; corn improvement; potato improvement, involving seed production and selection and disease control; demonstrations on beans and peas; urging of permanent cropping plans, involving balanced rotations combined with appropriate livestocking systems providing outlets for bulky crops; general horticulture and home gardens; record keeping; marketing organizations.

An outline of the livestock program is as follows:

CATTLE

BEEF

Selling surplus.

DAIRY

1. Elimination of inferior and scrub bulls by replacement with purebred, with known production.
2. Exchange of bulls to retain proven sires.
3. Purchase of few better bulls to head pure bred herds.
4. Cost accounts on dairy herds.
5. Cow-testing associations; organize more.
6. Dairy buildings:
   1. Sheds for cows,
   2. Milk houses (caring for milk and cream).
7. Feeding the dairy cow:
   1. Rations.
   2. Minerals.
8. Breeding problems.
9. Disease control:
   1. Sterility in heifers.
   2. Abortion.
   3. Tuberculosis test.
10. Expansion dairy outlets; cream pool; creamery.
11. Calf club.

SHEEP

1. Flock improvement by—
   1. Use of better rams.
   2. Culling inferior ewes.
   3. Retaining choice ewe lambs.
   4. Breeding ewes at proper age.
   5. Breeding early to secure growth on lambs.
2. Study of flock production from standpoint of—
   1. Wool production.
   2. Mutton production.
3. Sale of pure bred ram lambs to range sheep men; sale of market lambs through cooperative shipments.
4. Disease and parasite control.
5. Sheep clubs.

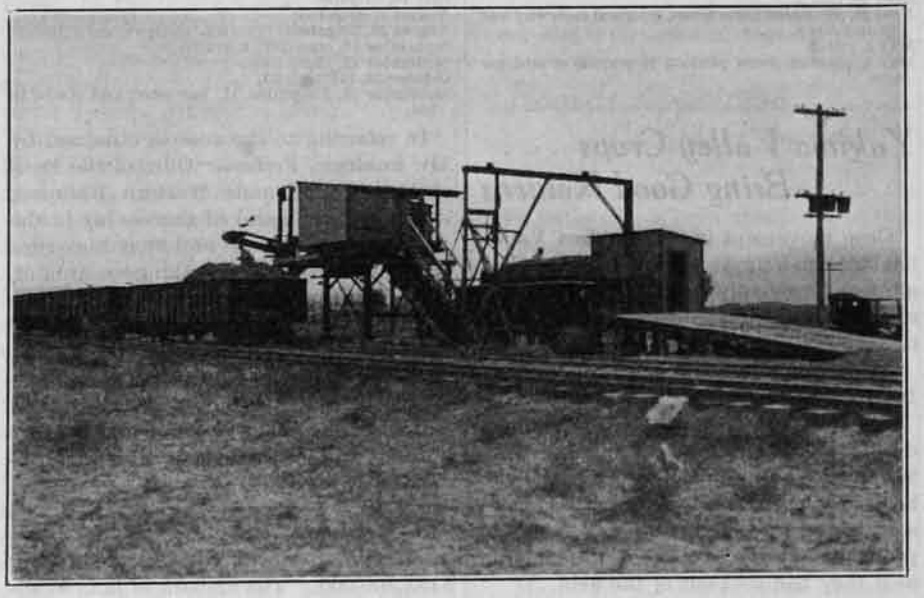
SWINE

1. Encourage keeping a few hogs on every farm.
2. Cooperate with few farmers in cost accounting.
3. Cooperate feeding tests.
4. Ton-litter contest.
5. Clubs.
6. Cooperative marketing.

POULTRY

1. Improved housing.
2. Increase flock size on farms where poultry is a major industry.
3. Poultry accounting.
4. Improved breeding.
5. Marketing; cooperative egg marketing; cooperative turkey pool.
6. Capon raising.

Some attention will also be given to such matters as rodent control and the campaign against sparrows; predatory animal control; insect control; extermination of noxious weeds; home economics.



Electric sugar-beet dump on the Minidoka project, Idaho

Growing Head Lettuce After Raising Onions

Growing head lettuce in the Uncompahgre Valley after the Bermuda onion crop is harvested is advocated by K. Nakamura, according to a recent press dispatch.

Mr. Nakamura states that a Japanese farmer on California Mesa last year sowed some head lettuce about August 10 and it made fine heads, ready for market in October. It was an experiment and the lettuce was not cared for as it might have been. He states that one of the big marketing organizations would like to get 15 or 20 carloads of this lettuce in the fall, and believes that the farmers in the valley should grow more of it, as it could be harvested after the crop at high altitudes is marketed. It is his impression that the crop could be seeded after the Bermuda onion crop is harvested, thus raising two crops on the same ground in one year.

Citrus Fruit on the Projects

NEARLY three hundred thousand 75-pound boxes of grapefruit, oranges, and lemons were grown on three irrigation projects in Arizona and California in 1925.

A recent compilation shows that 1,823½ acres of land on the Salt River project Arizona; the Yuma project, Arizona-California; and the Orland project, California, in that year produced 22,299,475 pounds of citrus fruit valued at 985,603, or $540.50 an acre.

More than 92 per cent of the total yield was produced on the Salt River project, Arizona, where more than 20,000,000 pounds of grapefruit, oranges, and lemons were grown, valued at $929,250, or $630 per acre.

The statistics are shown in the accompanying table:

Citrus fruit Grown on Reclamation Projects, 1925

Project	Acreage	Yields		Value	
		Total	Average per acre	Total	Per acre
		Pounds			
Salt River	1,475	20,650,000	14,000	$929,250	$630.00
Yuma	1½	1,350	900	68	45.00
Yuma Auxiliary (Mesa)	73	967,875	13,258	29,075	398.29
Orland	274	680,250	2,483	27,210	99.30
Totals and averages	1,823½	22,299,475	12,229	985,603	540.50

TIETON WATER USERS REPLY TO QUESTIONS

The Tieton Water Users' Association, Yakima project, has sent out a questionnaire to each of the 1,225 water users on the division, asking, in substance, the following questions:

(*a*) Do you want more water for your land?

(*b*) Are you in favor of the 35-year plan of payments?

(*c*) In case the 35-year payment plan is made a law, do you favor taking over the operation and maintenance of the project?

Six hundred and one replies were received, 594 of which answered "yes" to the first question and 7 "no." All were in favor of the second, and 421 voted "yes" on the third question and 168 "no," a few not voting on these two questions.

NEWLANDS FARMERS WANT ELECTRICITY

Water users on the Newlands project, Nevada, have been active recently in planning for and constructing power distribution lines to supply farms with electricity. Approximately 15 miles of such lines have been built or are under construction. The expense is borne by the water users themselves under cooperative arrangements. The Nevada Valleys Power Co., which distributes power generated at the Lahontan power plant, which is under lease to the Canyon Power Co., has submitted a proposal to the water users for the construction of lines and distribution of power over the project. Farmers in the Sheckler, Harmon, and Stillwater districts have formed tentative organizations to promote power development in their respective localities.

Should the Colorado River development be authorized by Congress, the general prosperity and wealth of the Southwest would be enhanced almost beyond calculation.

Aided and Directed Settlement

SOLUTION of the perplexing problems that have confronted the development of Federal reclamation in the country for the past decade is believed to be in sight, according to a statement issued recently by Secretary Work.

The proposed measure, which the Senate Committee on Reclamation has approved, to be used as an experiment in financing and aiding settlers on two projects, the Secretary believes, will determine definitely whether this method of developing lands under Government irrigation is feasible and practical. His statement follows:

"Reclamation Bureau officials are gratified at the progress being made in Congress toward the enactment of legislation which promises a satisfactory solution of reclamation problems, both from the viewpoint of Congress and the Department of the Interior. The bill recently drafted asking an appropriation of $500,000 to cover a period of three years for experimentation on two reclamation projects to determine whether financial assistance to settlers would be both feasible and practical, has been approved by both the Senate Reclamation and Appropriation Committees. It is believed that Congress will before adjournment accept this measure, which embodies what the bureau feels are perhaps the first steps in a definite solution of one of the most perplexing problems which has confronted reclamation development in this country for the past decade.

"Legislation for State aid to reclamation settlers was first introduced in the Sixty-eighth Congress, and a law was enacted in 1924 obligating States to aid those selected settlers on new projects who possessed $2,000 or its equivalent in farm equipment. With the passage of this act the Reclamation Bureau was, of course, obliged to observe this law and proceed under it. The State of Washington cooperated with the Reclamation Bureau in the administration of the new act, but Oregon and Nevada failed to extend their cooperation when the Department of the Interior sought to administer the new law in those States, especially those provisions relating to State aid for the new settlers.

"The legal division of the Interior Department recently, after an extensive survey and study of State statutes relating to public lands, found that several of the States could not, under their constitution, extend aid to settlers as provided for in the national act. This situation was explained to the Senate Committee on Reclamation last week, and I immediately offered the same substitute for State aid which the department offered and supported last year in the Kendrick bill. This substitute proposal was accepted by the Senate committee, and a bill at once drafted, which was introduced in the Senate and favorably reported out of committees.

"Reclamation Bureau officials believe that aid in preparing land for new settlers will be necessary. Many foreign governments have extended similar aid to pioneer land settlers, which has resulted in some instances in profitably tilled land, and I am sanguine that the proposed new plan will at least furnish a basis in this country for constructive experimentation. It is felt, however, that the public mind perhaps is not at this time sufficiently advised in this direction to either approve or disapprove such a policy, from an immediate permanent viewpoint, and the Reclamation Bureau is not willing now to recommend heavy expenditures in such a line of development until experimentation has proved the wisdom of such a course."

Organization Activities and Project Visitors

DR. Elwood Mead, Commissioner of Reclamation, was in New York City during March as the representative of the Department of the Interior on Engineering Council for the consideration of the question of a Department of Public Works.

Thomas Dignan, an attorney in Glasgow, Mont., has been in Washington, D. C., recently representing the two divisions of the Milk River project in the matter of adjustments.

George E Stratton, superintendent of the Milk River project, spent some time at the Washington office in consultation with the commissioner on project matters.

O. H. P. Shelley, newspaper editor of Red Lodge, Mont., visited the Washington office during March to discuss questions relating to adjustments on the Milk River project.

Col. B. F. Fly, guardian of the Yuma Mesa, has been appointed special Washington representative of the Truckee-Carson irrigation district, Newlands project

Gov. D. W. Davis has submitted his resignation as director of finance.

Randolph E. Fishburn, American consulting engineer, and Armando Santacruz, Mexican consulting engineer, members of the International Boundary Commission, were in Yuma during February, in connection with a survey of the Colorado River to determine definitely the status of about 1,800 acres of accretion land at present undeveloped and for which water is available.

Superintendent Weber of the Orland project has been in Berkeley recently for a conference with the district counsel and the counsel for the Orland Unit Water Users' Association regarding certain stipulations connected with the adjudication suit.

Assistant Engineer E. T. Eriksen of the Orland project spent considerable time at Colusa, Willows, and Red Bluff in an examination of the county records for use in the adjudication suit.

Assistant Engineer E. R. Romberg, of the Grand Valley project, was in Denver for several days' vacation.

W. H. Olin, agriculturist of the Denver & Rio Grande Western Railroad; Waldo Kidder, agriculturist, Colorado Extension Service; and B. W. Fairbanks, livestock extension agent of the Colorado Extension Service, visited the Uncompahgre project recently.

District Counsel B. E. Stoutemyer was on the Minidoka project for a couple of days to attend public meetings held by the water users of the Burley irrigation district for the purpose of explaining the terms of the proposed agreement under the act of December 5, 1924.

Yakima Apples Shipped Abroad

Two cars of fancy Winesaps left the Yakima project recently bound for England and Germany. The German market requires the larger sizes and the shipment to that country carried sizes ranging from 125 to 175 apples per box. The English market takes a smaller apple, and the fruit going there ran from 175 to 216 per box.

The apples are being shipped across country and will be loaded for export in New York.

Superintendent Youngblutt, of the Belle Fourche project, was in Washington recently in conference on repayments and terms under which water would be delivered to settlers in 1926.

Engineer Walker R. Young has been placed in charge of the Kittitas project with headquarters at Ellensburg, Wash.

John A. Lee, power-house foreman on the Riverton project, has resigned to accept a position with the Sunnyside Mining & Milling Co., of Eureka, Colo.

Associate Engineer J. R. Iakisch, of the Shoshone project, made an inspection trip recently to the Lower Yellowstone project in connection with the preparation of a report on proposed drainage construction on the latter project.

Prof. Ivan C. Crawford, dean of the School of Engineering of the University of Idaho, was a recent visitor at the American Falls Dam.

Recent visitors on the Milk River project included Frank Scotten and J. C. Dow, of the Montana Power Co.; District Counsel Roddis; W. Y. Cannon, Montana manager for the Utah-Idaho Sugar Co.; Robert Howard, superintendent of the Chinook Sugar Factory; and E. R Schepplemann, chief clerk of the Lower Yellowstone project.

Assistant Engineer E. W. Fritsch, of the Newlands project, was called to Evansville, Ind., recently on account of the serious illness of his father, who died two hours after his arrival.

A conference was held in Reno during February for the consideration of the application of the Lake Tahoe Co. to lease the Government 63-acre tract at the outlet of Lake Tahoe. Those present at the conference included Superintendent Richardson, of the Newlands project, representing the Government; C. T. Bliss and Henry F. Droste, representing the Lake Tahoe Co.; E. J. Foulds, representing the Southern Pacific Co.; and Roy Stoddard, C. E. Kent, B. S. Holmes, and A. D. Drumm, representing the Truckee-Carson irrigation district.

Victor L. Minter, former chief clerk on the Carlsbad project, has resigned to accept the position of secretary of the Carlsbad Chamber of Commerce. He has been succeeded as chief clerk by Walter C. Berger, former bookkeeper on the Yuma project. Jean C. Thrailkill, formerly on the Riverton project, will succeed Mr. Berger as bookkeeper at Yuma.

A. C. Cooley, of the Department of Agriculture, attended the recent economic conference at Hermiston, Umatilla project. It is believed that much benefit will accrue to farming operations on the project as a result of the conference, which was attended largely by project water users.

C. R. Wheeler, assistant clerk, has been transferred from the Williston project, North Dakota, to the Klamath project, Oregon-California.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1926

ADMINISTRATIVE ORGANIZATION FOR THE BUREAU OF RECLAMATION

HON. HUBERT WORK, SECRETARY OF THE INTERIOR

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E. K. Burlew, Administrative Assistant to the Secretary; **J. H. McNeely,** Assistant to the Secretary; **W. B. Acker,** Chief Clerk

Washington, D. C.

Elwood Mead, Commissioner, Bureau of Reclamation

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W. F. Kubach, Chief Accountant — H. A. Brown, Chief of Division of Settlement and Economic Operations — C. N. McCulloch, Chief Clerk

George C. Kreutzer, Director of Reclamation Economics

Denver, Colorado, Wilda Building

R. F. Walter, Chief Engineer; S. O. Harper, General Superintendent of Construction; J. L. Savage, Designing Engineer; L. N. McClellan, Electrical Engineer; Armand Offutt, District Counsel; Harry Caden, Fiscal Agent; Andrew Weiss, Assistant Director of Reclamation Economics; B. E. Hayden, Industrial Agent.

Project	Office	Superintendent	Chief clerk	Fiscal agent	District counsel	
					Name	Office
Belle Fourche	Newell, S. Dak.	F. C. Youngblutt	R. C. Walber	R. C. Walber	Wm. J. Burke	Mitchell, Nebr.
Boise	Boise, Idaho	J. B. Bond	E. R. Mills	C. F. Weinkauf	B. E. Stoutemyer	Boise, Idaho.
Carlsbad	Carlsbad, N. Mex.	L. E. Foster	W. C. Berger		Ottamar Hamele	El Paso, Tex.
Grand Valley	Grand Junction, Colo.	J. C. Page	W. J. Chiesman	C. E. Brodie	J. R. Alexander	Montrose, Colo.
Huntley	Ballantine, Mont.	A. R. McGinness	J. P. Siebeneicher	M. M. Wilson	E. E. Roddis	Billings, Mont.
King Hill [1]	King Hill, Idaho					
Klamath	Klamath Falls, Oreg.	H. D. Newell	N. G. Wheeler	Joseph C. Avery	R. J. Coffey	Berkeley, Calif.
Lower Yellowstone	Savage, Mont.	H. A. Parker	E. R. Scheppelmann	E. R. Scheppelmann	E. E. Roddis	Billings, Mont.
Milk River	Malta, Mont.	G. E. Stratton	E. E. Chabot	E. E. Chabot	do	Do.
Minidoka	Burley, Idaho	E. B. Darlington	G. C. Patterson	Miss A. J. Larson	B. E. Stoutemyer	Boise, Idaho.
Newlands	Fallon, Nev.	D. S. Stuver	G. B. Snow	Miss E. M. Simmonds	R. J. Coffey	Berkeley, Calif.
North Platte	Mitchell, Nebr.	H. W. Bashore	L. H. Mong	T. R. Pacl	Wm. J. Burke	Mitchell, Nebr.
Okanogan	Okanogan, Wash.	Calvin Casteel	W. D. Funk	N. D. Thorp	H. L. Holgate	Portland, Oreg.
Orland	Orland, Calif.	R. C. E. Weber	C. H. Lillingston	C. H. Lillingston	R. J. Coffey	Berkeley, Calif.
Rio Grande	El Paso, Tex.	L. M. Lawson	V. G. Evans	L. S. Kennicott	Ottamar Hamele	El Paso, Tex.
Riverton	Riverton, Wyo.	H. D. Comstock	R. B. Smith	V. E Hubbell	Wm. J. Burke	Mitchell, Nebr.
Salt River [2]	Phoenix, Ariz.	C. C. Cragin [3]				
Shoshone	Powell, Wyo.	L. H. Mitchell	W. F. Sha	Mrs. O. C. Knights	E. E. Roddis	Billings, Mont.
Strawberry Valley	Provo, Utah	W. L. Whittemore	H. R. Pasewalk	H. R. Pasewalk	J. R. Alexander	Montrose, Colo.
Sun River	Fairfield, Mont.	G. O. Sanford	H. W. Johnson	F. C. Lewis	E. E. Roddis	Billings, Mont.
Umatilla	Hermiston, Oreg.	H. M. Schilling	C. M. Voyen	C. M. Voyen	H. L. Holgate	Portland, Oreg.
Uncompahgre	Montrose, Colo.	L. J. Foster	G. H. Bolt	F. D. Helm	J. R. Alexander	Montrose, Colo.
Yakima	Yakima, Wash.	J. L. Lytel	R. K. Cunningham	J. C. Gawler	H. L. Holgate	Portland, Oreg.
Yuma	Yuma, Ariz.	P. J. Preston	M. J. Gorman	E. M. Philebaum	R. J. Coffey	Berkeley, Calif.

Large Construction Work

Minidoka, American Falls Dam.	American Falls, Idaho.	F. A. Banks [4]	H. N. Bickel	O. L. Adamson	B. E. Stoutemyer	Boise, Idaho.
North Platte, Guernsey Dam.	Guernsey, Wyo.	F. F. Smith [4]	Chas. Klingman	T. R. Pacl	Wm. J. Burke	Mitchell, Nebr.
Umatilla, McKay Dam.	McKay Dam, Oreg.	R. M. Conner [5]	C. B. Funk	W. S. Gillogly	H. L. Holgate	Portland, Oreg.
Kittitas	Ellensburg, Wash.	Ralph Lowry [4] Walker R. Young [4]	E. R. Mills		H. L. Holgate	Portland, Oreg.

[1] Project operated by King Hill Irrigation district.
[2] Project operated by Salt River Valley Water Users' Association.
[3] General Superintendent and Chief Engineer.
[4] Resident Engineer.
[5] Construction Engineer.

Important Investigations in Progress

Project	Office	In charge of—	Cooperative agency
Sacramento Valley	Berkeley, Calif.	N. B. Hunt	Sacramento Valley Development Association and State of California.
Huerfano	Denver, Colo.	E. B. Debler	
Dubois	American Falls, Idaho	F. A. Banks	Dubois Project Finance Association.
Milk River eastern tributaries	Hermiston, Oreg.	E. R. Crocker	
Spanish Springs storage	Fernley, Nev.	A. W. Walker	
Harney Valley	Boise, Idaho	J. B. Bond	
Owyhee	do	do	
Vale	do	do	
Salt Lake Basin	Salt Lake City, Utah	W. M. Green	State of Utah.
Methow-Okanogan	Okanogan, Wash.	Orrin C. Smith	Okanogan irrigation district.
North Platte (Casper) pumping	Guernsey, Wyo.	F. F. Smith	State of Wyoming.

The NEW RECLAMATION ERA is sent monthly to all water users on the reclamation projects under the jurisdiction of the bureau who wish to receive the magazine. To others the subscription price is 75 cents a year, payable in advance by check or money order drawn in favor of the Special Fiscal Agent, Bureau of Reclamation.

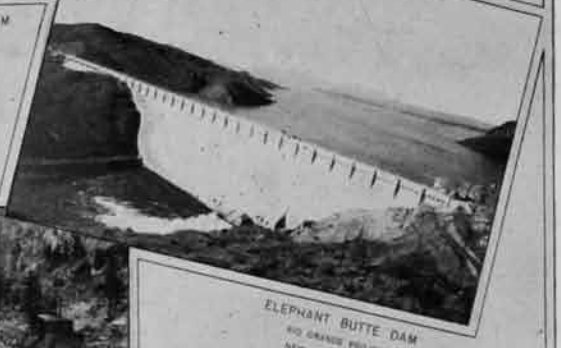
DEPARTMENT OF THE INTERIOR

BUREAU
OF
RECLAMATION

SUN RIVER DIVERSION DAM
SUN RIVER PROJECT
MONTANA

PATHFINDER DAM
NORTH PLATTE PROJECT
NEBRASKA-WYOMING

ARROWROCK DAM
BOISE PROJECT
IDAHO



SUNNYSIDE DIVERSION DAM
YAKIMA PROJECT
WASHINGTON

ELEPHANT BUTTE DAM
RIO GRANDE PROJECT
NEW MEXICO-TEXAS

SHOSHONE DAM
SHOSHONE PROJECT
WYOMING

COLORADO RIVER DIVERSION DAM
GRAND VALLEY PROJECT
COLORADO

ROOSEVELT DAM
SALT RIVER PROJECT
ARIZONA

1428