INTERNATIONAL WATER COMMISSION

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Report of Inspection Trip over Colorado River Levee Systems below Yuma, Arizona, September 17, 18, and 19, 1929

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Complying with verbal instructions of the Chairman of the American Section, the writer made an inspection of the levee systems along Colorado River, exclusive of the levees of the Yuma Project of the U. S. Bureau of Reclamation, on September 17, 18, and 19, 1929.

The lands in Mexico in the delta of the Colorado River which are now under irrigation from that stream are mostly owned or controlled by American citizens. The largest holding is that of the Colorado River Land Company, S. A., a corporation of which Mr. Harry Chandler of Los Angeles, California, is a principal stockholder. Other large holdings owned or controlled by Americans are those of the Southern Pacific Land Company, the Imperial Development Company, the Daugherty Estate, Globe Mills Company, and Mt. Signal Land and Cattle Company. Together these American interests control 876,500 acres, less, perhaps some minor sales since June, 1928, and of this something more or less than 200,000 acres is irrigated. (See Report of June, 1928.) One of the larger American operators is Chester H. Allison, a lessee of Colorado Land Company, and more recently also of the Mexican Government, who works chiefly through Delta Canal Company and Baja California Canal Company, the stockholders of at least the latter company being understood to include several others than Mr. Allison.
The Imperial Irrigation District Levee System

The inspection trip started early in the morning of September 17, the writer first proceeding from El Centro to Andrade with M.J. Dowd, Chief Engineer and General Manager of Imperial Irrigation District and of the Compañía de Terrenos y Aguas de la Baja California. At Andrade we were joined by R. M. Priest, Superintendent of the Yuma Project, U.S. Bureau of Reclamation, and Frank Higley, superintendent of river control for Imperial Irrigation District and subsidiary company. Using the District speeder, the trip was made from Andrade to the lower end of Pescadero Levee; i.e. from mile 0 to mile 31. Frequent stops were made for discussion of the condition of the levee system of the District and company. From the inspection and discussion the following facts or opinions were developed:

(1) It is understood that it is the opinion of the Imperial Irrigation District officials that the district levee system is now safe against floods up to 200,000 cu.ft. per sec. from the head down to mile 12 1/2. To care for such a river, however, the following, it was stated, is necessary below mile 12 1/2:

- Mile 12 1/2 to mile 14 3/4 -- Raise a maximum of 3 feet.
- Mile 14 3/4 to Ockerson stub levee, mile 17 3/4 -- No increase in height needed.

Ockerson stub levee to Pescadero Dam -- Raise and strengthen in 1931 if Allison east-side levee is not maintained. There is now a drop of 4 feet in this levee directly below Ockerson stub levee, the low point being at about mile 21 1/2. If the Allison east-side levee is maintained, this raising will not only be required in 1930, but will need to be carried 3 or 4 feet higher than would be required by the normal raising of the river bed.

(2) The representative of the Irrigation District stated that he
will not recommend to the board of directors that the District raise the levee between Ockerson stub levee and Pescadero Dam in 1930, maintaining that if the levee breaks, the district can safely fall back on its east line of defense at Volcano Lake levee.

His reasoning for this stand is that due to the Allison land development in the Volcano Lake area, there is now free passage for the river southerly to the Hardy, furthermore, that if a break occurs in this section of the levee next year, it will be due to the raising of the flood plane by Allisons' east-side levee, and the District will not be responsible.

While the District holds that it could afford to protect this section of the levee against normal raising of the river bed by silting, it is its position that its expenditure of the amount considered necessary to protect against the east-side levee would not be justified by the risk involved to Imperial Valley.

(3) The Board of Directors of Imperial Irrigation District has given instructions to do no further maintenance work on the levees below Pescadero Dam, going so far during the high water of this season as to stop the dumping of rock directly below the dam where the levee had been cleared to receive it. It is fully recognized that the levee is not safe from Pescadero Dam down, but it is maintained that the hazard is not to lands in Imperial Valley. The district holds to the position that with the Boulder Canyon Dam now assured within a period of eight to ten years, it can protect Imperial Valley at Volcano Lake levee.

(4) The Imperial Irrigation District contends, as previously, that the Rodriguez levee is of no advantage to Imperial Valley, that its construction prior to the silting in of the low area below and opposite to Pescadero
Cut was a mistake, and that it cannot be practically maintained against the constantly rising flood plane caused by silting.

**Allison East-side Levee System**

After completing the inspection of the Imperial Irrigation District levee system as above described, Messrs. Dowd and Higley left Mr. Priest and the writer at Mr. Allison’s Pescadero siphon camp where later in the day they were joined by Mr. J.B.Silva, local representative of the First Zone of Reclamation and Irrigation of the Mexican Government; Mr. H.M.Rouse, Engineer for the Colorado River Land Company, and Mr. G.L.Seligman, locally in charge of the Allison east-side development. The evening was devoted to going over maps and other data and on the following day, September 18, the east side levee system was inspected from the new siphon camp on the east bank of the river easterly to San Luis, and from the former to the first break in the new levee leading southerly. From the examination of data and the field inspection the following facts of general interest in connection with the work of the Commission were developed:

(1) The San Luis levee extends from the lower end of the Yuma Project levee a distance of 3.7 kilometers (2.3 miles) to the boundary line between Sonora and Lower California, and from that point a distance of 9.057 kilometers (5.62 miles) to the new siphon installation. The total length of this levee from San Luis to the new siphon installation is 12.757 kilometers, or 7.92 miles.

(2) The Vacanora Canal of the Baja California Canal Co. (Mr. Allison’s company on the east side) extends, or was under construction in 1929, from the new siphon installation southeasterly for a distance of 28.359 kilometers (17.58 miles) to the new Mexicali and Gulf Railroad. This canal is the borrow pit of the new levee which it parallels. The following construction work, which was carried on in sections, was accomplished prior to high water in 1929:
K. 0.0 to K. 14 -- Canal and levee completed.
K. 14 to K. 19 + 615 -- Levee completed.
K. 19 + 615 to K. 19 + 700 -- Levee one-half completed.
K. 19 + 700 to K. 21 + 240 -- Levee completed.
K. 21 + 240 to K. 22 + 725 -- One-third of levee completed.
K. 22 + 725 to K. 25 + 500 -- One-fourth of levee completed.
K. 25 + 500 to K. 28 + 360 -- Levee completed and canal completed from K. 27 + 900 to K. 28 + 360.

From K. 28 + 360 it is the intention that water carried by Vacannora Canal will be turned into old sloughs which bear south to about Monuments 30 to 31 on the south boundary of the holding of the Colorado River Land Company. There has been no location of the canal below that line, although it is the intention to extend the canal to the Mexican national lands which have been leased.

(3) In order to hold the Colorado against the Pescadero levee, an attempt was made to confine the channel within a width of 900 to 1000 feet opposite that levee by the construction of an experimental loop levee from the Baja California siphons westerly and southeasterly back to the Vacanorra levee. It was hoped that this experimental levee would have maintained water against both siphon installations, and it was the intention, if necessary, to accomplish this by the annual construction of Andrade type dams. However, this experimental levee failed at 3:30 P. M. on June 8, 1929, and has since almost completely disappeared.

(4) Surveys for location of the east-side levees were started October 9, 1928. Construction work was started November 23, 1928, and
ended May 24 to 26, 1929. A total of 1,600,000 cu. yds. of earth was removed in the construction of the levees and canals.

(5) The east-side siphons, known as the Baja California siphons, installed in the spring of 1929, consist of five 32-inch units. They began operating about June 20, 1929, to keep open the constructed channel of Vacanora Canal.

(6) The Vacanora levee broke at 9:15 A.M. on June 2, 1929, at Sta. 5 + 500. The San Luis, or Baja California, levee broke on the same day at 7:15 P.M. at Sta. 5 + 500.

(7) Photographs were taken (1) of intake of the Baja California siphon installation from the north side; (2) of the outlet end of this installation, showing levee and temporary construction camp; (3) down Vacanora Canal from the siphon installation; (4) of the main break in the Vacanora levee about 1 kilometer south of the siphon installation; (5) of the main break in the San Luis or Baja California levee, looking westerly; and (6) of the San Luis or Baja California levee looking toward San Luis from this break. Copies of these photographs are attached hereto.

An additional photograph (7) was taken of the Pescadero siphon installation, this showing (extending over the Pescadero levee) the two 42-inch units installed in 1929, a copy of this also being attached. The Pescadero siphon installation now consists of three 36-inch units installed in 1927, two 42-inch units installed in 1928, and the two 42-inch units installed in 1929. The maximum diversion by these siphons was made June 1, 1929, and amounted to 1005 cu. ft. per sec., as reported by the operator in charge.
Rodriguez Levee

This was inspected throughout its length on September 19 by Messrs. Priest, Silva, Rouse, and Seligman and the writer. This levee was constructed and has been maintained to date under the immediate charge of Mr. Rouse. It leaves Pescadero levee just below mile 38 and extends for a distance of 26.340 kilometers (16.33 miles), or about 2 kilometers below the new Mexicali and Gulf Railroad. From the examination made the following facts were developed.

(1) Rodriguez levee was started in the spring of 1927 for the purpose of affording protection to lands under J. C. Allison's Delta Canal which became exposed with failure of the extension of Pescadero levee during high water of 1926. Of the original allotment of $200,000 for the work, 20 per cent, or $40,000 was contributed by the Mexican Government and the remainder by Colorado River Land Company. According to figures supplied by General Manager H. H. Clark of the Colorado River Land Company, the cost of construction and maintenance on the levee during 1927 amounted to $289,150 and the cost of raising and maintenance in 1928 and 1929 was $40,978 and $75,000, respectively, or a total to date of $405,128. The levee in the main skirts inside the high-water line of February, 1927, but is on the river side of that line at a number of points, particularly near Kilometers 3, 12, 14, 15, 17, 20, 21, and 24.

(2) The levee is without rock revetment at any point. In places it has been protected by short brush retards extending out from the stream side. For considerable distances it is barely wide enough to drive on with an automobile.
(3) The river side of the levee has silted up very materially since construction, although not adjacent to the levee throughout its length. The river is now swerving west from the old extension of Pescadero levee and is silting next to Rodriguez levee particularly opposite Sta. 9 + 500. (See accompanying Map A.) Between this point and kilometers 14 to 15 silting has already amounted to 3 to 4 feet. At about K. 15 the river begins to swing away from the levee and there is practically no current against the levee below K. 18.

(4) A picture of the levee was taken at about K. 12 (Photograph 8) which shows the disparity in elevations between the river and land slides. At that point the levee is about 12 feet high on the land side and about 3 feet high on the river side. Another picture (Photograph 9) depicts the silting during 1929 at Sta. 12 + 500, the Indian hut shown having been occupied and the land surrounding it having been farmed in the spring prior to the 1929 high water.

(5) Some parties consider the levee dangerous as far up as K. 5. This opinion is concurred in by the writer. At K. 5 the hazard is from the nearby old channel of Bee River. The river is not eroding at this point but silting has been considerable and the differences in the land level in front of and behind the levee appeared to be as great as at K. 12. Spilling of high water back into the old channel of Bee River was what was feared by the Colorado River Land Company and the Allison interests following the break in the Pescadero levee extension in 1926, although the danger of this was not conceded by Imperial Irrigation District because of the low land to the west and south.
If Rodriguez levee should fail near its upper end the entire area in the Allison lease under Delta Canal No. 2 (and the Pescadero siphons) would without doubt be flooded and in all probability the water would back up to Volcano Lake Levee.

The Controversy Regarding Responsibility for Maintenance of the Levees

Differences regarding responsibility for maintenance of the levees in Mexico have been long standing, and have been aggravated by the east-side and Pescadero siphon development of Mr. Allison and the Colorado River Land Company. To understand the present situation it is necessary to go back to the construction of Pescadero Cut in 1921-22.

The construction of Pescadero Cut was at first opposed by Colorado River Land Company. However, a written agreement for its construction was signed by the District and the Company October 30, 1921. Because of its present bearing, the agreement is given in full.

THIS AGREEMENT, made this 30th day of October, 1921, by
and between the COLORADO RIVER LAND COMPANY, a corporation, and
the IMPERIAL IRRIGATION DISTRICT, a municipal corporation,
WITNESSETH:

That the Colorado River Land Company, in consideration that the Imperial Irrigation District will, during the fiscal year 1921-22, in the manner outlined in its official budget, and in amounts as conditions may require, not exceeding in the aggregate the sum of $115,000.00, repair and keep in repair the Ockerson Levee north of the Bee River and the Volcano Lake Levee; that the
said Colorado River Land Company consents to the said Imperial Irrigation District making a cut on the south side of the Bee River, and putting the necessary obstruction in the river for turning the same, at the expense of the Imperial Irrigation District; and that the Colorado River Land Company, in consideration of the said Imperial Irrigation District performing the above covenants, the said Colorado River Land Company agrees that it will repair and build the Saiz Levee from a point on the Saiz Levee some three miles east of the westerly end thereof to a connection with the Volcano Levee.

As the turning of the Bee River over the lands of the Colorado River Land Company may do damage to said lands, any damage done thereby is considered a part of this agreement, and any future damages on account of said turning of the river are hereby waived by the Colorado River Land Company.

**IT IS FURTHER AGREED** that each of the parties hereto mutually waives any right or claim to any damages which may result from a break or failure of any of the levees built, repaired or maintained under this agreement, and each party hereto specifically disavows the assumption of any obligation by the execution of this contract, for the benefit of any party not specifically made a party hereto.

This agreement is made, and acceded to by the Colorado River Land Company although great, and possibly, irreparable damage will result from the turning of this river, for the
general good of the entire district on both the American and
Mexican sides, and with the hope that it will engender a co-
operative spirit between the two districts in the future which
has not in the past existed.

It is hoped to be able to return the Colorado River to
its original channel; until this is possible, it is the intent
and purpose of both parties hereto that provided the proposed
cut from DeBe River into the Pescadero River, and thence to the
Hardy River, is successful, that they shall jointly continue
the levee work along the new channel of the Colorado River
thus formed to the end that such new levee shall form the main
protective levees for the entire Imperial Valley.

(Corporate Seal) COLORADO RIVER LAND COMPANY
By O. F. Brant, Vice President

IMPERIAL IRRIGATION DISTRICT
By J. S. Nickerson, President
By F. H. McIver, Secretary

At least two points seem clear from the reading of the above
contract, although at present there is controversy between the District
and the Company regarding them. These are that damages resulting from
turning the river down Pescadero cut, or from breach or failure of any
of the levees built, were waived by both parties (paragraphs 2 and 3),
and that it was the intent of both parties that if the Pescadero cut
should prove successful, they should jointly continue the levee work along
the new channel of the Colorado River, to the end that such new levee
should form the main protective levee for the entire Imperial Valley
(paragraphs 4 and 5).

While Pescadero Cut was successful in turning the river, the
levee built below Pescadero Cut failed in 1926 (see writer's report of
June, 1926, to April, 1927, page 56) and has not been reconstructed.
This levee was built at its upper end by the District and continued
by Mr. Allison and Colorado River Land Company. The District maintained
that construction of the levee below Pescadero Cut was impracticable in
advance of the building up of the river cone and the silting of the low
surrounding area, and they declined to participate in reconstruction.
It was to meet the situation resulting from this condition that
Rodriguez Levee was constructed in 1927 by the Colorado River Land
Company interests, and the Mexican Government.

The controversy regarding reconstruction of the extension of
Pescadero Levee was complicated by two matters of importance. One
was the pending Boulder Canyon legislation, the other the effort initiated
by the Colorado River Land Company interests to obtain a large
Congressional appropriation for returning Colorado River to its old
channel along Sonora Mesa. Apparently the effects of this controversy
have carried to the present and have intensified the differences between
the district and the company.

A new cause of ill feeling is found in the construction of the
Pescadero siphon diversion by the Colorado River Land Company interests
beginning in 1927. This furnishes a substitute supply for that obtained from the district canal system by Delta Canal No. 2, and of course yields no income to the District, although the District must stand ready to serve the lands under the siphons if and when they cease to function. After installation of the Pescadero siphons the Colorado River Land Company interests (it is alleged by the District) obtained an order from the Mexican Government annulling article 4 of the water tariff and regulations, which stipulated that 3,125 cubic meters per hectare would be the minimum amount of water which lessees could ask for annually, this amounting to about 1 acre-foot per acre. The District has only recently filed protest with the Mexican Government against repeal of this article.

The most recent occasion for disagreement between the District and the Colorado River Land Company interests has of course been the new east side development by the Allison interests as described above. This in turn has led to the refusal of the District to maintain the lower levee system to which reference has been made.

Contributions to Protective Work

In Mexico

In the writer's report of June, 1926, to April, 1927, contributions of Imperial Irrigation District and its predecessors to flood protection works in Mexico since 1914 were given as $3,364,237.33, and the expenditures of the old company, the Southern Pacific Company, and the United States Government prior to 1914 were estimated at in excess of $4,200,000. This made a total of $7,564,237.33. Additional figures furnished by Imperial
Irrigation District in August, 1929, bring their expenditures for construction and maintenance since January 1, 1914, to $4,154,087, and the total from all United States sources to $8,354,087. In the writer's report above referred to the expenditures by Colorado River Land Company interests and the Mexican Government (which contributed $40,000) were given as $340,082. A statement submitted by Colorado River Land Company under date of September 25, 1929, lists expenditures by them of $581,908, exclusive of the $40,000 paid by the Mexican Government, of which $405,128 has been for Rodriguez levee construction and maintenance.

Imperial Irrigation District has always maintained that the Mexican land interests have never paid their full share of the cost of necessary protective work in Mexico, emphasizing their contention by the statement that the development of Mexican lands which has taken place could not have been possible except for the expenditures by the District and its predecessors and the United States. The Colorado River Land Company interest hold that they have contributed amply through water rates paid to the District and its predecessors. For instance, it maintains that for the 6-year period 1923 to 1928, the average annual revenue to the District in Mexico in excess of expenditures by the District "in and for" Mexico has been $406,652 (Letter dated February 29, 1928, from General Manager of Colorado River Land Company to the President of the Regional Consulting Board of Commerce and Industry at Mexicali). The rejoinder of the District to the contention of the Company is that the District is entitled to interest on that portion of its investment in Mexico which is for the purpose of delivering water, according to the terms of its concession, to
lands in Mexico. It has also been claimed by one of the directors of the District that the District is entitled to a profit on its operations in Mexico. While the writer has at hand no official figures, an officer of the District has stated that, according to his calculations, the District has received from Mexican land interests approximately $3,000,000 less than due it.

Summary and Conclusions

(1) There are very serious hazards in the present flood control situation along the Colorado below Yuma. These are a direct result of the conflict of interest and long-standing controversy between Imperial Irrigation District and the Colorado River Land interests. The existing west-side levee system below the Ockerson stub levee is not safe for either Imperial Irrigation District or the developed Mexican lands, although the immediate hazard is more to Mexican lands, particularly those under the Pescadero siphons, than to Imperial Valley in California. The construction by the Allison interests of the east-side levees has precipitated further differences between the District and the Colorado River Land Company interests. The District has announced that it will do no further protective work below Pescadero Dam and the Chief Engineer of the District states that he will recommend that no work on the levees above Pescadero Dam except as such work may be required by a normal raising of the river bed, claiming that maintenance of the east-side levee system will create an abnormal rise against which the District cannot afford to protect itself, since it can fall back on the Volcano Lake levee.
(2) There is urgent need for a thorough and impartial study of the existing flood menace along the lower Colorado and for an equitable allocation of costs and responsibilities to the interests benefited. In the United States the private interests are represented by Imperial Irrigation District, which is itself a public agency. In Mexico, the private interests are those of the Colorado River Land Company and its various lessees, the other private landowners within the area now protected and benefited by the irrigation system, the Mexicali and Gulf Railroad, and other industries. With reference to the public interests involved, it is difficult to escape the conclusion that greater responsibilities lie with the governments of both the United States and Mexico than have thus far been assumed; or at least, waiving the point of greater governmental responsibility, it is believed that both governments would be greatly benefited by undertaking a larger portion of the burden of flood control below the international boundary. The reasons for this belief are as follows:

(a) There is no indication that the existing conflict regarding flood control will be adjusted short of large damage to developed lands in Mexico and at least a critical situation with reference to Imperial Valley in the United States. Neither the United States nor Mexico can afford to take the risk involved under the present chaotic situation.

(b) Adequate handling of the flood control situation will facilitate international adjustment of the water supply and thus make more secure use of water on both sides of the international boundary.

(c) The physical data necessary for planning a final solution of the lower Colorado flood control problem have never been gathered, and will
never be gathered if left entirely to the private interest involved, or to the two governments acting separately. Provision for the gathering of such data and its annual revision as the river changes would naturally be one of the first steps if the two governments were jointly to assume a substantial share of the burden.

(d) Assumption by the two governments of a larger share of the cost of flood control would result in a greater governmental responsibility and authority in the design and construction of the flood control works.

(e) Regulation of Colorado River at Boulder Canyon will reduce but will not eliminate the flood control problem. It will, however, be shifted from control of very large flows to control of perhaps 40,000 to 80,000 cubic feet per second. Without a definite and more or less fixed channel, a flood of 40,000 cubic feet per second may compare in the damage done with past floods in excess of 100,000 cubic feet per second. If the two governments were now to assume a greater burden and responsibility, the ultimate solution could be the more easily and the more economically accomplished.

(3). It is believed that if the two governments working jointly were to reach an agreement as to the desirable flood control measures and as to the share of the cost each of the various private and public interests should carry, the major interests would abide by such agreement and assume the cost allotted to them. The Colorado River Land Company interest have signified their willingness to follow such a plan. It would seem that Imperial Irrigation District would have ample reason to do the same.
(4) Decision by the two governments as to their course and as to the proper responsibility of others should not be further delayed. In reaching this decision it is very desirable that the larger aspects of the problem be kept clear of the local differences.

Memorandum by R. M. Priest

At the request of the writer, Mr. R. M. Priest, Superintendent of the Yuma Project, prepared answers to six specific questions. His memorandum, which gives the questions asked, is attached hereto.
1. Intake of Baja California siphons.
2. Discharge end of Baja California siphons.
3. Down Vacanora Canal from siphon installation.
5. Main 1929 break in San Luis Levee.
6. San Luis of Baja California Levee looking east from near the main 1929 break.
7. Intake of Pescadero siphons.
10. Rodriguez Levee looking northeast at kilometer 5.
10. Rodriguez Levee looking northeast at kilometer 5.
MEMORANDA FOR PROFESSOR FRANK ADAMS

COLORADO FLOOD CONTROL

Probable effect on Yuma Project of present controversy and lack of understanding regarding river control in Mexico.

The controversy between the Imperial Irrigation District and Colorado River Land Company is such that apparently neither party is going to take what seems to be the proper precautionary measures along the Imperial Irrigation District's levee between mile posts 19 and 31½ to prevent the Colorado River from again entering the Volcano Lake area, and particularly that section below Pesadero Dam, this being mile post 24½. This latter section, according to District officials, has been abandoned by them and they state that further maintenance below Pesadero Dam will not be done by the Imperial Irrigation District. This means that seven miles of levee will be subjected to the vagaries of the river and will be either cut away by erosion or topped by a high flood and destroyed. As the Rodriguez levee, built and maintained by the Colorado River Land Company, connects with the Imperial Irrigation District levee at about mile post 28, failure above this point would permit water to enter behind the Rodriguez levee and would cause the submergence of large areas now in crop. The affect of such an occurrence on the Yuma Project would probably be the lowering to a small extent of flood heights until remedial measures were taken. If the District's levee is maintained to mile post 31½, as in the past, the flood plane can be expected to gradually rise until channelization is effected to tidewater with probably some intervals of lowering as the river finds lower ground into which it can discharge, but this will only be temporary as the building up of the silt cone will again increase flood heights. I, therefore, do not anticipate any immediate adverse conditions to affect the Yuma Project on account of the present controversy between the Imperial Irrigation District and the Colorado River Land Company.

Seriousness of the present situation to lands in Mexico and Imperial Valley in the United States.

In my opinion the present situation is a very serious one, both to Mexican lands and Imperial Valley, but particularly to the Mexican lands. This is obvious for the reason that the Imperial Irrigation District levee to mile post 28 is the last line of defense for a very large area of improved Mexican lands and it is the first line of defense for Imperial Valley lands in the United States. Should this levee fail, the Imperial Valley can fall back on the Saiz and Volcano Lake levees, and though I do
not consider the Volcano Lake levee near its western terminus a dependable barrier, it did withstand an extremely high flood in 1921. This embankment could be strengthened at a reasonable cost, but due to the unstable foundation on a portion of it, could not be considered as a desirable structure to protect the large investment in Imperial Valley. The building up of the lake bed by the deposition of silt would raise the flood heights, which would, to keep pace, necessitate the periodical raising of the Volcano Lake levee until equilibrium was established. With the present elevation of the Volcano Lake levee at its western end 47 feet above sea level, and the distance to mean sea level approximately 40 miles, it is therefore evident that if the river maintains a slope of 1.2 feet per mile, and it can reasonably be assumed that it will do this, the Volcano Lake levee is not high enough. To me it seems imperative that the Imperial Irrigation District and the Mexican interests cooperate to the fullest extent in the maintenance of the levees along the present river channel, for only in this way can the interests of both parties receive the greatest benefits.

Immediate steps that should be taken to remove the existing hazard.

A brief outline of the lower levee system below mile post 19 on the Imperial Irrigation District's levee is as follows:

Mile post 19 is about opposite the extreme lower end of the Yuma Project and is the point on the Ockerson levee constructed in 1911; from this point the Bee River levee was built at the time the diversion of the river was made from the Bee River into the Pescadero by the Imperial Irrigation District in 1922, by what has become known as the Pescadero Cut. To make this diversion a rock fill dam was made across the Bee River and is known as the Pescadero Dam, and at times referred to as the Bee River Dam. This is at mile post 24½. The levee was constructed to mile post 29½ in 1922 and was extended in the spring of 1926 to mile post 32½ from which point it was extended in the same year two miles further by the Mexican interests. However, the summer flood of 1926 destroyed most of this two mile extension before it was completed. Also, during the summer flood of 1926 the levee was breached by the erosive action of the river at mile post 31½. In 1927 the Rodriguez levee was constructed by the Colorado River Land Company, cooperating with the Mexican government, from mile post 28 on the Imperial Irrigation District's levee in a southwesterly direction for a distance of about 18 kilometers to protect lands then being developed.

The Bee River levee at mile post 19 is at this date approximately four feet lower than the grade of the Ockerson levee at this point, and though this levee has been raised three feet at mile post 28 and tapering out at mile post 19, this last summer's flood, with a discharge of 89,000 second-feet at the peak, stood within one and one-half feet of the top of the levee at one point and so saturated the fill that rock trains could not operate over it until the track was supported by ties laid longitudinally. It is also reported that the high water mark at another point just above the Pescadero Dam was within eight inches of the bottom of the ties. Imperial Irrigation District officials are responsible for the statement
that they do not propose to raise any part of this levee before next summer's flood, that it is high enough to care for the gradual increasing flood heights due to the building up of the bed for at least another year, and that should it fail by being toppled or eroded away no serious results would occur. It is also stated that on account of a new levee on the Sonora side of the river that flood heights have increased and if the District's levee is topped it will be on this account. The parties responsible for the Sonora levee are also heavily interested in the lands protected by the District's levee in Lower California.

Flood heights are increasing each year against the Rodriguez levee due to the building up of the delta cone, and to me the condition is very critical. This levee has been raised annually since it was constructed and in so raising the added material was placed on top and in no place has the section been increased. The point has now been reached where future raising requires long hauls and the bottom of a large channel of the river which parallels the levee closely from kilometer 7 to 18 is as high or higher than the land protected by the levee. The water surface in this channel during a stage of about 30,000 second-feet at Yuma stood about 9 feet higher than the cultivated ground behind the levee. Although this levee has been successfully maintained it does not seem humanly possible to hold it much longer under the existing circumstances. It therefore seems necessary, if large improved areas are to be saved from inundation, that some other method be adopted than trying to build up a high fill with insufficient cross sectional area, and immediate steps should be taken as there is too much at stake to take further chances.

I believe that all parties concerned, that is, the Mexican government, Colorado River Land Company, and the Imperial Irrigation District, should cooperate to handle this problem. It is too big to allow selfish reasons to enter, for even with cooperation it will be found a serious one to successfully handle. For, if this Rodriguez levee should be topped or fail the river would surely divert itself toward the north, and, though there may be higher ground that would prevent immediate movement of waters to Volcano Lake levee, the same condition will arise again and the same result will be the answer, and each time it will be getting closer to Imperial Valley; for in that direction is the line of least resistance; cleared land and lower elevation will increase the hazard.

Under the circumstances and conditions now operating, the Colorado River will probably at its first abnormally high water, find its way through or over the top of some part of the present levee system below mile post 19, seriously menace the Imperial Valley, and inundate large areas of cultivated ground in Lower California. To temporarily overcome this hazard as far as possible under the existing conditions, it will be necessary to raise and maintain the Imperial Irrigation District levee from mile posts 19 to 31½ and extend it as far as it is feasible beyond this point. It seems imperative that the river be led away from the Rodriguez levee before next summer's flood, even though heroic measures be necessary such as diverting it toward the south and east as was done with the Bee River in 1922 when it was diverted through the Pescadero Cut. The cost of such an undertaking will be considerable and should not be borne by one party; as all concerned are equally
interested they should then all share in the cost. In fact, all of the maintenance and other necessary control work on the levees that protect both the Imperial Valley and Mexico should be done with forethought and well formulated plans and the cost shared by the parties interested, including the Mexican government.

Field work necessary to provide data for planning permanent control of the river below Yuma; probable time required to gather these data and probable cost.

As the cost of permanent control of the river below Yuma to the Gulf of California will be a considerable amount, field work should exhaust the possibilities so that the most economic and feasible plan could be adopted. Topographic surveys in connection with aerial photography should provide sufficient data in one low water season with a large organization. As the territory which would be mapped is in most places densely overgrown with brush and trees, it would be necessary to cut lines for most of the topography taken. But with the use of aerial photographs the possibilities of large areas could be eliminated. As no data is at hand two routes arbitrarily present themselves: one along the old Colorado River channel, and the other by way of the present river into the Hardy River, and thence to the Gulf. Without field data the route by way of the old Colorado channel appears to have the best possibilities. First the river did flow to the Gulf of California along this line for as far back as history dates and would still be in this location were it not for its erosive action and overbank pour that formed other channels. The river did not as is commonly believed build up a cone upon which to flow, finally reaching an elevation so high that it sought lower ground, but did flow in an orderly manner in its own channel, the bed of which did not rise from deposition other than what was necessary to maintain its equilibrium due to the extension of the delta into the Gulf of California or from its meanderings, but did from overbank pour during flood stages form small channels that came together and made larger ones, then on account of the meanderings due to the erosive action of the stream, cut its way to one of these main channels and diverted itself during the flood stage of the summer of 1909 into Volcano Lake, the outlet of which to the Gulf of California is through the Hardy River. The so-called delta cone is the building up of the banks of the river from overbank pour during the flood stages, and were it not for its tendency to meander, the river would not pour over its banks except during periods of highest floods. Therefore, since the river flowed for many years along the eastern side of this great valley it has by its meanderings and overbank pour probably built up many silt barriers that would prevent it from diverting itself to the westward if levied, even though the levees should fail occasionally, because there would not have been overbank pour to form channels into which it could change its course. The distance and grade was that established by the river itself and if again put back into this channel, the greatest safety factor for the protection from floods will have been established. It would also place practically all of the irrigable land on one side of the river.

To attempt to carry the river across the bottoms to the Hardy along
its present inclination is a dangerous and hazardous undertaking. Without data, but with the assumption that a long distance through low ground must be traversed, a large part of which is believed swampy, the inevitable building up, to establish grade which is characteristic of the river, will create the same conditions that exist today along the Rodriguez and lower Imperial District's levees, which would in effect put the river on a cone with low ground on each side and should a break occur, an avulsive change would surely take place. Should this be to the north the flood waters would be trapped and restoration difficult, even though the flow would be cut at Boulder Dam, damage to improvements would be great and the Volcano Lake levee menaced which would again be a threat to the Imperial Valley in the United States if regulation had not been effected.

The cost of field work to determine the most feasible and economical plan for permanent control, from my limited personal knowledge of the area to be mapped, it is estimated, should not exceed $75,000 and may be done for considerably less. This work would be in the nature of a topographic survey covering the possibilities as reconnaissance would determine.

Probable nature of the flood problem below Yuma with the river regulated to a maximum discharge of 40,000 cubic feet per second plus such floods as may be expected from water entering the river below Boulder Dam.

With a regulated flow the maximum of which will be 40,000 cubic feet per second, and without rectification of the river channel to the Gulf of California, I feel convinced that the process of building up will continue as it has since the river changed its course into the Bee River in 1909. This has become particularly aggravating since the Pescadero Cut was made in 1922, and has now reached a point where serious consideration is necessary and it is opportune to formulate definite plans for the future control of the lower river. Under existing conditions today a discharge of 40,000 cubic feet per second below mile post 19 on the Imperial Irrigation District's levee, as well as on the Rodriguez levee, creates a flood condition by putting the water surface out of its banks near mile post 19 and seriously endangers the Rodriguez levee at Kilometer 7 to 16. This condition will continue to grow more hazardous if rectification of channel is not made.

Even if the water was clear, and I believe that on account of meandering the river will burden itself with silt below Boulder Dam for many years, conditions would not materially change for the better. Therefore, with an anticipated continuing of silt laden waters it can be expected to become worse. Flash floods such as might be expected from the Gila and Bill Williams Rivers, though of short duration end of but 20,000 to 30,000 cubic feet per second, added to the 40,000 second feet flow from Boulder Dam would, on account of the river flowing so much higher than the surrounding land, make development unsafe, with the probability of levee failure and the diversion of the river with consequent damage. The greatest difficulty would be brought about following a year or two of minimum discharge; the existing waterways and channels would have silted up and overgrown through this period so that
accommodation could not be had for larger quantities, thereby making the creation of head necessary for the waters to get away; this head would increase flood heights to a considerable extent. The solution to the problem seems to be control of the stream to tidewater and the maintenance necessary so that variable quantities can be accommodated. It will be essential to maintain the channel for without planning such future maintenance, control or rectification would not bring the desired results.

The Yuma Project could for several years stand the increasing flood heights brought on by conditions now existing in Mexico, but eventually levees would have to be raised and seepage conditions would gradually become worse.

Whether the general flood plane in Mexico is likely to be raised with the river regulated as suggested in preceding paragraph. If so, to what extent (a) with the river in its old channel along Sonora Mesa, and (b) with the river passing through Pescadero Channel and from there to the Gulf.

It is my opinion that with the river regulated the general flood plane will continue to rise in Mexico if not controlled. This is based mainly upon the fact that the plane has risen and from recorded gage heights along the Imperial Irrigation District and Rodriguez levees is still rising. Clearer water, when that time comes, will, I believe, reduce the rate but even then the coarser sands that will be moving will drop wherever velocities decrease and this will be where the river is unchanneled and thus continue the process of building up the flood plane. The building up of the flood plane in this region is brought about by the effort of the river to stabilize itself as near as it possibly can. It is characteristic of the stream to maintain a slope of approximately 1.2 feet per mile and it will attempt to do this by either scour or deposition. It, therefore, has since its diversion been building up the flood plane to accommodate itself. This building up is being hastened by the assistance of the brush and trees through which it now flows. These obstructions decrease velocities which cause the dropping of the silt burden and as the area into which it flows is low the delta does not move forward at a very rapid rate along with the tendency of the channels to move off to the sides following the lines of least resistance. With the river back in its old channel I would not expect the flood plane to rise if the channel was maintained in a proper manner other than the natural rise that would come from the advancement of the delta into the Gulf. If the channel was not controlled by levees and properly maintained it would not be economically sound to expend funds to channelize it to the Gulf. With the river passing through the Pescadero channel to the Gulf I would expect the flood plane to rise in Mexico wherever this plane was too low to accommodate the characteristics of the river heretofore mentioned. To excavate a channel low enough and by a route shorter than that required by the river to consume the total loss in grade to prevent the building up of the flood plane would require a drop. If this was not provided recession would work back up the river and eventually endanger Laguna Dam.
CONCLUSIONS

Immediate adverse conditions will not be felt on the Yuma Project from the present controversy regarding river control in Mexico. In the course of two or three years increasing flood heights can be expected against the lower levee of the project and may require their raising if conditions in Mexico are not rectified.

The situation appears to me so serious that unless well coordinated plans are formulated and carried out the first large flood that comes down the river will, if not restrained, break into and flood large areas of improved land in Lower California and be impounded against the Volcano Lake levee where it will be a serious menace to Imperial Valley in the United States. As a flood of 30,000 to 40,000 second feet stands with its water surface some nine feet higher than the ground it protects, and with the flood plane rising at the rate of two to three feet a year against this levee, it does not seem humanly possible to hold it against another flood if defense is made from the levee itself.

Immediate steps should be taken to divert the river away from the Rodriguez levee by the extension of the Imperial Irrigation District's levee from mile post 31½ as far as practicable and if necessary to accomplish the result construct another diversion dam similar to what was done to divert the river into the Pescadero in 1922. The cooperation of the interested parties is the only way the problem will be satisfactorily solved and without such cooperation, failure and great damage to property is inevitable. The control of the river in Mexico is vital to the Imperial Irrigation District, The Republic of Mexico, and Colorado River Land Company, as well as other interested parties. They should all work together and share the costs of the project.

Aerial photographs and field surveys should be made to determine the most practicable and economic solution to the river problem, for it will continue to be a serious one, even after regulation when the Boulder Dam is completed.

The flood problem will not be wholly solved after regulation, particularly in Mexico. If complete control is not effected to the Gulf, conditions will be serious at such times as 40,000 second feet or more are flowing into this territory.

The general flood plane will rise in Mexico after regulation, if complete control is not effected in such a manner as to prevent it. The extent will be governed by the silt deposited. If clearer water is flowing, then the coarser sands or scour from the bed will be dropped as the silt is today. If the river picks up a burden of silt from eroding banks, and unless prevented by control it can be expected to do this for it meanders at all stages, the building up of the flood plane will be more rapid than if only the heavier sands were being dropped. Variable discharges will tend to close up channels by filling in and overgrowing, which will also be a factor in the building up process.
With the river back in its old channel along the Sonora Mesa, properly controlled and maintained, the most orderly regime will be established as the river followed this course as far back as known.

With the river passing through Pescadero Cut to the Gulf, the flood plane will continue to build up to accommodate the desired regime of the river. This might be prevented by shortening the distance to the Gulf, and excavating and maintaining a channel at an accommodating grade; this would require a drop at some point to overcome recession that would work upstream and eventually endanger Laguna Dam.

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(sgd.) R. M. Priest