Report on Lower Colorado River & Delta

by

J. A. Ockerson

Oct 4, 1910.

DEPARTMENT OF THE INTERIOR

WASHINGTON

Seattle, Wash., Sept. 3, 1910

Hon. R.A. Ballinger,
Secretary of the Interior,
Seattle, Wash.

Sir:-

I return herewith the papers relating to the situation near the mouth of the Colorado River.

The matter is complicated mainly by the ownership of large areas on both sides of the Colorado River, in Mexico, and by the pressure that will be brought to bear to have the work so extended as to protect all property, etc., subject to ravages of the overflow not only in the U.S. but in Mexico as well. For the protection of American interests in the Salton Sink and Imperial Valley, and the irrigable lands in the U.S., an effectual remedy is obvious in-

1. Completing the levee now partially built south of the Imperial Canal extending (in Mexico entirely) from the Colorado river levee, below the intake, across New River drainage area to the high ground west of New River;

2. Providing a suitable and practicable intake for The Imperial Canal, which involves fixing the low level of the Colorado River in the vicinity of and at the intake, in the U.S. Territory. This obvious arrangement will not probably satisfy the landed interests in Mexico, or, probably, be aided by the Mexican Government.

If the present intake could be closed and the Imperial Canal be extended to a new intake above the Laguna Dam, and the owners of this Canal passing in Mexico be compelled to complete their levee for the protection of Salton Sink against water coming into this Canal in Mexico, the matter would be solved in so far as American interests are involved, but the work of extension to Laguna Dam would cost probably $2,000,000, or twice the current appropriation, but be under control of the Government.

Very respectfully,

W.L. Marshall,

Consulting Engineer.

DEPARTMENT OF THE INTERIOR

PROTECTING LANDS AND PROPERTY

IMPERIAL VALLEY, Cal.

Yuma, Ariz., Oct. 4, 1910

Sir:-

I have the honor to submit the following report, covering my investigations of the lower Colorado River and its delta, together with a project for the control of that stream, in a manner that will protect the lands and property in Imperial Valley, Cal.

On July 19th, 1910, the following telegram was received:

"Washington, D.C.

"J.A. Ockerson, care Mississippi River Commission,
St. Louis, Mo.

The President has designated yourself Engineer to investigate Imperial Valley situation on the Colorado River near boundary between U.S. and Mexico for which Congress recently appropriated one million dollars. Please report to Interior Dept. here for conference prompt action necessary.

Frank Pierce,
Acting Sec'y."

On the evening of July 19th, the writer left St. Louis, and reported to the Interior Dept. on the morning of July 21st. After a general conference as to the hope of investigations to be made and the character of work to be done, the results were embodied in the following letter of instructions:

DEPARTMENT OF THE INTERIOR.

"Washington, D.C., July 22/10

J.A. Ockerson, Esq.,
Washington, D.C.

Sir:-

By Joint Resolution of Congress, approved June 25 1910, it was provided:

"That the sum of one million dollars, or so much thereof as may be necessary, is hereby appropriated out of any money in the Treasury not otherwise appropriated, to be expended by the President, for the purpose of protecting the lands and property in the Imperial Valley and elsewhere along the Colorado River, within the limits of the United States, and the President is authorized to expend any portion of such money within the limits of the Republic of Mexico, as he may deem proper, in accordance with such agreements, for the purpose, as he may make with the Republic of Mexico.

On July 8, 1910, the Acting Secretary of the Interior addressed to the President a communication, copy of which is herewith enclosed, your attention being particularly directed to that paragraph thereof, reading as follows:

"The ascertainment of what is necessary to be done for the purpose of accomplishing permanent avoidance of these recurring menaces to life and property on both sides of the International Boundary Line will require a thorough examination of physical conditions, which, to be effective, should have the co-operation of both governments and will consume considerable time. In the meantime, Engineer Hill states that unless prompt relief is afforded a water shortage, if not famine, is probable in the Imperial Valley within the next two months.

In a country where the heat reaches an intensity of 120 degrees and even higher, the great loss of property and menace to both animal and human life, which may ensue, should such a catastrophe occur, renders it imperative that prompt measures be taken toward averting the same. To that end, I respectfully recommend that you designate an engineer, having familiarity with problems involving river control, to proceed immediately with an examination, for the purpose of determining whether such emergency exists, and if so, to take the steps necessary to avoid the same."

"You have been employed and designated by the President to make investigation of the situation referred to in said Joint Resolution and communication -------.

You will report as to whether the existing emergency is such as to require immediate action, and, if so, what is necessary to be done to accomplish the purpose set forth in said Joint Resolution.

Representations that the situation is critical, requires that you should proceed with the utmost dispatch and make the report required as to the present conditions and immediate necessities by wire.

You will also, in this connection, make appropriate examination upon the ground and recommend the course, which, in your opinion, will prevent injury and destruction of property in the U.S., through recurrence of the difficulties which have heretofore from time to time arisen, by reason of the unreliability of the Colorado River----.

For any service or information, which the Dept. of the Interior, or any of its officers, which will tend to facilitate your labors, you will, of course, not hesitate to make requisition.

Very respectfully,

Frank Pierce,

Acting Secretary"

The critical conditions described in paragraph 3 and 4 of letter of instructions, lay in the shortage of water supply in Imperial Valley, due to some difficulty in the intake at the river, and also in the Imperial canal, below the headgate. In order to get the earliest practicable information, as to the relative elevations of the bed of the river and bottom of intake; the sill of the headgates and bottom of the canal, I wired to the Project Engineer, Mr. F.L. Sellew, at Yuma, requesting a survey, covering localities named, and on my arrival at Yuma, July 30th, the results were available for my inspection.

The plats showed clearly that the bed of the river was above the sill of the head gates, and lack of water in the canal was due mainly to the silting up of both the intake and the canal. (See plate 1.)

Two courses were open to remedy these defects. With proper appliances, the simplest plan would have been to dredge out the intake. Indeed, this should have been done immediately after the passage of the summer flood, and in all probability a disastrous shortage of water would have been averted. Or, the water could be raised to such an extent, by means of a submerged dam just below the intake, as to fill the canal without dredging.

The Cal. Development Co., W.H. Holabird, Receiver, under date of Mar. 2, 1910, secured from the War Dept. a waiver of objections to the construction of a temporary dam. This was renewed by the Dept. July 20, 1910. This structure was begun in Feb., 1910, but a sudden rise

in the river carried away the work that had been done, and for the time being it became unnecessary, on account of high stage of river, or until the season of spring floods had passed.

The type of dam, proposed by the Company, in its application to the War Dept. for a permit to construct the same across the Colorado River, which is a navigable stream, is shown in Plate 2.

A trestle is carried across the river, as a matter of convenience, as there is no floating plant on the river available for such construction. Then the bed of the river is covered with bundled of willow fascines, about forty ft. long, and weighted with stone and successive layers used until the necessary height is reached. This makes a satisfactory submerged temporary dam of limited height, the expectation being that it would be carried away by floods, so as to offer no hindrance to scour of bed at high stages of river.

After the Spring floods had passed and low stage conditions of river returned, water shortage in Imperial Valley again became serious, as shown by the following tabulation of volume of water passing the headgates:

The difference in the volume passing Hanlon's heading and that reaching Imperial Valley represents the quantity diverted to irrigation in Mexico and losses due to seepage and evaporation.

STATEMENT OF THE CAL. DEVELOPMENT CO. showing amount of water entering Concrete Heading and amount delivered to the Imperial Valley, through the Imperial Canal System from March 10th to Sept. 1st, 1910.

	HANLON HEADING	IMPERIAL VALLEY
March	Max. 1500	Max. 1482
	Min. 1175	Min. 1012
	Mean 1395	Mean 1374
April	Max. 1689	1445
	Min. 950	1048
	Mean 1511	1307
May	Max. 1650	1326
	Min. 1300	971
	Mean 1427	1112
June	Max. 1569	1188
	Min. 1420	1061
	Mean 1512	1140
July	Max. 1592	1173
	Min. 746	417
	Mean 1120	782
August	Max. 1651	1113
	Min. 811	395

It seems that 1200 to 1800 sec.ft. are necessary to satisfy the demands of the area now under cultivation and to meet the requirements of the large herds of stock and for domestic use, as these are wholly dependent on the canal for their entire supply, as there are no wells; neither are there any storage tanks for use in tiding over an emergency, such as might come from a break in the canal, that would cut off the entire water supply for a time and cause great suffering to the people and to live stock.

In the latter part of July, the volume passing the headgates had dropped down to 746 sec.ft. and the conditions became alarming. Only 395 sec.ft. reached Imperial Valley.

Such was the state of affairs on my arrival at Yuma. It was soon learned, however, that the Cal. Development Co. had secured a dredge, with which to clear out the deposits in the intake, and had also taken steps to build a submerged dam, on which work was begun July 22nd. By Aug. 23rd, a trestle was completed across the river and

rock dumped therein had raised the water surface two ft. and the water in the intake stood above the tops of the head gates, giving a flow down the canal of 1700 sec.ft.

This dam was constructed by dumping rock from side-dump cars, until the required height was reached, and as no fascines were used, it might readily be carried beyond the point where it could be classed as a temporary structure. Plate 1 shows the crest of the dam and the elevation of the bed of the river, above and below, on Aug. 23. A photograph of the trestle is shown in plate 3.

An interview, on Aug. 24th, with prominent officials of several of the Imperial Valley water companies, indicated that the water supply was adequate for all their requirements and the losses to the Valley, while of considerable proportion, were mainly confined to loss of the corn crop, owing to lack of water at planting time and to one or two cuttings of alfalfa.

Shortly after my arrival here, I made a tour of the valley and observed the condition of the crops and abundant evidences of lack of water were to be seen. Many alfalfa fields were dry to the roots and but very little corn was in evidence. Cotton appeared to be doing fairly well and now promises a good crop.

The effort of the Cal. Development Co. to secure the necessary water supply to the valley, was watched with care, and as they seemed to have the work well in hand, and were energetically striving to reach the desired result, both by dredging and by a submerged dam, my attention was then turned to the larger question, of how ti prevent injury and destruction of property, through the recurrence of the difficulties arising from changes in the route of the Colorado river.

Reports of the foregoing work were wired to you from time to time, as the work progressed.

The Imperial Canal, known as the property of the Cal. Development Co., taps the Colorado river at a point about 1600 ft. above the International Boundary line. From this point, the water flows in a southwesterly direction for a distance of about 1500 ft., with a bottom width of about 60 ft. and 100 ft. wide at the top, to the concrete headgates about 1000 ft. North of the International Boundary line. These gates are said to rest on bed-rock. There are 11 openings, 12 ft. wide and 10 ft. high and a navigation by-pass 12 ft. wide. The estimated capacity of the gates is 10,000 cu.ft. per sec.

The elevation of the floor, or sill, is 100.9 ft. above sea level, U.S.R.S. datum, and when built in 1906 it was about 5 ft. below the bed of the river. As the bed of the river is continually changing, with even slight changes of stage, it seems now that the sill of the gates should have been placed several feet lower, in order to meet the probably lowering of the low water plane, due to the regulation of the river and flood control, by means of levees. In fact, the bed of the river, in June, 1910, was 10-1/2 ft. below the sill of headgates, the water surface being 5 ft. above the top of the gates, Yuma gage reading 22 ft. After leaving the headgates, the water flows through a canal for a distance of about 4 miles, where it enters the old bed of Alamo river, a high water channel, formerly emptying into the Salton basin. It makes a detour to the southward into Mexico, on account of a high sandy mesa, which prevents carrying the water to Imperial Valley through U.S. territory. This old channel, on Mexican soil, measures about 44.2 miles in length and reaches a maximum distance of about 9 miles southward of the International Boundary. It crosses back to the U.S. at a point of 34.3 miles from the Colorado River, as measured on the Boundary line. The main canal crosses boundary 41.5 miles from river, making total distance in Mexico about 50 miles. Each cultivated acre is entitled to 4 acre ft. per annum. The capacity of this Main Canal at present is about 1800 sec.ft., and it served this year 203,246 acres of land in Imperial Valley, Cal., and 22,000 acres in Mexico. The mean velocity of flow in the canal is reported to be from 1.5 to over 3 ft. per sec. The distance from the concrete headgate to Sharps Heading is 53 miles and the total fall between the sills of the two gates is 75.5 ft., giving an average slope of 1.5 ft. per mile. For alignment of canal, see map herewith.

In my opinion, the shortage of water could have been avoided by the use, earlier in the season, both in the intake and the canal proper, of an efficient type of dredge of the proper capacity.

This only applies to the present demand for water. Should the demand largely increase, as now seems inevitable, it will be necessary to reconstruct the main canal on more efficient lines both as to section and slope. Whether this is done or not, the safety of the valley requires that the various wooden controlling works be replaced at an early day with substantial concrete structures. Without such enlargement and reconstruction, the great outlay necessary to draw the supply from Laguna Dam would not be justified.

An extension of the intake to Laguna Dam would serve to definitely fix the source of supply beyond any probable danger thereto and a main canal could be carried therefrom, which would serve many acres in the higher lands, which are above the reach of the present system.

The Laguna dam, being merely a weir, does not serve the purpose of storing water and hence would have no value for conserving the high stage supply.

The extreme low water discharge, measured at Yuma, up to date, is 2694 sec.ft. This occurred in Jan. 1903, fortunately at the season of the year when little water is needed. The Yuma Valley project covers some 190,000 acres, and the Imperial Valley, which can be reached from present intake, about 400,000 acres.

Then, South of the Boundary line, and West of the river, in Mexican territory, lies 860,000 acres of the cream of the Colorado Delta, which could be made highly productive with a good water supply. The principal owners and their holdings in Mexico are as follows:

The following table shows, from the discharge observations at Yuma, the available water supply in the Colorado River, without storage, and the area that could be irrigated therewith, if drawn upon as needed and utilized without waste:

This table shows that there is sufficient water in the river, during even the low stages, to supply several times the area now under cultivation. It is based on the monthly average of water used in Yuma Valley irrigation, per acre, the total required for the year being estimated at 5-1/2 acre feet, which covers evaporation and other losses.

The following table gives the monthly discharge for the years 1903 to 1909, inclusive, the total acre feet per month, and year, and the means by months and years.

It indicates clearly that the annual supply of water is sufficient to irrigate the major portion, if not all, of the entire Colorado Delta, if adequate storage were provided.

An exhaustive study of the whole question of the conservation of the flood waters of the Colorado watershed and the economic use of the Laguna dam, in connection with the irrigation of the Colorado delta, should be taken up without further delay. It will require considerable time to do this properly and it is none too soon to begin.

The troubles experienced in Imperial Valley, under present conditions, are very largely due to lack of capital for the needed preliminary investigations and for the design and construction of proper and economic works, for the diversion and control of the water from the Colorado River. Exception should be made to the concrete head gates, which are apparently serving the purpose for which they were designed.

The development of Imperial Valley has been little short of magical. Within a decade it has changed from a barren desert to highly productive fields, orchards and vineyards, occupied by a thrifty people some 15,000 in number.

Thriving towns dot the valley, in which may be seen large, well-appointed school buildings, substantial business houses and comfortable homes, all proclaiming that this development is not ephemeral, and under proper conditions, the prospects for the future are exceedingly bright.

The extraordinary fertility of the soil results in greatly increasing demands for more and more area under cultivation, with large increase in the amount of water required therefor. But, to continue this rapid expansion of cultivation without insuring an ample water supply, by means of better control of intake and more adequate main canal and controlling works, is to invite troubles greater than have yet come to them.

With the assurance of such prolific returns, it does not seem probable that this opportunity of practical conservation will long be neglected.

The control of the course of the Colorado River, for the purpose of Protecting Lands and Property in the Imperial Valley, and elsewhere, along the Colorado River, within the limits of the U.S.

SURVEYS AND EXAMINATIONS.

In obedience to the fourth paragraph of your instructions to "make appropriate examination upon the ground and recommend the course, which, in your opinion, will prevent injury and destruction of property in the U.S. through the recurrence of the difficulties which have heretofore from time to time arisen, by reason of the unreliability of the course of the Colorado river," a survey party was organized, which reached the field and went into camp near the International boundary line, on Aug. 16th.

Great difficulty was experienced in securing competent men to serve under conditions of extreme heat and at a point remote from habitations and travelled highways.

Equipment and teams were secured from the Reclamation Service at Yuma, and a supply line was established, in order to minimize the discomforts of the heated season as far as practicable.

The party consisted of J.G. Morgan, Chief of party, R.B. Ray, transit-man, L.F. Tripp, levelman, four rodmen, cook and 6 Cocopah Indian Axemen.

SURVEYS 1.

The instrumental survey with tertiary triangulation and stadia covered the Colorado River from a point about 6 miles below the concrete headgates at Hanlons down to the Abejas river break and thence down the dry bed to within about 20 miles of tide water, a total distance by river of about 35 miles. The survey was also extended down the Abejas river a distance of 5 miles. It includes the location of both bank lines with elevations thereon and with cross-sections in the Abejas and the dry bed of the Colorado river. A line was also cut through the timber and brush along near the west bank of the Colorado, approximating as near as practicable the site of the proposed levee and extends the entire length of the survey.

Levels were carried over this line and an accurate profile thereof, has been developed. The distances were measured with steel tape.

The notes of this survey have been platted on a scale of one inch to 1000 ft. On this map the route of the proposed levee and the crossing of the Abejos river have been projected and this will constitute the working plan for construction work. Profiles of the lines leveled over have also been platted for the purpose of determining the height of levee required and estimating the cubic yards of earth therein.

SURVEYS 2.

Several sections of the Abejas were also platted on a large scale for the purpose of selecting the best site for the crossing and for estimating the quantity of material required for trestle and for the rock fill.

The surveys were completed on Oct. 4 and covered a period of 42 working days in the field -- which is an exceedingly good record when we consider that the work was done during the hottest part of an unusually hot season. Many who are accustomed to the climate declared in the beginning that survey of the lower Colorado River during the summer months was impracticable.

Mr. Morgan, his assistants and the Cocopah Indian Axemen all deserve credit for carrying the work to a successful conclusion under such trying conditions.

In addition to the instrumental survey examination were made by myself of the Colorado river from Yuma down for a distance of some 40 miles; the Abejas river from the Colorado river down several miles; of the Hardy river from its source at Volcano Lake to its junction with the dry bed of the Colorado; the lower portion of the Pescadero river; Salt Slough; New river and the Alamo. The water in the Hardy river, which now carries the entire volume of the Colorado, was found to be practically clear, the sediment having been eliminated in its passage down the Abejas river to Volcano Lake.

SURVEYS 3.

Examinations were also made, covering to a considerable extent the various canals and headings of the Cal. Development Co., together with a general view, of a large part of the irrigated portion of Imperial Valley and the delta south of the International Boundary Line in Mexico.

The records of the Reclamation Service at Yuma have been fully drawn upon for facts relating to stage and discharge of the Colorado river and were of great service in the study of the problems relating to flood control.

PHYSICAL CHARACTERISTICS OF THE LOWER COLORADO RIVER.

The geological history of the Salton basin and the formation of the Colorado delta have been discussed so fully of late years that it is deemed best to confine this report to the salient features, which bear directly on the particular problems in hand.

The lower Colorado river has the usual characteristics of sedimentary streams, although some of the features of its regimen are accentuated, such as the percentage of sediment, the slope, the very fine material composing its bed and banks, and the extreme elevation of its delta above Salton basin. The ratio of sediment to water is 1 to 363, while in the Mississippi river this ratio is 1 to 1500. The total annual volume of sediment amounts to 53 square miles one foot deep.

The material of the bed is so easily eroded that its elevation becomes a function of the stage, while no fixed relation between stage and volume of discharge can be traced. For instance, in June, 1904, at a stage of 126.3, the discharge measured 50,000 sec.ft., while at the same stage in Dec., 1908, the discharge was 72,000 sec.ft.

The river flows on the crown of an elevated delta, having an area of about 3600 square miles. It has a slope of about 2.6 ft. per mile, toward the Gulf of California, and lies some 400 ft. above the bottom of the adjacent Salton basin, which gives very steep slopes to the westward for the overbank discharge during floods, and the tendency to leave its bed for one of the high water outlets, with its steeper slope, is continually present. Dee map herewith.

The slope toward the eastward mesa is about 2 ft. per mile. The chief high water outlets, or channels, which under normal stages are dry, are the Alamo, now occupied by the Imperial Valley canal, the Paredonis, Abejas and the Pescadero. The New river occupied the thalweg to the westward of the delta and flows in a Northwesterly direction to the Salton Sink, or in a southwesterly direction to Volcano Lake, and thence to the Gulf, via the Hardy river, according to the magnitude of the overflow. North of Volcano Lake, it is a dry bed with little or no water except such as may reach it through the Paredonis at overflow stages of the Colorado river, or water from the waste gates near Mexicali. At the present time, the flow to the Southward is cut off by a levee.

The average flood slope of the river from Yuma to tidewater of the Gulf of California is about 1.6 ft. per mile, estimating the distance from Yuma at 80 miles by river, while the average slope from the river, along the Alamo and New rivers, to Salton sink is about 3.5 ft. per mile, but this latter slope is not uniformly distributed, and in places is much in excess of this figure. These various slopes are shown in a general way on plate 4.

The havoc created by the river in 1906, when it flowed down this very steep slope, through material so easily eroded, is sufficient warning that strenuous measures should be used to prevent such catastrophes in the future. Imperial Valley can never be safe in the face of

such menace, until ample works are erected to confine the flood waters to narrow limits along the river proper. An interesting exhibit of the development of the Salton Sea is shown in hydrographic plate 7.

Records of stage have been kept continuously at Yuma since 1878. The lowest stage recorded to date was in October, 1879, when the gage read 113.2 ft. above sea level.

The highest stage recorded was on Feb. 26, 1891, when the gage read 133.2 ft. above sea level. This gives the extreme range in stage at Yuma since gage was established as 20 ft.

Regular discharge measurements were inaugurated by the U.S. Reclamation Service in 1903. Since that time, the lowest volume measured was on Jan. 12, 1903, when the river carried but 2694 cu.ft. per sec., with gage reading 16.8 ft.

The largest volume recorded was on June 24, 1909, when the flood reached 149500 cu.ft. per sec., with gage reading 130.7 ft.

The oscillation of the bed, incidental to changes of stage, is shown in plate 5, where it will be seen that the elevation of the low water bed at the discharge station at Yuma, on Dec. 16, 1908, was 113.5 ft. at the deepest part, while during the following great flood of 1909, the bed was scoured down to an elevation of 77.2 ft. above sea level -- a difference of some 36.3 ft. In this way, the stream readily adjusts itself to the volume which it is required to carry if confined to a fixed channel.

The Colorado river has the usual characteristics of sedimentary streams of great slope. The high water channel ranges from 1000 to 3000 ft. or more in width, and is quite shallow, while the low water channel is 500 to 1000 ft. wide, and wanders over the whole range of the high water bed. The high water bed is more or less obstructed with vegetation, which springs up in the interval between floods. The high water bank, which lies along the concave side of the stream, is usually well-defined and nearly vertical, 6 to 8 ft. in height. The opposite bank is often quite indefinite.

The trees along the banks are in many cases buried in the deposits for several feet in depth, and the roots of smaller growth also extend well down. The upper adobe soil, from 2 to 6 ft. thick, or sometimes even more, is filled with cracks, through which water readily finds its way.

In order to construct levees that will be reasonably safe, it is evident that both roots and cracked soil must be carefully eliminated, by means of muck ditches of ample depth. The lack of this precaution is responsible for the failure, which occurred a few hundred feet below the Hind dam which had successfully closed the break of 1905-6.

The banks adjacent to the river are covered with a dense growth of willows, arrow weed and some cottonwood trees of moderate size.

No coarse sand or gravel is found on the low water bars, which are composed very largely of fine silt.

FLOOD CONTROL BY MEANS OF LEVEES.

That the river is exceedingly amenable to controlling works is shown by its action in the reach from Yuma down-stream, for a distance of 25 miles, where the flood control is effected by means of levees, as shown on map herewith.

The left bank levee, for 12 miles down, was constructed in 1905, and the levee on the opposite bank was constructed by the Cal. Development Co., in 1906-7.

It will be noticed that these levees are less than 1500 ft. apart below the concrete headgates, yet the great flood of 1909 was carried through without endangering the levees and with little increase in the flood height above the higher natural banks. The confined flood eroded the bed to the extent required to make room for the increased flood volume, and this too without any effort at bank protection on either side.

After the flood of 1910, the left bank levee was breeched by bank erosion at a point about 12 miles below Yuma. The record for stability will, however, compare favorably with similar structures on more stable streams, particularly when the close proximity of the levees to the river is taken into account.

The effect of an extension of the levee system will be to lower the low water plans, whereas a tendency to elevate this plane, due to advancement of delta into the sea, the depletion of the river by irrigation outlets and other causes, may easily counter-balance the lowering tendency of levees in the course of time.

So there does not seem to be any great obstacle in the way of constructing and maintaining an adequate

levee system, which would prevent the river from endangering the Imperial Valley and other portions of the delta and would confine the flood waters closely to the high water bed of the river. A levee located a reasonable distance from the westerly bends would probably remain intact for some time. If a levee had been built in 1893 from the intake down to Arizona-Mexico line, with a location 3000 ft. West of the Westerly bends, it would be intact to-day, so far as bank erosion is concerned.

Maintenance of levees necessarily means, not only keeping up at all times the section of the levee, freeing it from weeds and brush, and keeping it free from burrowing animals, but the erosion of river bank must be checked whenever it threatened to breach the levee; or, if found to be more economical in special cases, build a loop around the threatened break before a flood can take possession of it and submerge the adjacent land.

The fact that the river shifts about so readily, to escape even a comparatively slight obstruction, is sufficient evidence that it would yield readily to proper treatment. The banks are not high and the depths are small both of which favor economy in construction of bank projection. Maintenance can be secured by vigilance, rather than by extraordinary expenditures of money.

CHANGES IN ALIGNMENT OF RIVER.

Bank erosion on the lower Colorado river is quite active, and is doubtless accentuated by the escape over the bank, at flood stages, which serves to develop obstructions below the outlets of such character that it is easier for the water to pass around them than to remove and a route is developed along new lines.

The ground shows many evidences of these changes. The comparative stability of the banks along the upper portion of the delta, where levees have been effective in cutting off flood escape, suggests that like treatment of the lower portion would bring similar results.

Plate 6 shows the right or west bank shore lines of the surveys of several years and illustrates the extent of the shifting tendency of the stream.

It will be noticed, if the earlier surveys be given consideration, that the movement of the river has been largely to the Eastward, and this confirms to some extent the suggestion heretofore made, that the movement is influences by outlets, all of which flow to the Westward.

The early surveys were not connected with definite points that can now be identified, and it is believed that their wide divergence from the later surveys is due to errors in azimuth, and that such radical change in the position of the river, as shown, could not have occurred.

Some of the differences shown are doubtless due to differences in stage at which the surveys were made, the bluff banks of the Westerly bends being the only lines along which comparisons of value can be made.

CHANGE IN LOW WATER PLANE.

A comparison of the gage heights at Yuma, using ten year perious, beginning with 1878, shows that the average low water plane, up to the latter part of 1909, has gradually risen:

Average elevation of low water-plane	1878-89-114-5	ft.
do	1890-99-116.6	"
do	1900-09-117.4	"

(See hydrograph herewith).

A remarkable exception is, however, to be noted in the low water-plane at the end of the year 1909, following the great flood of that year. It was 3.5 ft. lower than any of the six preceeding years, including the years of the great Colorado river break. It was lower than any of the preceding twenty years by 1.7 ft., and lower than any of the preceding thirty years, excepting only the years 1879, 1883 and 1885, the first of which was still lower by 0.8 of a foot.

This lowering of the low water plane in 1909 has been attributed to a "cutting back" from the break in the Colorado river, which now flows down the Abejas river. This is evidently a mistake. These ir no evidence of any cutting back in the main river, following the breaks of 1905-6, which were much nearer to the Yuma gaging station.

Then too the fact that previous years show even lower low water planes without any great breaks in the river would indicate that some other cause must be sought.

Since the last ten year period shows an average elevation of the low water plane of 2.9 ft. above that of the first ten year period, the depression at the end of 1909 becomes much more marked than any that have previously occurred since record of stage began.

Two higher floods than that of 1909 have been recorded, one in 1891, and the other in 1905, but they were of very short duration, and it is altogether probable that the maximum discharge of 1909, which reached 149,500 sec. ft., exceeded in volume any of the floods of the previous thirty years.

The flood of 1909 was the first to be influenced by the Laguna dam and its basin, covering some ten square miles, which was completed in the spring of that year.

The flood water was stored to such an extent as to leave a considerable portion of the sediment therein before moving on down the river. With a lighter load and higher flood velocity, unusual scouring effect on the bed and banks might be expected. This, coupled with the unusual magnitude of the flood, and the effect of the levees which confined it to the channel, readily account for the excessive depression of the bed, which was followed by the low water plane.

Unfortunately, no sediment observations were made at Yuma during the flood of 1909, and this means of verifying the assumed influence of the Laguna basin is not available.

LOWERING OF BED OF RIVER DUE TO "CUTTING BACK".

That there has been no cutting back from the Abejas river during the summer of 1910 is clearly shown by the slope diagram plate 8, the elevations for which were taken at frequent intervals following the flood of 1910. The Colorado river proper was left dry for the first time in Sept., 1909, due to the Abejas break, which developed as a permanent outlet with the flood of that year.

Superficial observations in the vicinity of where the channel has abandoned its old bed for a new route with a steeper slope, are apt to give an exaggerated idea of the depression of the new bed.

The change in the direction of flow occurs at a high stage of river, when the beds of both streams are elevated above the normal, and the effect of the outlet is to contribute still larger deposits to the bed of the depleted stream, due to a diminished velocity therein.

After the low water stage is reached, it is seen that the dry water bed is several feet above the bed of the flowing stream and this is generally given as the measure of the cutting down of the bed at that point, due to the outlet. This, however, is not the case. If the river had

continued to flow in its own bed, it would itself have been cut down decidedly with the advent of low water, following the law of all sedimentary streams. The best tangible measure of the lowering of the bed is the relative heights above water surface, of the average high water banks, immediately above and below the point of diversion. The lower portion of the dry bed at the break is only 3 ft. above the present low water surface.

The portion of the stream flowing over a new and steeper slope will ultimately reach a grade commensurate with the material in which it flows, and the proportion of sediment which it carries and the normal slope of the stream will be equalized, both by filling and raising up the lower end of the steeper portion and the cutting back for an indeterminate distance upstream. In the case of the present break, the steep portion of the slope is largely neutralized by excessive curvature in the stream and by sediment deposition along the lower reaches thereof.

The cutting back if it reached the Colorado might in extreme cases easily depress the low water plane to such an extent at the Imperial Canal intake as to leave the sill of the headgates above water.

This would, of course, be disastrous to the present works for supplying water to Imperial Valley. No such danger from the Abejas is imminent so long as the flow is toward the Gulf of California.

Even this could be remedied in time by constructing new controlling works and headgates with a much lower sill at a point about a mile, or so, above the present headgates, where the river washes the foot of bluffs of stable material. The proposed gates to be served with water direct from the river without the use of an intake which serves as a catch basin for drift and silt.

To make this position secure, the left bank of the river should be fixed by means of suitable revetment; or, the intake might be carried to Laguna Dam, as has often been discussed.

EFFECT OF OUTLETS OR BREAKS WHICH RETURN TO TIDEWATER.

Any diversion of the Colorado river that occurs so far below the head of the Delta as to carry its waters to the Gulf of California, even with a slope much above the normal, for a few miles, can have little or no injuricus effect on the Laguna dam, as such minor cutting back if any, could readily be arrested at Yuma, where a hard stratum

is to be found not far below the high water bed. The cost of such a defensive structure would be nominal, as compared with the cost of closing a break in the river and constructing a levee down to tidewater.

An examination of plate 5 shows this hard formation, on which rock could be placed to a height necessary to neutralize the effect of the "cut back" if need be.

It is not improbable that borings further down stream, as far as Pilot Knob, might reach this hard stream, at reasonable depth.

It must be understood, however, that for an outlet which would reach the great depth of Salton Sink and the excessive slope incidental thereto, the "cut back" would become a very serious menace to structures on the river for a long distance upstream.

And it is this major danger which must be safeguarded in the interests of Imperial Valley, as even those outlets far downstream would build sub-deltas, which in a brief space of time might reach such height as to overtop the defenses to the northward and thus divert the water to the Salton Basin.

The spectacle of the New River gorge, 80 ft. deep, and a thousand feet wide, eroding its way upstream at the rate of 15 miles per month, as it did in 1906, was an object lesson to the people of Imperial Valley, not easy to forget, and they have ample reasons for dreading a recurrence of such a catastrophe. Had it reached the Colorado river, it would certainly have lowered the bed to such an extent that irrigation therefrom would have been impracticable.

METHODS WHICH HAVE BEEN PROPOSED FOR PROTECTING IMPERIAL VALLEY.

One method of flood control, which has been carried out in a measure by the Cal. Development Co. is the construction of a line of levee, which turns back from the river at a point about 6 miles below the International boundary line, and runs in a southwesterly direction. This levee is finished to a height of 5 ft. above high water for a distance of 14 miles. It is covered with gravel and carries a railroad track upon it.

From the end of this levee, there is an incomplete line for a distance of about 11 miles farther.

This line was constructed in the spring of 1910, and is deficient in both height and section.

If the levee line had been carried down along the river, at the time the upper section was built, it would have reached a point about 6 miles below the present Abejas outlet and no break there would have occurred. At the end of the levee, the flood height would be about 25 ft. lower than the flood height where the present levee turns back, which is equivalent to a reduction of flood height to that extent in the territory which the present levee was intended to protect.

There is a gap of 10 miles to the west end of the Volcano Lake levee, which is about 7 miles in length, and terminates at the high ground west of Volcano Lake. This latter levee is also too low to meet emergencies that might occur at any flood stage of river. Where this levee crosses New river, flood gates with concrete abutments are provided but have been rendered useless by a loop constructed around them by order of the Mexican Government.

It has been suggested that this line should be completed to the proper grade and the Abejas break be allowed to flow on unmolested. This would undoubtedly protect Imperial Valley from floods for a short time; but it only solves part of the problem, and even that but temporarily.

The effect of any cutting back in the Abejas, which might develop to such proportions as to lower the bed of the Colorado river below the sill at the headgates, would receive no check by such construction.

That even the flood control would be of short duration can be seen when we realize that the levee is built down into a basin, which has a slope of some 3 ft. in a mile, and that this basin itself would in a brief period of time be raised by deposits on the sub-delta of the Abejas, which is limited in area, so that any levees of practicable height would be overtopped. It is related that during the brief interval between the preliminary profile and the construction of the Inter California Railway, the deposit of sediment had raised the line several feet. This shows how ineffectual an interior level line may be.

More than likely, some newly developed branch of the Abejas, attracted by the steeper slope to the northward, would again find a route for the Colorado River to the depths of the Salton Sink.

As this proposed method only temporarily solves one phase of the problem, it may well be rejected as inadequate.

Another remedy, which has been proposed, is to confine the work to a closure of the break and restore the river to its former channel. This, also, would prove of temporary value, but another break would be sure to occur in the very near future, perhaps with the next great flood, and the expense of making the closure would not be justified.

A critical study of the whole situation, in all its bearings, leads to the conclusion that the protection of lands and property in Imperial Valley requires that the Colorado River be restored to its former channel and that an effective line of levee for flood control be constructed from a point on the Cal. Development Co's levee, about 6 miles below the International Boundary line, and following along down stream at a distance of about 3000 ft. from the westerly bends of the river for such distance as will carry the flood height down to an elevation below the intervening land in the vicinity of Volcano Lake, a diversion of the stream occurring below such point would result in the water reaching the Gulf of California and the tendency to flow northward would be climinated.

Such a levee will be about 25 miles long and will require about 1,300,000 yards of earth work and 450 acres of clearing and grubbing. To complete this large amount of work before the spring floods will require the use of 320 scrapers, with double team of mules, estimating each scraper at 40 cubic yards per day of 10 hrs. The end of the levee would be about 20 miles above tide water.

The levee should be built to a grade of 5 ft. above high water, this height being specified for the purpose of having excess material, wherewith to remedy deterioration rather than any fear of overtopping from floods. Neither railroad track nor gravel covering for levees are recommended, for it is believed to be more important to extend the levee as far as practicable, rather than dissipate available funds for mere convenience of maintenance. These can be added later, if thought desirable.

The crown should be 8 ft. wide and the side slopes one of three and a berm width of 40 ft. should be left between toe of slope and edge of borrow pit, which must be on the river side of the levee.

The borrow pit should not exceed 2 ft. in depth, at the side next to the levee, and then slope gradually to the farther limit. Traverses 50 ft. in width should be left across the borrow pit, at intervals of about 400ft. The entire ground covered by the levee must be cleared of roots and stumps, to such depth as will eliminate danger from seepage under the levee. A much ditch of such depth as will reach through the cracked adobe soil, even to the extent of several feet, must be constructed, under the axis of the levee and filled in with clean selected material, well tramped by the scraper teams.

Other details of construction will be covered in specifications, when bids are called for.

A large proportion of the lower part of the Colorado delta is now utilized for grazing purposes, the California-Mexico Ranch Co. having 18,000 head of cattle therein.

The periodic overflows supply the moisture needed to develop luxurious pasturage and fills the water holes to supply the cattle.

The construction of the levee proposed will destroy this automatic process of watering the tract, as gates or openings in a levee of this character cannot be recommended. This can, however, be realized in a more certain and simple way, by putting a waste gate in the south side of Imperial canal, where it approaches near the former bed of the Paredones, and flood the tract from there, via the stream named, during flood stages of the Colorado.

As it is now, only the high iverflow stages reach the upper portions of the pasturage tract. Using the means suggested, through the Imperial headgates, at times when the water is abundant, would insure an annual supply of the magnitude required.

The space between the levee and the river could be used for grazing, and also a large area below the end of the levee. So, on the whole, the levee should not be seriously objectionable, even to the cattlemen. Then, too, the soil is so productive that cultivation must be resorted to in the near future, and a canal along the lines named would supply the necessary water. In short, a levee is essential to any scheme of cultivation in this portion of the delta.

CLOSURE OF THE BREAK AND DIVERSION OF THE WATER BACK TO THE BED OF COLORADO RIVER.

The break is on the right bank, about 20 miles by river below the California Mexican Boundary line and some 5 miles from the end, of the track on the levee. It will, therefore, be necessary to extend the track in order to bring the necessary material to the point required.

At this time, the entire flow of the river goes down a high water outlet of long standing, known as the Abejas river, and finds its way down the Pescadero and other channels to the Hardy River, and thence down to its junction with the Colorado river. In its passage to the

Hardy the silt is practically all eliminated and this deposit is rapidly raising the foot of the steep slope with the result that a slope line is developed which is not greatly in excess of normal river slope.

As near as can be measured from the data at hand, the present route to tidewater, via the Abejas river, Volcano Lake, Pardones and Hardy rivers, is about 7 miles shorter than by the Colorado River.

The slope of the Hardy River is much flatter than that of the Colorado,- hence the tide runs farther up. Mean tide would reach about the mouth of the Pescadero, on the Hardy, and measuring to that point, the distances by the two routes would be practically the same.

The crossing for the closure will be about 2000 ft. down the Abejas, where a trestle about 1000 ft. long will be required. The distance between the high water banks being 2100 ft. and the present channel width 550 ft. This will be the ordinary standard railway trestle, with 4 pile bents, spaced 16 ft. between centers. The piles will be driven to a penetration of 20 ft., or more, where required.

The entire crossing will then be uniformly blanketed with run of quarry rock from Pilot Knob, some 25 miles distant. The rock will be hauled in and dumped from battleship cars, of 50 cu.yds. capacity each, and dumping will be continued until the water level is raised, so as to run down the old river bed and the dam will be finished up to the grade of the adjacent levees, with which it will connect.

The dam will have a top width of 20 ft. and side slopes of 1 on 2.

As the break lies in a sharp bend of the river, the dam must be placed well down the Abejas in order to prevent its early destruction by erosion. On this account the work will be somewhat more difficult than closing a break in a straight reach as has been done heretofore.

The width of the channel at the crossing is at present 550 ft., and the maximum height of the dam for a short distance will be 20 ft. up to grade. Assuming a settling or shrinkage of one-third, the dam will require about 67,000 cu.yds. of material in its construction, under conditions as they now are. Intervening flood conditions may radically change these figures.

If the closure could be erected at a stage of river like the present, no difficulty need be anticipated, but a sudden rise in the midst of the work might result in serious complications and the destruction of the work in progress.

The closures should be commenced at the earliest practicable date, in order to take advantage of the probable low water season.

If the work could be done at a very low stage, the whole operation of closure might be economically handled in the dry, by utilizing the temporary dam, just below the intake , raising it to the required height with ballasted willow mats, so as to divert all of the water through the concrete head gates, which have a capacity of 10,000 cu. ft. per sec., down to a spillway leading to the Paredonis channel. This would very materially simplify the whole problem, but like any other method of closure, would be subject to serious damage by floods, which might come during any stage of the work. Its success would require a very low stage of river for perhaps ten days. The canal between the head gates and the suggested spillway would be expected to enlarge by sluicing out the sedimentary deposits, which have reduced its capacity to a marked extent, and this of itself would be highly beneficial to the supply system of the canal.

INTERESTS AFFECTED BY THE PROPOSED IMPROVEMENT WORK

First: The people of the Imperial Valley are vitally interested, since their very existence depends on the maintenance of a barrier that will effectually prevent the Colorado River from invading the Salton Basin. The appropriation made by Congress is for the purpose of protecting lands and property in Imperial Valley but incidentally other interests will be largely benefited by any work that may be done.

Second: The Cal. Development Co., and its Mexican Association Co., which must have stable river conditions, in order to successfully carry out its obligations to supply water to the various water companies in Imperial Valley and Mexico.

Third: The S.P. Ry. Co., which receives large revenues from the transportation of the people, the products of the Valley and the supplies required therein. They also have a direct interest as holders of bonds and judgment for a large amount, covering land holdings of the Mexican side of the Development Co. They are interested in the prosperity of the Cal. Development Co., in order that they may repay the cash advances and other obligations.

Fourth: The property owners on the south side of the boundary line, in Mexico, whose lands could never

be brought under successful cultivation without effective flood control. Large areas, now flooded, such as Volcano Lake, covering perhaps 100 sq.miles, nor worthless, would be reclaimed for cultivation.

The case of the Colorado River Land Co. differs from that of the other parties interested in the proposed improvement, in that the right of way for a levee must pass through their land and furthermore a levee will interrupt to a certain extent the natural irrigation from floods which they now have. So here the questions of betterment and possible damage are entitled to consideration.

This Company is said to own 686000 acres of land in the lower part of the Colorado delta. At least one-third of the northern portion of this land is not watered to any valuable extent by ordinary floods, and the most valuable area for forage lies in the lower half of the remaining portion of the tract.

It is proposed to carry the levee down far enough so that any tendency of the river below the end of the levee to follow outlets to the westward will be minimized and even a break would not become a menace to the lands and property in Imperial Valley as the flood control would reach within 20 miles of tide water where the maximum flood height is about the same as that of Volcano Lake.

The area between the end of the levee, the mouth of the Hardy, the Colorado river and the Cocopah range covers about 265000 acres which will not be materially affected by the levee and this area covers the best of the forage tract now devoted to cattle.

Between the two tracts described, lies an area which under normal conditions has been flooded to a greater or less extent at high stages.

The maximum flood volume at Yuma for the past 8 years are as follows:

It is believed that to flood this middle tract to such extent as to be materially beneficial, the flood volume must reach at least 75,000 cu.ft. per sec., and it will be seen from the table that during only half of the years has this condition been realized. Yet it is likely that to wholly exclude the flood waters from this tract will deplete to a material extent the area that is now used advantageously for cattle. So here is the measure of the possible injury to the company arising from the exclusion of floods.

Mention should also be made of the lands which will lie between the levee and the river. This land will doubtless be flooded every year with rare exceptions and hence should be prolific in forage suitable for cattle, so the damage here may properly be regarded as nominal.

Having enumerated the possible damages arising from eliminating the overflow it is proper to consider the benefits accruing to the Colorado River Land Co. therefrom.

In the first place, it is highly improbable that this vast fertile tract of over 600,000 acres will be long devoted to stock raising. At the present time there is about 35 acres to each head of stock on the range.

Under irrigation and cultivation, this 35 acres would yield about 1225 bushels of barley or 350 tons of alfalfa, so there is every inducement to change to cultivation as rapidly as conditions will permit.

Cultivation to any considerable extent without flood control by means of a levee is impracticable both on account of the protection of the irrigation system and the protection for the crops from direct flood damages.

The construction of the levee therefore becomes of substantial benefit to the Colorado River Land Co. in this respect.

Furthermore, the exclusion of floods from the Volcano Lake district will reclaim 65,000 acres or more which is now wholly valueless.

So on the whole it seems clear that the betterments far outweigh such injury as may be properly chargeable to works for flood control.

These are rather matters that should be adjusted by and between the local interests in order that the projected work be not delayed which might even jeopardize the experditure of the money appropriated.

Fifth: The Government of Mexico will receive substantial benefit, since the proposed improvement will make it possible to change a very large tract, which now affords meagre pasturage for comparatively few cattle, to a state of cultivation, which will bring returns of many dollars per acre, and these revenues will add materially to the prosperity of our sister Republic.

Sixth: Works for effective flood control will contribute in a measure to the safety of the structures

built by the U.S. at great expense, for agricultural development of Yuma Valley and the anxiety heretofore felt for the safety of Laguna dam, when breaks of the Colorado have occurred, will be effectually set at rest.

RECOMMENDATIONS.

In accordance with the investigations made and the conclusions reached therefrom, I have the honor to recommend the closure of the Abejas river so as to divert the flow of the Colorado river back to its former bed.

The construction of a line of levee southward from a point on the Cal. Development levee about six miles south of the head gates and following along the river at a distance of about 3000 ft. west of the westerly bend, down to the proposed diversion dam across Abejas river and continue the same to a point about 42 miles by river below the head gates at Hanlons, a total length of levee of about 25 miles.

A break below the lower terminus of the proposed levee would be so near the Gulf of California that there would be no fear of the Colorado River reaching the Salton sink from that locality.

These recommendations are based on the supposition that the right of way for access to the break and on which to construct the proposed levee will be granted to the U.S. free of cost, as it is the practice on the Mississippi river on similar work.

The break must be closed during the low water season and the entire work must be completed before the arrival of the usual spring floods. Active construction must therefore begin at a very early date and the necessary negotiations with the Mexican Government should therefore be concluded with the least possible delay.

My acknowledgements are due to Mr. F.L. Sellew, Project Engineer of the Reclamation Service, who has rendered substantial assistance in many ways which materially facilitated my work and did much to mitigate the hardships incident to field work in the summer in a section where very high temperatures are common.

To Mr. W.H. Holabird, Receiver of the Cal. Development Co., and his Chief Engineer, C.K. Clarke; Mr. D.O. Anderson, of the Colorado River Land Co; Mr. W.K. Bowker, of the C-M Ranch Co., and the officials of the several water companies in Imperial Valley my thanks

are due for prompt response to my many requests for information as to their respective fields of work.

Respectfully submitted,

J.A. Ockerson,

Consulting Engineer.

Hon. Frank Pierce,
Assistant Secretary of the Interior,
Washington, D.C.

List of Maps and Plates to accompany report of J.A. Ockerson, Consulting Engineer on the Protection of Lands and property in Imperial Valley, Cal.

Map No. 1 - Map of the Colorado Delta and Imperial Valley

Map No. 2 - Map of the Colorado River survey of Aug. - Sept., 1910

Plate 1 - Imperial Canal Intake

" 2 - Temporary dam and Trestle

" 3 - Photograph of present dam

" 4 - Slope diagram of Outlets

" 5 - Cross-sections showing bed rock and changes in river bed due to floods.

" 6 - Changes in bank line of Colorado river since 1873.

" 7 - Hydrograph of Salton Sea

" 8 - Slope diagram of Colorado river 1910

" 9 - Hydrograph of Colorado River at Yuma 1878-1910

COLORADO RIVER HISTORY

1540: Exploration, by water, of the lower river by Francisco Alarcon

1540: Exploration, overland, of the lower river by Melchior Diaz

1604: Exploration by Don Juan de Onate

1701-1702: Exploration by Padre Eusibio Francisco Kino

1721: Exploration by Ugarte

1744: Exploration by Fernando Corsay

1771 and 1776: Exploration by Padre Garces

1826: Exploration by Lieut. R.W.H. Hardy

1827: Exploration by Jas.P. Pattie and father

1850-51: Exploration by Lieut. G.H. Derby

1857: Exploration by Lieut. J.C. Ives

1893: Cal. Development Co. incorporated in State of N.J. O-p.31

1894: C.D.Co. secured option on 100,000 acres in Mexico from Cuillermo Andrade O-p.31

1898: June. Contract consummated to purchase 100,000 acres from Guillermo Andrade by C.D.Co. O-p.31

1900: Construction by C.D.Co. begun at Hanlons Heading, in late summer K- p.3.

1903: Need of levees. (Capt. Edgar Jadwin, Corps of Engineers) I p.5

1904: Spring. Second intake cut from river to canal, by C.D.Co. O-p.33 Also, Intake No. 3 made.

1904: June 10. Contract between Republic of Mexico and Sociedad de Yrringacion y Terrenos de la Baja California Anonima, permitting appropriation of 10,000 sec.ft. from Colorado River in Mexico (Approved by Pres. Diaz) O- p.24.

1905: June 20. Agreement between C.D. Co. and S.P.Co. O-p. 20

1905: June 20. Agreement between C.D.Co., Mexican Co. and S.P. Co. O-p.22.

1906: Aug. or Sept., disastrous flood occurred, washing out $150,000 gate and cutting channel 1800 ft. wide O-p.25

Oct. (?) Rock dam completed across cut in ditch O-p.35

Nov. 6: C.D.Co. succeeds in closing gap O-p.12.

Dec. 7: Flood passed under levees immediately south of break, washing out levees below dam, etc. O- p.12.

Dec. 21: Mexican Government served preliminary informal notice on Mexican Co. to furnish proof satisfactory that it had means, within 30 days there after, to shut out and control waters of the Colorado River or else condession to Mexican Co. would be cancelled and the water shut out of Mexico. O- p.35

Dec. 26: Doran gives financial statement of C.D.Co. O-p. 16.

1906: Dec. 13 to 31. Telegrams E.H. Harriman and Pres. Roosevelt.

1907: Jan. 4 to 7. Telegram President Roosevelt and E.H. Harriman.

June 25, 1910, Congressional Record, Vol. 45, No. 163, p. 9522, letter from the President (H.Doc.No.972) stating that the situation on Colorado River is exceedingly serious and that unless quick relief can be had thousands of people and millions in land values will be jeopardized. Also, letter from F.H. Newell to Senator Flint, dated June 23rd.

June 25, Joint Resolution (S.J. Resolution No. 120) making appropriation to permit President to protect people and property in Imperial Valley in Cal., appropriating one million dollars was passed by the Senate. On the same day (Cong. Record, p.9559) the message was laid before the House)see page 9565) and under suspension of the rules Senate Joint Resolution was passed.

June 23: Newell to Flint- Apparently a similar work must be undertaken immediately to prevent the possibility of disaster. Cong. Record, Vol. 45, No. 163, p. 9523.

June (?) Conference at Los Angeles of representatives of Imperial Valley, S.P. Co., Cal. Development Co. etc.

June 25, Act. passed.

July 4, L.C. Hill in Washington from Phoenix

July 19, Ockerson to Washington

August, Investigation

Sept. "

Oct. 4, Ockerson reports

Nov. 3, Ockerson to Wash. for conference

Nov. 4, Report

Nov. 5, Ballinger to President.

Nov. 18. Small force organized for survey for railway.

Nov. 23. Ockerson at Yuma

Nov. 25. Bids opened p. 42

Dec. 1. Ockerson reports season far advanced

Dec: 9. Contract between Colorado River Land Co. and Ockerson

Dec. 12. Ockerson wires cannot send tools, etc. over line

Dec. 13. Ockerson wires delay costing Government $700 per day p. 14

Dec. 17. Ockerson wires work blocked p.14

Dec. 17. Ockerson writes have no formal documents p. 15

Dec. 19. Ockerson wires no instructions yet for local officials. p. 17.

Dec. 21. Ockerson wires no concessions as yet

Dec. 24. Formal exchange of notes

Dec. 28. Ockerson wires duties being paid

Dec. 31. Ockerson wires no customs officers yet.

1911.

Jan. 3.	Ockerson writes promises of officials no use. Want instructions to them.
Jan. 8.	Track gang began work.
18.	Pile driver and tools reached Alejos
21.	Pile driving began
29.	Insurrectos capture Mexicali
Feb. 2	Last bent driven and rock dumping began
4	Track completed to Alejas river
7	Sudden rise
17	Trestle again closed
19	Ockerson informed that Mexican Government proposed sending 300 soldiers
21	Insurrectos take Algodones
22	Mexicans authorized local police
28	By end of month 1300 carloads of rock dumped
March	Insurrectos stop equipment, etc.
" 7	North end seven bents gave way
" 13	Raft of drift wrecked bents- drowned one man
" 28	Pile-driving resumed
Apr.	Insurrectos plundered stores and were constant menace to work
" 6,	Ockerson wires, must organize patrol
" 8	Ockerson ordered to leave
" 16	Mexican troops arrive at camp
May 10	Mexican troops go to Algodones
15	Dam completed
15	Ockerson authorized to protect levee
20	Ockerson reports results
25	Ockerson at Washington
26	Ockerson talking to General Marshall & Newell

June 1, Sec'y Fisher calls board -- Newell, Marshall, Ockerson, Lippincott & Otis

June 7, Board report.