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Hydraulics Laboratory

LIMITED

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Reference: Letter of 3 March, 1958, from General [illegible] Young

Subject: RECOMMENDATIONS FOR IMPROVEMENTS TO SAINT JOHN HARBOUR, N.B.

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SUMMARY

Three proposals for improving and extending the harbour of Saint John, N.B., based on the results of a hydrographic survey are discussed in detail

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RECOMMENDATIONS FOR IMPROVEMENTS TO SAINT JOHN HARBOUR, N.B.

1. INTRODUCTION

A hydrographic survey of Saint John Harbour and adjacent waters was conducted during the summer of 1958 and spring of 1959 to obtain data on the basic causes of shoaling in the harbour and navigation channels. The data obtained during this survey have been analysed and [illegible] in Reference 1.

A study of these data shows that the harbour may be enlarged and improved and that maintenance dredging may be greatly reduced or eliminated. The Saint John River, through a simple diversion, may be developed as a source of hydro-electric power [illegible] Saint John.

2. PROPOSALS

The proposals for improving the harbour are described under the following headings.

(a) Improved Dredging and Spoil Disposal Methods

Bucket dredging does not change the structure of the silt until it is [illegible]ded into the barges. In suction dredging, however, the silt is pumped with water and the turbulence disperses it [illegible] basic components. The by-pass water, [illegible] to 10 percent of the intake, carries a large percentage of the colloids [illegible] which either settles [illegible] immediately or is carried off [illegible] the current. The disadvantage of this method is that the colloidal part remains in the harbour and mostly sand is dumped in the disposal area. The by-pass water should be reduced to a minimum, even though the efficiency of dredging is reduced.

The disposal area off Black Point, [illegible].5 miles from the harbour, was [illegible] fortunate [illegible], for [illegible] currents both in the surface [illegible] the bottom due to [illegible] reflection, [illegible] silt [illegible] during [illegible] of the tide cycle. [illegible] will be carried [illegible] 10 miles up [illegible] the Bay [illegible] (Fig. 32, Ref. 1). [illegible] of it will return between high water and half-falling tide but the amount will be reduced. When a barge is discharged at high water (Fig. 31, Ref. 1), the current will first carry the silt about 2 miles west, then, after low water, the residue will be [illegible] ward flushing effect is much stronger closer to the shore, it is advisable to dump dredged material within 1000 feet of Black Point.

(d) [illegible] and [illegible] without Changing Present Hydraulic Conditions

Some improvement [illegible] changing hydraulic conditions [illegible] Between [illegible] Island and [illegible] Po[illegible] is a gap [illegible] feet [illegible] breakwater. Waves from [illegible] and on [illegible] flood and [illegible] currents pass through the [illegible] navigation [illegible] the Harbour and Courtenay Bay. Closing the gap would give greater protection and would force all the water to flow around the Island, thus increasing the current velocities due to the intensified density conditions which exist when both salt and fresh water quantities increase. The present [illegible] velocities in the navigation lane to the City Harbour [illegible] only slightly under the [illegible] value and the increase [illegible] would be sufficient to maintain depths greater than [illegible] without dredging. An improvement would also be expected [illegible] the lane to Courtenay Bay.

If the proposals discussed under (c) are not accepted density currents will remain, and it would be better to use, rather than oppose, them. To prevent shoaling in navigation areas the bed velocities should be equal to the scouring velocity at the depth required. This may be achieved by increasing the existing velocities, as suggested for the approach channel, or by placing harbour facilities in areas where these velocities exist. One such area will be [illegible] the City Harbour and Partridge Island, along the [illegible] of the river channel, when the gap in the breakwater at [illegible] Point is closed. Harbour facilities could be extended [illegible] Slip No. 1 to Partridge Island and from the Sugar Refinery to America Rock (Fig. 1). Increased protection could be obtained by constructing a small breakwater east of Partridge Island, for protection against long-period waves which occasionally disturb navigation entering the City Harbour (Fig. 46, Ref. 1).

Courtenay Bay [illegible], unfortunately, does not have the same hydraulic structure as the City Harbour and the Partridge Island area. The Bay is essentially a short [illegible] leading to a still-water basin. The discharge from [illegible] can be neglected, although its effect on density currents [illegible] perceptible. Diverting it outside the Bay would eliminate the density currents.

There is a direct relation between the velocities in the channel and the tidal prism of the Bay. Reducing the area of Courtenay Bay by constructing the new causeway will reduce the tidal prism substantially and, consequently, the velocities in all parts of the Bay will be reduced and the rate of siltation increased.

Because greater depths are required in Courtenay Bay for navigation, the question arose as to how much the annual dredging would be increased to maintain these greater depths. To maintain the depth at 20 feet, an average of 1.8 to 2.0 feet of silt must be removed annually. An earlier attempt to maintain a depth of 32 feet resulted in the deposition of an average depth of 5.2 feet annually. This agrees with the theory established by Lervi, Goutscharow and Niebuhr that the amount of sandy silt transported depends approximately on the second to third power of the bed velocities. The bed velocities in the channel changed from approximately 1.0 to [illegible] ft./sec. and in the Bay from 0.6 to [illegible] ft./sec. The transporting forces in both cases were reduced by 60 to 70 per cent of the initial values; consequently, siltation increased 2 to 3 times.

Siltation in Courtenay Bay can be reduced only by increasing the bed velocities. This can be achieved mainly by restricting the flow section of the channel. A wharf from America Rock along the navigation lane and spur dykes from Courtenay Bay breakwater would probably increase the current in the channel sufficiently to maintain a [illegible]-foot depth at low water without dredging. No solution can be offered for the shallow-water area of the Bay.

Final Proposals Based on Changes in the Hydraulic Environment of the Estuary

The final proposals are based on the conclusion that the density current is the dominating factor influencing shoaling. Abolishing the density difference would change the harbour and adjacent area from an estuary into a bay having no density current. The most satisfactory solution would be to [illegible] the river [illegible] to the [illegible] Cove, 7 miles [illegible] toward [illegible] currents [illegible] would be subjected to tidal variation. The sand supply from the Bay of Fundy would be reduced and the colloidal material would be excluded entirely. This would be only a partial solution as long as there was no breakwater to protect the Bay from the sand which [illegible] breakwater between Red Head and [illegible] a harbour area of 3.6 square miles. this protection and provide a harbour area of 3.6 square miles. A marine dredging plant may be required to clear littoral drift from the entrance.

It has been suggested that only the breakwater be constructed. [illegible]

A power plant could be installed at the diversion channel, operating as either a continuous-load or a peak-load station. With a storage area (of 260 square miles) in the lake-like river system a yearly output of 384 million kilowatt hours appears practicable. (Fig. 3, 4, 5).

A somewhat similar proposal is to block off the harbour, or a part of it, such as Courtenay Bay, with a water-tight dam. Navigation would enter and leave through the locks and the river would discharge into the sea between Partridge Island and Negro Point. Practically no siltation would take place, since the bay would be filled with fresh water and the salt water which carries the sand and causes the colloidal material to flocculate would be prevented from entering the Bay. Experience with the new Queen Elizabeth II Dock in England (Ref. 3) proves, however, that a substantial amount of silt enters the dock during each locking. This, it was found, is "due to the density difference of the two bodies of water".

In the United States, engineers engaged in solving shoaling problems in estuaries are keenly aware that the mixing of fresh and salt water is the major factor in causing shoaling in an estuary. E.A. Schultz and H.B. Simmons state in Reference 4 that: "If the basic cause of shoaling is density currents, then the only real solution to shoaling problems is to prevent the upland discharge from entering the estuary by diverting it to the sea by some other route". This is the solution most favoured and was submitted as a main proposal in Reference [illegible].

The economy of the scheme is difficult to evaluate because it depends in general on the industrial growth of the Province and, in particular, of the cities of Saint John and Fredericton. Latest information indicates that a substantial increase in industries, requiring bulk transport by deep sea-going ships, will occur in the near future. A deep-sea harbour and low-cost electricity, supplied by the diversion scheme, would evidently be advantageous. It has been estimated that the price per kilowatt installed would be 3½ mills compared with 7 to 9 mills for steam power.

A seismic investigation conducted recently shows that the proposed diversion channel would not encounter rock, [illegible] estimating [illegible] of the diversion channel.

[illegible] model studies would be required to design the final layout.

During the survey it was found that the basic hydraulic data, such as tide observations and discharges in the river system, were insufficient. The harbour gauge at Pugsley Wharf, in operation for more than 50 years, records the water levels of the City Harbour, but these levels differ from those [illegible] Island and Cape Spencer by 1 to 2 feet and 4 to [illegible] recordings were [illegible] Fundy (tide [illegible] To establish a relationship between this gauge and the levels of the adjoining bays, three additional gauges (which can be staff gauges for intermediate observations) are required; one at the seaward side of Partridge Island, and one each at Cape Spencer and Lorneville.

In the Reversing Falls area a gauge was installed for the duration of the survey at Indiantown. This gauge is [illegible] Its [illegible] gauges should be installed - one below the Falls and the others in the river system.

3. REFERENCES

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[illegible] [illegible] Preliminary Report.
N.R.C. Report No. MH-78, October 1958.

3. Allen, F.H.; Price, W.A. Density Currents and Siltation in Docks and Tidal Basins.
The Dock and Harbour Authority, England.

4. Simmons, H.B. [illegible] a major [illegible] Corps of Engineers, U.S. Army, Tech. Bull. No. 2, April 1957.

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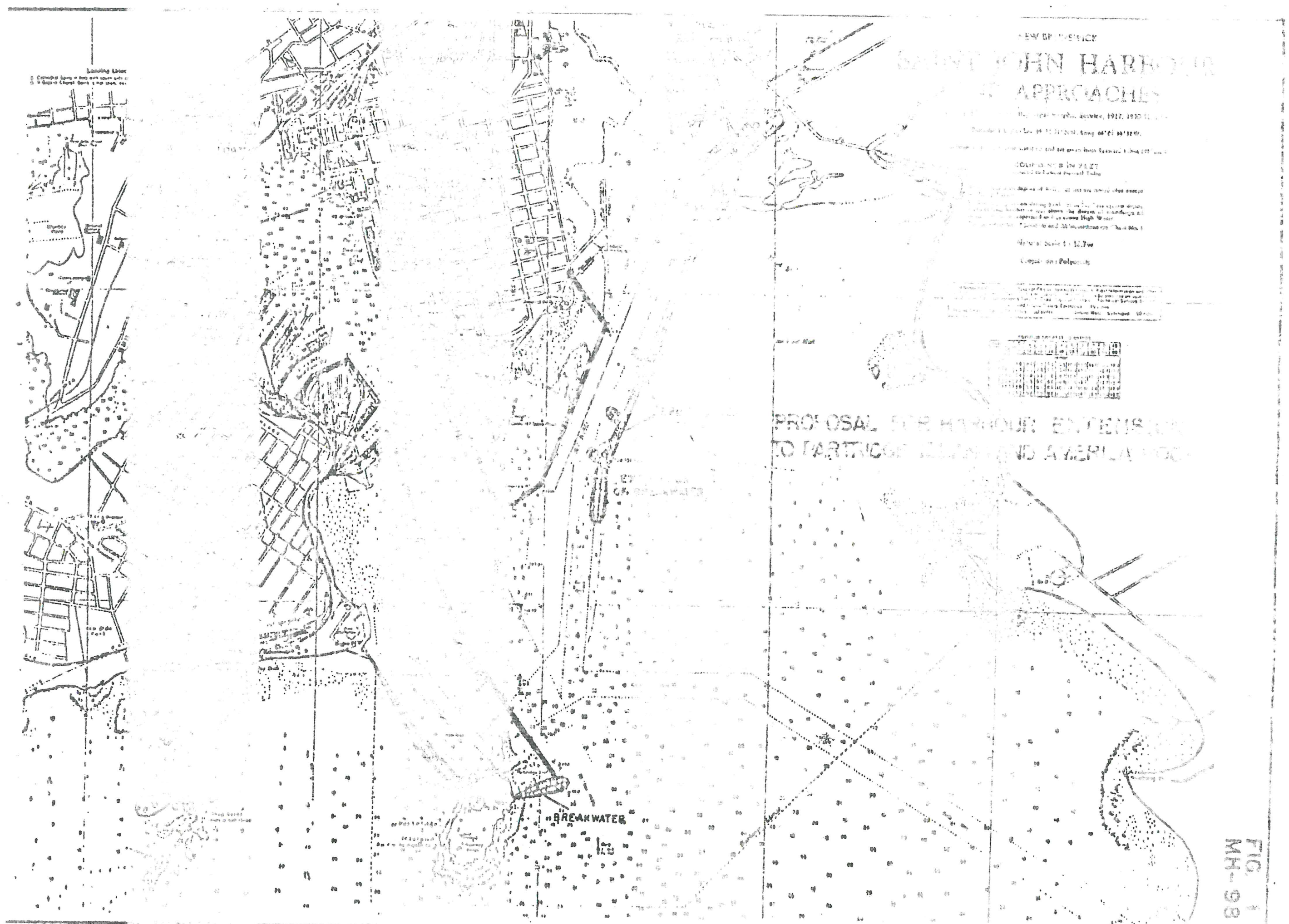

FIG. 1
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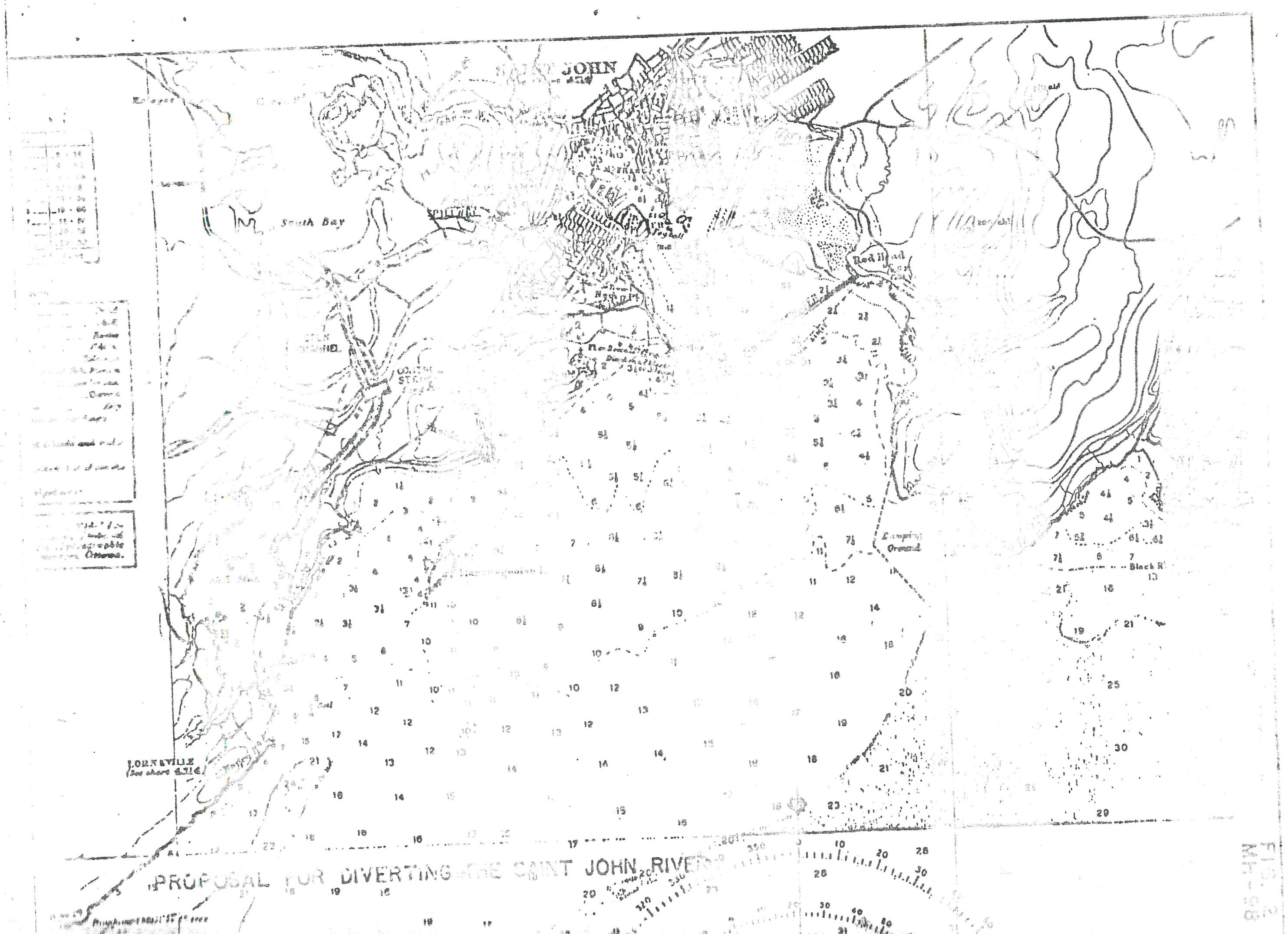
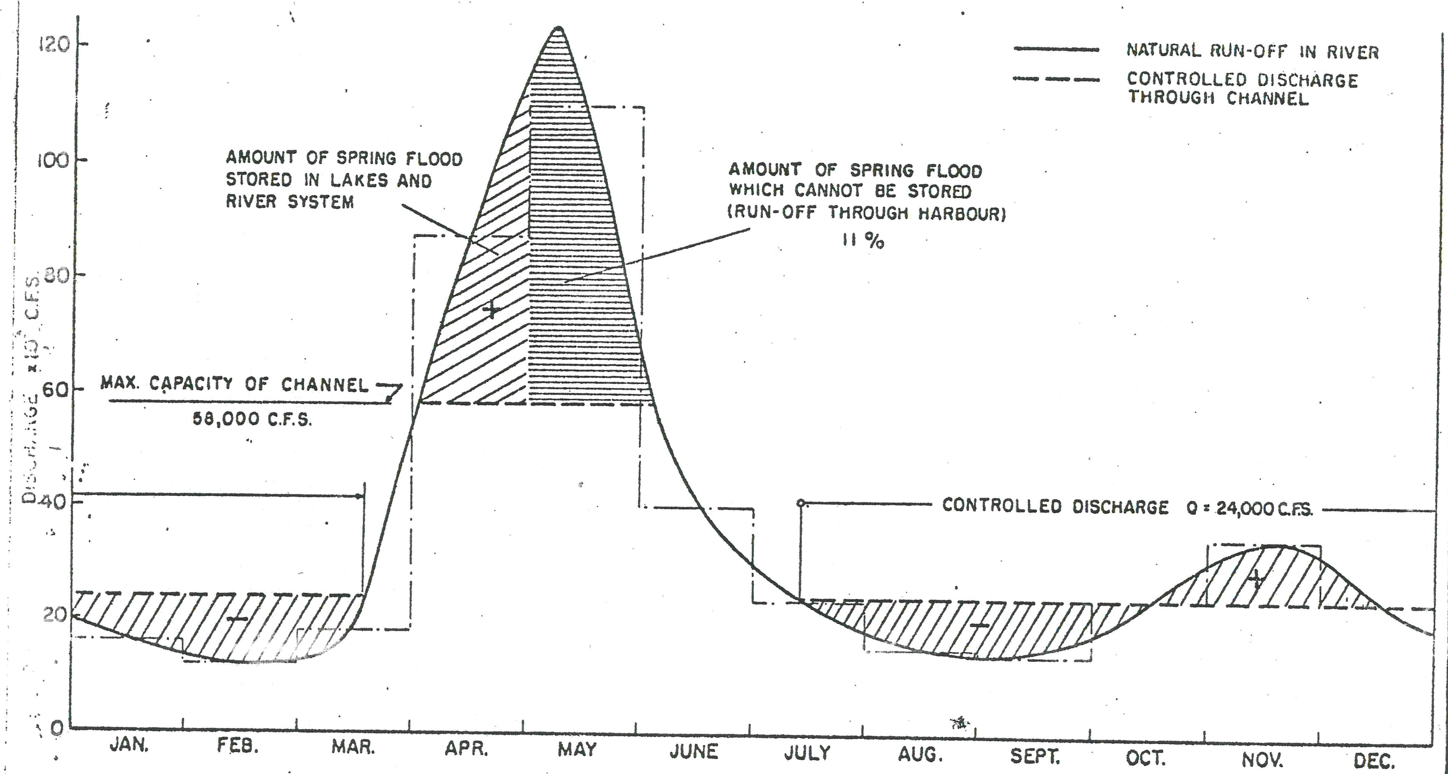

SAINT JOHN
South Bay
Red Head
Camping Ground
Black R
LORNEVILLE
PROPOSAL FOR DIVERTING THE SAINT JOHN RIVER

FIG. 2
MH-98



WATER UTILIZATION PLAN FOR DIVERSION SCHEME

BASED ON MONTHLY MEANS OF PERIOD SEPT. 1918 TO SEPT. 1956

FIG. 3
MH-98

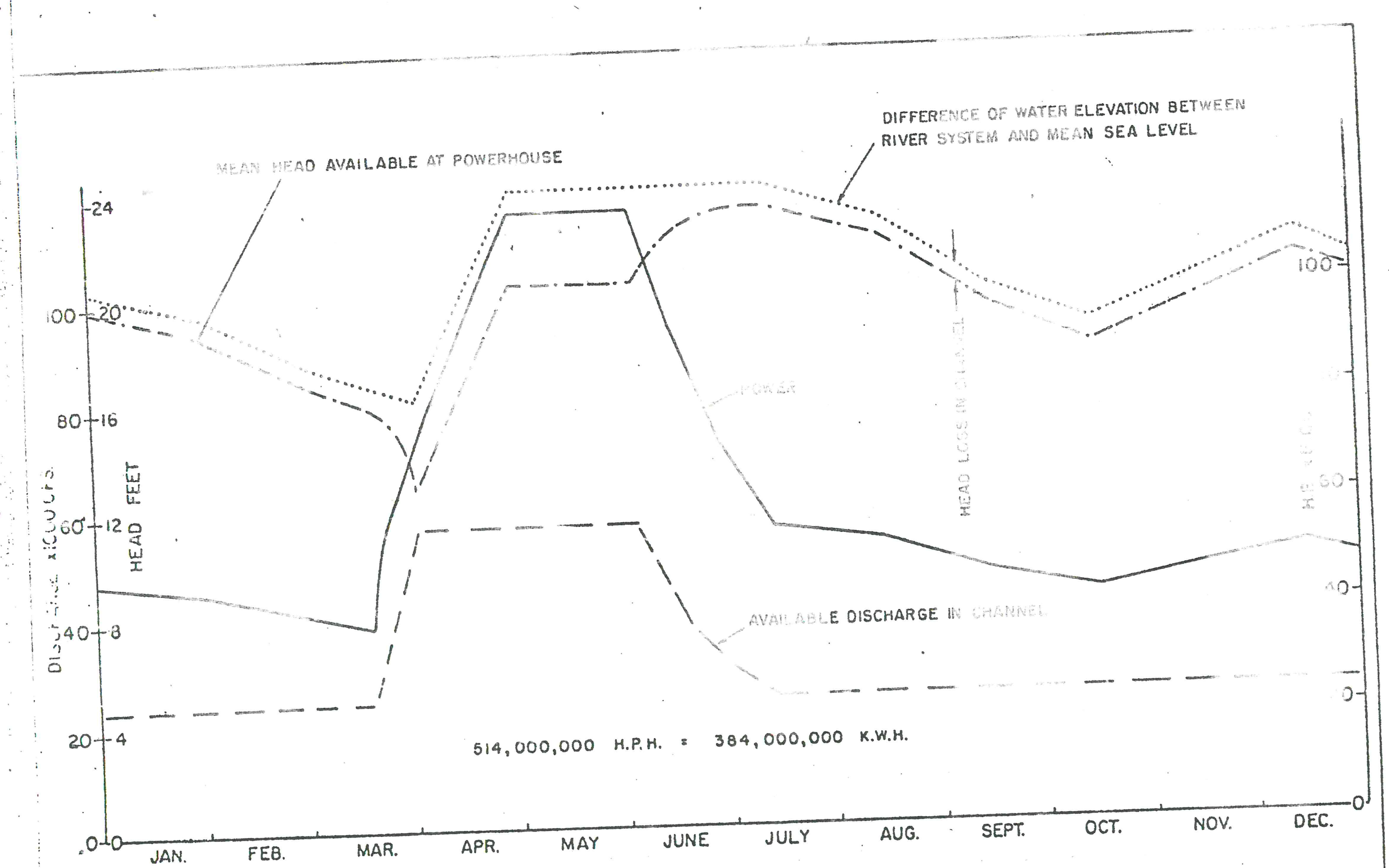


FIG. 4
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POWER PRODUCTION FOR DIVERSION SCHEME (SEASONAL)
BASED ON MONTHLY MEANS OF PERIOD SEPT. 1918 TO SEPT. 1956

FIG. 5
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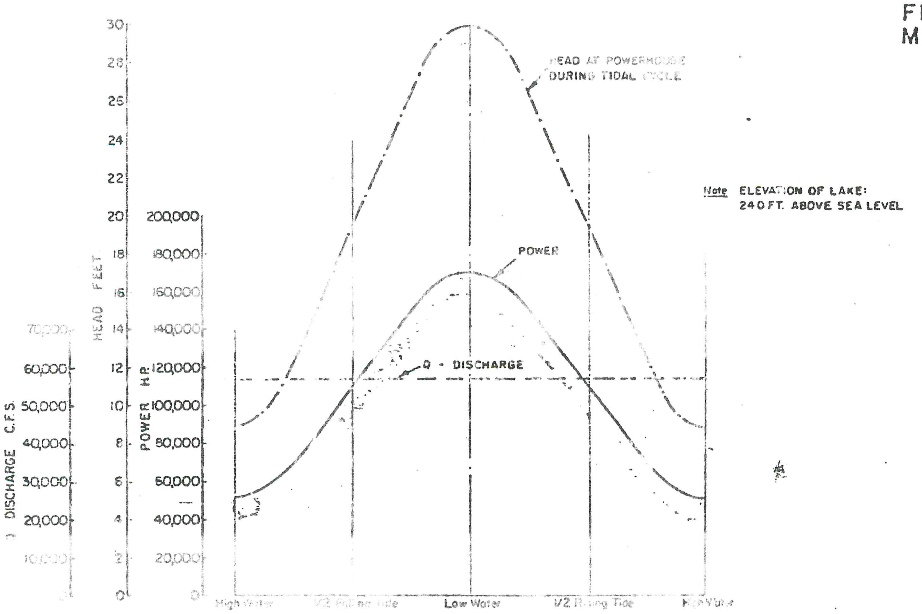
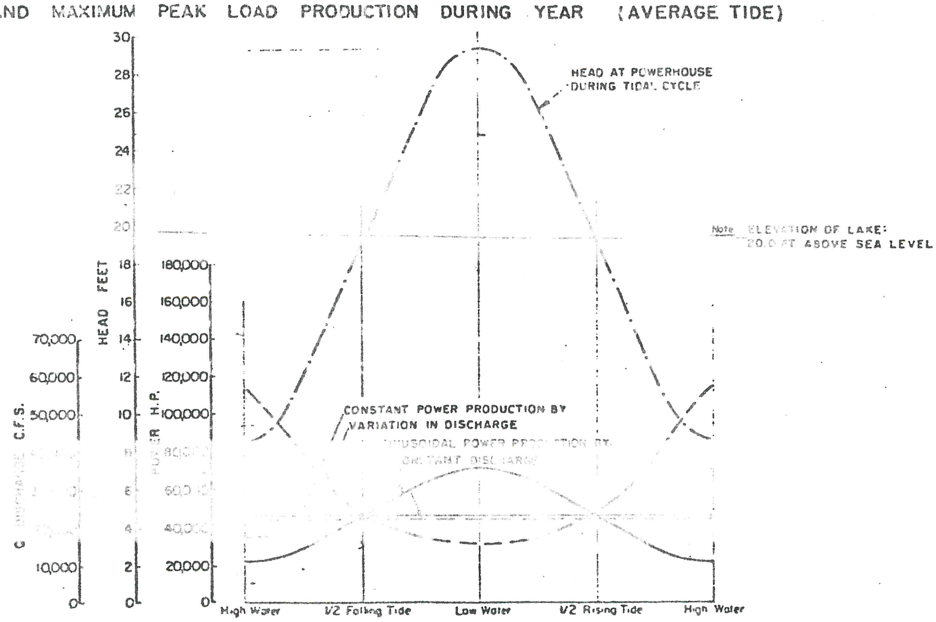


POWER PRODUCTION DURING TIDE CYCLE IN FLOOD SEASON APRIL AND MAY, PROPOSAL I, AND MAXIMUM PEAK LOAD PRODUCTION DURING YEAR (AVERAGE TIDE)



POWER PRODUCTION DURING TIDE CYCLE IN SUMMER, FALL AND WINTER SEASONS, PROPOSAL I (AVERAGE TIDE)