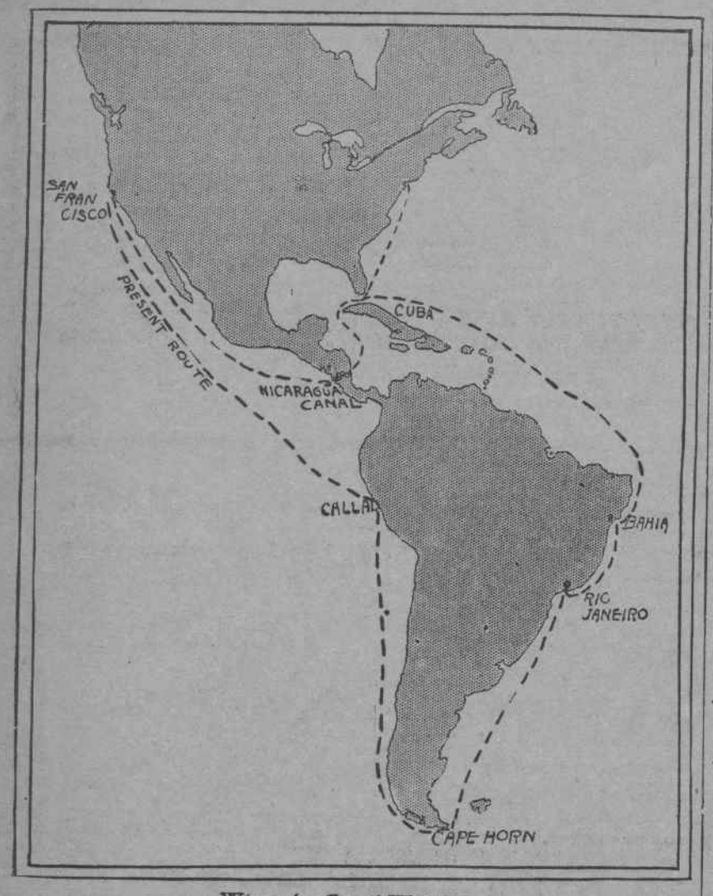
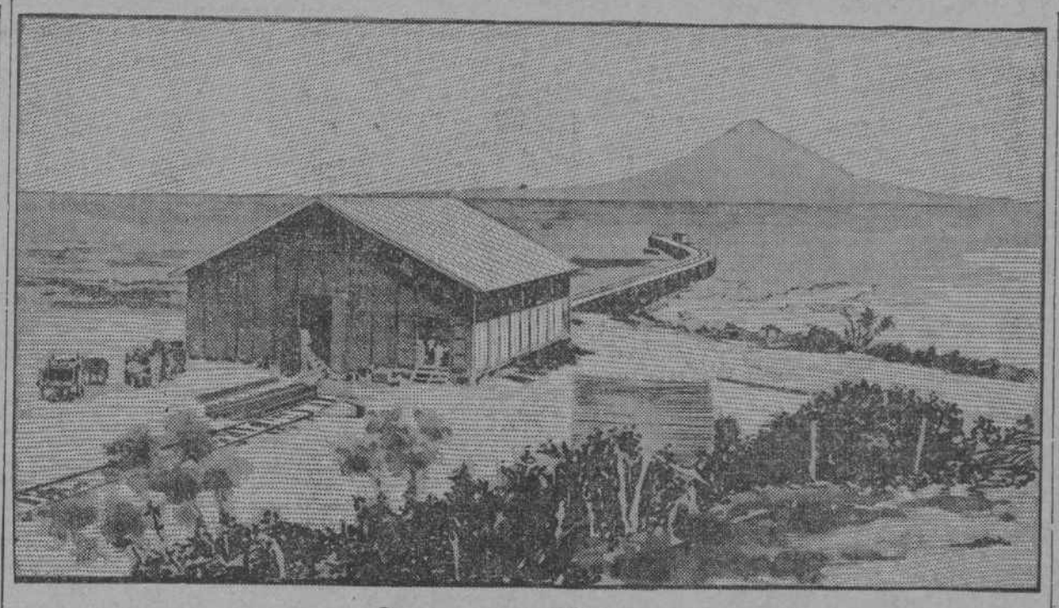
NICARAGUA ROUTE PREFERRED TO ANY OTHER.



What the Canal Will Save.

This map shows the immense saving in distance that will be made by the building of the Nicaragua Canal. New York and San Francisco will be practically next door neighbors, instead of being separated by the enormous line of South America.



Scene on Lake Nicaragua.

This is a view of San Jorge Landing, on the shore of Lake Nicaragua, where a pier has been built for the landing of vessels. In the distance looms Ometepe Mountain, which rises to an altitude of 5,350 feet. It is an inactive volcano, and is situated on an island in the western part of the lake.

Rear Admiral J. G. Walker.

Admiral Walker was the president of the Nicaragua Canal Commission that prepared the report, made public by the Journal to-day, declaring so strenuously in favor of the feasibility of the canal. He is also president of the new commission.

No Likelihood That the Panama Investigation Will Cause the Commission to Change Its Views as to the Best Canal Way.

tire basin this estimated rainfall is too great. Suppose it to be taken at 84 inches, or 7 feet. There results:

	Inches.
Rainfall direct on the lake	84
Run-off, 33 per cent, about	84
Total inflow	168
Deduct for evaporation and use	63
	105

This represents what must be taken care of by storage and discharge.

Increase Not Uniform.

This rainfall will not be extended uniformly over a year, but most of it will fall within the wet season of seven months. A mean discharge of about 40,000 cubic feet per second would discharge it all at this time. Or, if four feet be stored in the lake, a mean discharge of 22,000 cubic feet per second would take care of it.

Inasmuch as it is impossible to know in advance whether the rainfall of a season is to be heavy or light, it will not be safe to begin discharging at the full capacity of the outlet until enough water has been stored for possible deficiencies.

Consequently, instead of having seven months' time in which to discharge the surplus, a large part of it might have to be discharged in a less time, and a spillway of greater capacity would be needed. With a spillway capacity of 50,000 cubic feet per second the entire surplus could be handled in about ninety-two days.

HOW TO HANDLE THE RAINFALL.

E. S. Wheeler's Computations as to Dams and Wasteways Needed.

Mr. Wheeler's Report.

The report of E. S. Wheeler says:

"Between June 18 and October 29, 1898, a period of 132 days, the rainfall at Rivas was 76.36 inches; the lake rose 48.00 inches, the outflow lowered it 12.76 inches, and the evaporation of the lake surface lowered it 16.38 inches.

"Between May 17 and October 27, 1897, a period of 164 days, the rainfall at Rivas was 112.42 inches. This was the period of greatest rainfall shown in the Rivas records since 1879.

"At the beginning of these periods the streams and marshes were drained and empty; at the end they were overflowing and the entire run-off due to the rainfall had not yet occurred.

"An examination shows that the daily rate of rainfalls in 1897 was 18 per cent greater than in 1898. Using the ratio as before the rise in the lake would be 22 per cent greater. Applying this per cent the computed rise in the lake for 1897 would be increased from 143.7 inches to 148.56 inches.

"This, then, is the estimated amount of fluctuation that would have occurred during the period of greatest rainfall of the last twenty years if there had been no evaporation on the lake or outflow from it.

Question of Fluctuation.

"The question as to what amount of fluctuation in the lake will be necessary to take care of this rainfall will be considered. The estimated rise of 148.58 inches must be provided for by evaporation, outflow and temporary storage in the lake.

"Assuming the ratio of evaporation from the lake surface to be the same as in 1898, it would for the 164 days amount to 20.97 inches. Substracting this from 148.58 inches leaves 127.61 that must be provided for by outflow and temporary storage.

"The lake has an area of 3,000 square miles; a rise in its surface of 127.61 inches would be equivalent to 889,408,618,000 cubic feet. If this should run out of the lake in 164 days the mean discharge would be 62,769 cubic feet per second, and there would be no change in the elevation of the lake surface.

"If the lake should be permitted to rise one foot then the mean discharge would be reduced to 56,866, and each additional foot that the lake is allowed to rise will reduce the mean rate of discharge by an equal amount. The following table shows the required rate of discharge for each foot of fluctuation:

	Cubic ft. of Discharge.
No fluctuation requires	62,800
One foo requires	56,900
Two feet requires	51,000
Three feet requires	45,100
Four feet requires	39,200
Five feet requires	33,300

Use for a Wasteway.

"If a wasteway having a capacity of 33,000 cubic feet per second be provided the fluctuation in the lake could be limited to five feet for rainfall, as great as any that has occurred in the last twenty years.

"Since the canal itself will incidentally provide wasteways exceeding this in capacity, it appears that not more than five feet of rise will be caused by the largest rainfall. Therefore no addition need be made to the six feet already provided for dry periods."

The Commission has therefore concluded that in any plan of a canal by the Nicaragua route a spillway of 50,000 cubic feet per second capacity should be provided, and that the lake may vary in its level from elevation 104, the minimum, to 110, the maximum.

The endeavor would be to approach the dry season with the level of the lake at about 108, and during that dry season to draw it down to 106, if it did not go to that level from natural causes.

At the beginning of the wet season the lake would be allowed to rise, but when it reached 108 the spillway would be opened, gradually at first, and at its full capacity if necessary.

In this way there would be a margin of four feet for the lake to fall in dry seasons and the same amount for it to rise during wet seasons. This is believed to be ample.

A Uniform Decline.

From this period it would then have declined quite uniformly from loss by evaporation until the end of the dry season, May 15, when it would have stood at an elevation of 104.07 above datum, after which it bore a nearly constant relation to the accumulated rainfall and would have reached its highest level of 113.69 on January 20, 1899, a gain of 9.8 feet in about eight months, had all the water been held.

If, on the contrary, it had been desired to prevent any further rise at any particular stage, even the lowest, it might have been done by a spillway having a capacity of discharge at the rate of 45,940 cubic feet per second. With this spillway capacity for this year the lake could have been held at any desired stage, or by a reduction of the discharge it could have been allowed to fluctuate within any reasonable limits.

A spillway of 50,000 cubic feet capacity divided between the eastern and western outlets will afford ample facilities for the regulation and control of the lake and its drainage.

Fluctuation Computed.

By taking the difference between lake fluctuations and the 45,940 second feet at any date, as for example on July 14, and plotting this difference, the result will represent the fluctuation of the lake under the physical conditions as they existed between July 14 and the end of the record.

Had the sluices remained closed between January 1 and July 14 the lake would have risen to 107, and if then thrown fully open the lake would have risen only one inch higher during the entire season.

Had they been entirely closed again on October 28 the lake would have gained two feet more in storage preparatory to the next dry season, which it would have entered at 108.68. By closing earlier more water could have been stored.

This matter could readily be regulated by the judgment of the manager, who would doubtless have closed the valves throughout the dry season and thus have stored the entire outflow during that time.

Location of Spillways.

An important matter in connection with the regulation of the lake level is the location of the regulating works or spillway. It is seen that the lake may at times have to discharge as much as 50,000 cubic feet per second. An ideal arrangement would be to have the spillway entirely independent and separated from the canal proper or canalized river.

A careful search has been made for such a location on the west side between the lake and the Pacific, but no suitable place could be found that did not involve an expense almost as great as the construction of the western division of the canal itself.

It has therefore been suggested that the surplus water might be discharged through the canal itself as far as Bueno Retiro, and there turned into the valley of the Rio Grande, which it will be forced to follow on its way to the sea. This plan is objectionable for several reasons.

A Widening Necessary.

It will necessitate a widening of the canal proper from the lake to Bueno Retiro, a distance of about nine miles, the most of which will be excavation in rock. This part is the divide cut of the western division. Even if this cut be made reasonably wide, the current through it will be swift.

Of course, the greater the width the less the current, but it may be questioned whether a current of five feet a second in a canal 200 feet wide would be entirely satisfactory to navigation. Moreover, 200 feet width will only discharge about 35,000 cubic feet per second with a five-foot current, and there may be times when the discharge ought to run as high as 50,000 cubic feet per second. To carry this amount of water with a five-foot current would require a width of about 300 feet.

Difficulty of Control.

A further objection would be the difficulty of properly controlling these discharged waters after they had left the canal. The discharge of 35,000 to 50,000 cubic feet of water per second into the valley of the Rio Grande means the creation of a torrential river ten times the magnitude of the existing river in its highest floods.

The soil of this valley is for the most part light, sandy and easily put in motion by swift-running water. The distance from Bueno Retiro to the Pacific is about eight miles, and the river in that distance would have a fall of about eighty feet from the foot of the spillway.

Moreover, the canal itself will be located in this valley, and at the gorge the width is reduced to 2,000 feet. A stream like the one thus created might endanger the canal itself.

The difficulties of controlling it would be great, and a large amount of the material would be scoured and carried to the ocean, perhaps to the great detriment of the entrance to the canal.

It is possible that from 10,000 to 15,000 cubic feet of water per second might be discharged through the canal on the west side and into the Rio Grande River, if widened and straightened without damage, but the discharge of two or three times that amount is believed to be impracticable, except at unwarranted expense.

A Natural Avenue.

Nor does there appear to be any absolute necessity for discharging all the surplus water of the lake on the west side. The San Juan River is to-day, and has been, its natural and only avenue of discharge.

According to the estimates of the geologist and the hydrographer, its discharge in high stages has at times been as much as 50,000 cubic feet per second. The evidence appears to be conclusive that even this great discharge does not erose its banks to such a degree as to carry much sediment.

The Agua Muerta below the Machuca rapids indicates that no great amount of sediment is carried in the upper San Juan, and this, notwithstanding the fact that the currents have been greater than they would be under the new condition of affairs created by the canalization of the river.

The fact that the small tributaries that drain into the San Juan may at times discharge as much as 50,000 cubic feet per second between the lake and the San Carlos River is objectionable, but such discharges come at rare intervals and last but a short time.

Even if the regulating works could not take care of it the only effect would be to raise the water in the river and stop the discharge from the lake for a short period, or possibly turn the current toward the lake.

No Danger of Erosion.

If, then, the San Juan River, discharging sometimes as much as 50,000 cubic feet per second, in addition to that of its own drainage basin, as it exists to-day, with a fall from the lake to the foot of Machuca rapids of 48 feet, does not seriously erose its banks, it does not seem reasonable to expect more erosion when that fall is reduced and the discharge area of the river increased.

The Commission has therefore concluded that the discharge from the lake through the canal and down the Rio Grande River on the west side should not exceed 15,000 cubic feet per second, and that the remainder should be discharged through the San Juan River.

The principal regulating works are therefore designed to be located at the site of the dam near Boca San Carlos, capable of a maximum discharge of 85,000 cubic feet per second, while the works on the west side should have a capacity of 20,000 cubic feet.

CANAL ROUTE IN NARROW LIMITS.

Very Little Latitude Possible in Laying Down the Route.

The region within which a canal can be constructed is comprised within comparatively narrow limits. By the term "Nicaragua route" is understood a canal route which uses Lake Nicaragua as a part of its system. For convenience this may be divided into three divisions.

1. The division between the Pacific and the Lake, called the Western division.
2. The Lake itself.
3. The division between the Lake and the Caribbean Sea, called the Eastern division.

The Western Division.

Colonel Childs, an eminent civil engineer, in 1850-51 surveyed and located a route for a canal over this Western division.

His route, starting from the Pacific Ocean and going eastward from Brito, at the mouth of the Rio Grande, followed the valley of this river to a point about eleven miles from the Lake, thence across the divide to the valley of the Lajas, which it followed to the Lake.

There was no harbor at Brito, and he proposed to form one by the construction of jetties and by excavating the alluvium, of which the coastal plain is composed.

In 1873 a survey was made by Commander Lull, of the United States Navy, who proposed to construct a harbor at Brito, and follow the route suggested by Colonel Childs up the valley of the Rio Grande, but to cross the Divide further to the north and follow the valley of the Medio to the Lake. This line was somewhat shorter than the other, but involved heavier cutting in the Divide. A full description of this route is given in Lull's report.

Mr. Menocal's Idea.

Mr. Menocal, the chief engineer of the Maritime Canal Company, after further surveys, proposed to abandon the Medio route on account of the heavy cutting in the divide, and adopted practically the route suggested by Colonel Childs. His first project was for a canal in excavation along the north side of the valley of the Rio Grande.

Subsequently he suggested a modification of this project, which was adopted by the Maritime Canal Company, of building a dam at La Flor and creating an artificial basin 6.25 square miles in area reaching from near the westerly side of the divide to within four miles of the Pacific Ocean.

At the proposed site of the dam the valley of the Rio Grande narrows to about 2,000 feet, and the surface indications of the adjacent hills seemed to promise good foundations for a dam. The construction of this dam would practically extend the lake level westward to within four miles of the Pacific Ocean. From the basin thus created the Pacific Ocean was reached by a canal with three locks.

Idea of Board of 1895.

The Board of 1895 suggested still another project for a canal across this Western division, which did not differ in location materially from that at first proposed by Colonel Childs, but followed the left bank of the Rio Grande instead of the right.

These several routes are shown on the map accompanying this report, and a further description of them seems unnecessary, as full descriptions are to be found in the various reports and Congressional documents published by the United States Government from time to time.

The relative advantages and disadvantages of these several routes will now be considered, but solely on a physical basis without reference to relative cost.

The Menocal project of creating a basin in the valley of the Rio Grande by the construction of a dam at La Flor has the advantage of bringing the lake level close to the Pacific Ocean.

The deep part of such a basin could be more rapidly and conveniently navigated than a canal in excavation. Moreover, the flood discharges of the Tola and Rio Grande could be admitted into the basin without materially affecting the surface level, and it avoided all necessity for diverting the waters of these streams from the canal eastward of the dam.

Some Disadvantages.

The disadvantages of this plan are, first, the La Flor dam itself. Its crest would have to be at about 120 feet above sea level, allowing ten feet for freeboard, while the solid rock is found at about minus 45. The total height of the dam in the deepest part would, therefore, be not less than 165 feet.

Second—If a high dam be built at La Flor to hold the level of the basin at 110 feet above sea level, all the locks would have to be placed on the west side of the Rio Grande. This is a disadvantage, because the area suitable is limited.

The locks necessarily will be of high lift and located on the slope of the hills close to each other, where there is little room for additional locks should they become necessary by future developments in the commerce through the canal.

Moreover, a part of the canal itself will necessarily be built with heavy embankments or retaining walls in the slope of these hills, and the lower Rio Grande will either have to be crossed, taken into the canal, or discharged to the eastward of the proposed harbor.

Third—The creation of this basin would submerge many acres of land not at present of great value, but which would become valuable should a canal be built.

Canal in Excavation.

A canal in excavation, whether it follows the right or left bank of the Rio Grande, avoids the construction of the La Flor dam, presents no special engineering difficulties, enables good sites for locks to be selected and preserves for cultivation the fertile land bordering immediately on its banks.

Of the two routes in excavation the one on the east side allows the river to discharge through its natural mouth on the west side of the harbor. It is somewhat shorter than the other, but the most important advantage is that it enables the harbor at Brito to be constructed on the east side of the Rio Grande, which is considered advisable since it is contemplated to discharge a part of the water of the lake on the west side for regulation of lake level.

Lock and Dam Proposed.

The Menocal project could, however, be varied by providing a lock and dam at or near Bueno Retiro, and dropping down to a lower level. The basin would in this case be diminished in size and the dam would be lowered in height by the number of feet lift in the lock.

Less land would be submerged, but the basin would not be as deep nor as long. On the other hand, fewer difficulties would be encountered in constructing the locks from the La Flor dam to the Pacific and the canal could be carried down to the sea on either side of the river with less difficulty.

The Commission is of the opinion, in view of all the circumstances, that the best location is on the left bank or east side of the Rio Grande.

The lake division will be the same for any project.

The Eastern Division.

The projects that have been proposed and considered for the eastern division admit of more variants than those on the western division, but all projects for the eastern division look to canalizing the San Juan River by means of locks and dams from the lake to the vicinity of the mouth of the San Carlos River.

Three projects with their variants are all that need be considered on the eastern side.

The first is that for canalizing the San Juan River from its source at the lake to the sea. So far as the canalization of the river from the lake to Boca San Carlos is concerned, no doubt exists as to its practicability.

But for that portion of the river from thence to its mouth it is not deemed practicable, because of the difficulties of securing good foundations for dams, the torrential discharge of the San Carlos and Sarapiqui rivers and the great quantities of sand carried by them and deposited along the river channel of the lower San Juan.

PROJECT FOR A HIGH LEVEL CANAL.

Mr. Menocal Suggested an Elevated Waterway to Within Twelve Miles of Greytown.

A second project is that suggested by Mr. Menocal, which had for its object the extension of the lake level through the "divide cut," to within twelve miles of Greytown. It is similar to that suggested by him for the west side.

It looked to the construction of a high dam at Ochoa, a short distance below the mouth of the San Carlos River, by means of which the waters of the San Juan were to be raised to the level of the lake. From the south end of this dam embankments were to be built in the saddles of the San Carlos ridge to connect with the hills in Costa Rica, thus cutting off the escape of the raised waters of the San Juan on that side.

In this embankment line sluices were to be built to discharge the surplus waters of the lake which find their way down the San Juan River, as well as the floods of the San Carlos itself.

From the North End.

From the north end of the Ochoa dam similar embankments were to be built across the saddles in the hills on this side, until connection was made with the high ridge known as the "divide."

This was known as the San Francisco embankment line, and it crossed the Rivers San Francisco, Danta and Chancos. The number of dams, large and small was 67, those across the rivers named being the largest. This embankment line had a length of about 15½ miles from the north end of the Ochoa dam to the "divide," of which six miles were artificial.

Sluices were to be built at convenient places along this embankment to discharge the surplus waters of the drainage area to the northward.

By means of the Ochoa dam and the San Francisco and San Carlos embankments a large pool or basin of irregular shape was to be created and the surface of the water maintained at or near the level of that in the lake itself. The excavation in the upper river and in the pool was thus reduced to a minimum.

To the "Divide Cut."

From a point near the eastern end of the Ochoa dam the canal was carried in excavation to the valley of the Danta, or Florida lagoon, and from thence in pools and cuts to the valley of the Limpio, which it followed to the "divide cut." This cut is about three miles long and has an average depth of 134.4 feet, the maximum depth being about 350 feet.

After crossing the "divide" the canal descends, by means of three locks of high lift, into the valley of the Deseado, which it follows to the coastal plain, after reaching which it continues in a nearly direct line to Greytown.

A third project is to construct a dam in the San Juan River, just above the mouth of the San Carlos, giving slack water navigation from the lake to the dam, and thence by a canal in excavation along the left bank of the San Juan or near it to the junction of the San Juan with the San Juanillo, and from thence across the coastal plain to Greytown.

Each of the two latter projects admits of variants. The Menocal project can be varied by locating the dam across the San Juan above the mouth of the San Carlos River, starting with excavation to the eastward of that dam and thence following a route substantially as projected by Mr. Menocal himself.

Or a lock may be used in connection with this dam and the height of the embankments be correspondingly reduced. This would increase the depth of the divide cut by the same amount.

The practicability of a dam only a short distance above the mouth of the San Carlos River has heretofore been doubted, but the surveys show that such a dam is not only practicable but will be easier of construction than one at Ochoa.

Still Another Variant.

Another variant would be to build a dam near the lower Machuca rapids and lock down 24 to 30 feet, then follow the rest of the route practically as laid down by Mr. Menocal, the object of the latter variant being to avoid the construction of a high dam at Ochoa and to reduce the height of the San Francisco and San Carlos embankment lines. This would increase the depth of the divide cut.

Another variant would be to construct a dam at Tambor Grande and an embankment on the south side connecting with the hills in Costa Rica. This would take the place of the Ochoa dam and eliminate the San Francisco and San Carlos embankments. This is regarded as impracticable.

Other variants, such as increasing the number of locks or varying their location, suggest themselves.

The third project can be varied by constructing one or more dams, with locks, in the upper river, thus reducing the height of the dam at San Carlos. Or, after reaching the junction of the San Juan with the San Juanillo, any one of several routes may be taken to the sea.

The Menocal Project.

Mr. Menocal's project has an advantage in that it is two miles shorter than the other project following the bank of the river.

The disadvantages are:

First—The engineering difficulties encountered in building the Ochoa dam. This dam being located but a short distance below the mouth of the San Carlos River, its construction would be attended with no little risk.

Second—The San Francisco embankment line is another troublesome engineering construction. This embankment follows an irregular line from Ochoa to the Divide.

No less than sixty-seven dams will be required, some of them insignificant in size, but four of them of great length and of more than ordinary difficulty to build and maintain, because of their great height and the pressure of water to which they would be subjected, as well as to the fact that the soil on which they would have to be founded is overlain for a great depth with soft ooze.

A Third Disadvantage.

A third disadvantage is the Divide cut itself. This, as before stated, is over three miles long. In addition, it is curved, the curvature being in places the maximum that should be allowed in a canal of this magnitude.

This alone would render navigation difficult. Its great depth would also be a constant menace, for while it is believed that the rock for the most part would stand there is some likely to cause trouble. large portion of it—dacite, a rock that weathers rapidly—is of light specific gravity, and not to be trusted in a deep cut like that through the Divide.

Again, on account of its depth and length it would necessarily be made of the minimum width practicable for navigation; consequently, if the canal were working to its full capacity there would inevitably be some delay to vessels passing through it, since two large ships could not pass each other. Vessels would therefore accumulate at either end, to be passed at stated intervals in fleets.

The Lock and Dam Plan.

The variant providing for the construction of a lock and dam at Machuca, looking down, say 24 feet, would reduce the height of the San Francisco embankments and the Ochoa dam; but the excavation in the San Juan River and eastward to the eastern end of the Divide cut would be increased by this extra depth.

There would still be the Ochoa dam, though of less height, to be constructed in contention with the floods of the combined San Juan and San Carlos Rivers. If the dam be built above the mouth of the San Carlos River, instead of below it at Ochoa, there would yet remain the objectionable San Francisco embankments and the Divide cut.

The project which looks to the construction of a dam above the mouth of the San Carlos River and follows close to the north bank of the San Juan River as far as the junction of the San Juan and San Juanillo, has the disadvantage of an increase in length of about two miles, but on the other hand it is believed that difficulties of construction will be lessened because of the reduction in the height of the embankments and by avoiding the divide cut.

Several Hills to Be Cut.

There are, nevertheless, several hills of considerable height to be cut through on this route. The Tamborcito hill will require a maximum depth of 230 feet of cutting in rock, but it is less than a half mile in length and the material will be required on the work, while an attempt to circumvent the hills may involve an embankment founded upon a depth of 80 feet or more of black sand in the bed of the river.

From this point to lock No. 1 most of the canal trunk will be enclosed between embankments built of the silt from excavations. In short distances they may exceed 30 feet in height, with a pressure of twenty feet of water.

A variant on this project would be in the construction of two dams in the river above the one near the mouth of the San Carlos. But it has no advantage over the other except that it enables the lower dam to be reduced in height.

This is not considered of great importance, for while the construction would be easier the main difficulty would be in the foundations, and they would not be materially different.

It has several serious disadvantages, however, in obstructing the passage of large volumes of water at narrow sections of the river and in confining the navigation below the upper dam to a narrow channel excavated in large part through rock.

Numerous other adjustments in detail may be made, both in the alignment and grade, but they are not of sufficient importance to warrant consideration prior to final location.

GREYTOWN GIVES THE NEEDED HARBOR.

Two Jetties Will Be Necessary to Keep Open a Channel, and Dredging Must Be Done.

A suitable harbor with a safe entrance at the eastern end of the canal is an essential requisite to its proper operation. No such harbor exists now. About fifty years ago there was a good harbor at Greytown, with thirty feet of water in the anchorage and at the entrance.

The sand, however, that has been brought down by the San Juan River and deposited in the sea has closed the entrance and in a large measure filled up the harbor itself. This sand movement has been going on for ages, as the numerous lagoons that have formed parallel to the coast line testify.

The sand has been ejected from volcanoes in the region of the headwaters of the Costa Rican tributaries of the San Juan, carried down to the sea by the river and deposited on the ocean bed and then transported by wave action in one direction or another according to the prevailing winds and the resulting direction of the waves.

Not a Large Harbor.

By the term "harbor" it is not intended to convey the idea that a large harbor should be constructed for commercial purposes. A harbor of sufficient area to accommodate the vessels that arrive for the purpose of passing through the canal is all that is considered necessary.

It is not expected that vessels will lie in such a harbor for any length of time, but will move through, either in one direction or the other.

For canal construction purposes a harbor is necessary. One of the first things, therefore, to be done in undertaking the construction of the canal will be to form a harbor of reasonable depth. This has important bearing in estimating the cost of construction.

The San Juan River drains a basin of about 17,000 square miles. The silt deposited in its delta during past ages has built out the coast, with characteristic lagoons and extensive marshes, covering the broad plain between the present shore line and the original foothills of the Cordilleras.

The delta may be said to begin at a point twelve miles in an air line from the outer coast, where the San Juanillo leaves the main trunk. This stream has been turned parallel to the coast and finally reunites, through a series of lagoons, with the lower San Juan.

Flanked by Lagoons.

The latter is flanked by lagoons indicative of original beaches, the three to the north being typical of the prevailing direction of the drift on this portion of the coast, due to the angle of wave incidence.

These lagoons are nearly parallel to the existing coast line and are separated by strips of land enclosing long, narrow lakes.

It would seem that what is now the lower San Juan River was at one time the main stream and discharged most of the sediment, the waves produced by the trade winds carrying a part of the material to the westward and a part of it to the southward, the westerly movement of this sand having formed lagoons whose longer axes are nearly parallel to the coast.

The prevailing winds are from the northeastward, and while they rarely blow with great violence, they blow steadily and with considerable force, creating a sea which stirs up the light sand, of which the beach is composed, and carries it along in great volume.

One has only to observe the waves charged with black sand running diagonally along the beach to realize their potent agency in transporting this material.

Sand Movement Described.

The Board of 1895 gives a very complete description of the sand movement on this coast, a full discussion showing how the destruction of Greytown harbor as it formerly existed was brought about and the steps necessary to be taken in the construction of a new harbor.

The conclusions arrived at by that Board were that the Maritime Canal Company's proposed entrance is inadmissible and the Harbor Head entrance inexpedient, and that the best results will be obtained by locating the entrance approximately half way between the two.

This Commission is of opinion that equally good results at less cost can be obtained by a change in the entrance and form of the harbor itself.

The Commission has therefore located the east jetty about 2,000 feet westward of the position suggested by the Board of 1895, the harbor itself to be about 5,000 feet long by 1,000 feet wide, and the entrance between the jetties to be 600 feet.

The construction of a jetty across the path of moving sand must of necessity cause accumulations of drift to windward, hence the angle formed between any such projecting structure and the shore must gradually fill up and the shore line advance seaward until the capacity of this receptacle is exhausted.

Advance Diminishes.

This advance diminishes as the depth and consequent capacity of the pocket increases, but it shows that some expense must be incurred for the maintenance of the harbor either by jetty extension or by the removal of the material from time to time, which would otherwise find its way around the end of the jetty and into the channel.

A study has therefore been made of the various surveys of the harbor with a view to determining the probable amount of material to be controlled in the maintenance of the entrance. This amount is estimated to vary from 500,000 to 730,000 cubic yards annually.

The entrance to the harbor will be formed by two parallel jetties, about 600 feet apart, the easterly one about 2,670 feet in length, the westerly one 2,500 feet. They will extend seaward in a northerly direction, thus giving shelter from the sea, which comes generally from the northeastward.

As the sea strikes the shore line with considerable violence at times, these jetties will be constructed chiefly of heavy stones not easily moved by the force of the waves. To obtain suitable stone for this purpose in large quantities and with the utmost dispatch, so that a part at least of the jetty can be quickly constructed, quarries will have to be opened at the most favorable locations.

BRITO TO BE THE WESTERN HARBOR.

It Must Be Constructed, and the Engineering Task Is an Easy One.

At the westerly terminus of the canal there is no harbor. The nearest harbor is that at San Juan del Sur, about eight miles to the southeastward, but this cannot be put to any useful purpose so far as the canal itself is concerned, though it may be utilized in a measure during the early stages of canal construction.

A harbor will have to be constructed at Brito as at Greytown. San Juan del Sur could only be used to advantage during construction by the building of a railroad from there to the canal.

The remarks as to the capacity of a harbor at Greytown will apply with equal force to Brito. A harbor of refuge is not needed, but only such a harbor as will make the canal available for commerce.

Conditions Not Forbidding.

The conditions on this coast are not as forbidding as they are on the eastern. The sand movement is slight and the winds are mostly off shore, consequently the difficulties to be encountered will be more easily overcome. The mean rise and fall of the tide is about seven feet.

The sea during the greater part of the year breaks normal to the direction of the shore. The prevailing wind is from the northeast, and while west and south winds sometimes blow, they are of rare occurrence.

The shore is bold, and deep soundings are found at no great distance from it. The shore line trends from northwest to southeast, but the rocky promontory on the north side of the Rio Grande projects into the sea and gives a certain amount of protection.

On account of the rapid increase in depth from the shore seaward, an outer harbor is almost impracticable within the limits of reasonable cost, so that one is restricted to the formation of an inland harbor within the area that is now occupied by a swamp.

Material Available.

From borings made and all information obtainable, it is believed that this material is easy to excavate. In fact, it is known that some of the borings taken by the Canal Company in close proximity to the proposed harbor, which seemed to indicate rock at no great depth, were deceptive, and that the boring apparatus struck bowlders which were supposed to be solid rock.

The harbor proposed by Colonel Childs opened directly to the south, and was protected by two jetties, one springing from the sandy beach and running southward, the other, but smaller jetty, springing from