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SUBJECT N.R.C. POLLY'S GUT MODIFICATION, TEST SERIES A.C.N.-III
ABRIDGED EDITION

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ISSUED TO Internal.

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Reed
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27/12/56

N.R.C. POLLY'S GUT MODIFICATION, TEST SERIES A.C.N. IIIABRIDGED EDITIONINTRODUCTION

The purpose of the Cornwall Island Model, as outlined in the specifications drawn up by the Department of Transport, Special Projects Branch, St. Lawrence Seaway, is to investigate plans of improvements as follows:-

1. To improve navigation in the reach.
2. To determine what portion of the approximate 6 ft. natural head difference between the tailrace of Barnhart Powerhouse and Lake St. Francis may be economically recovered by excavation at the tailrace, and in the restricted portions of the river.
3. To determine the effects of regulating the water surface of Lake St. Francis.

Improvements for power shall conform to the requirements of navigation.

Model tests have indicated in a convincing manner that the scheme now approved for construction, ACN-II/7 plus W.E.S. Plan 2, fails to meet the navigation requirements and ignores the fact that the head gained at the powerhouse, as a result of the navigation improvements, will be nearly tripled with a relatively small amount of excavation. On outlining the main features of Laboratory Memorandum HY-8 - "Proposal for Improvement of Polly's Gut", 11 July, 1956, at the meeting held in Ottawa on 27 August, 1956, it was agreed that a series of model tests should be conducted to find a scheme which would:-

1. Release the increased tension in the Polly's Gut caused by the American design, W.E.S. Plan 2. (With a discharge of 310,000 c.f.s. the losses in the Gut are increased from 45,500 H.P., in natural conditions to 70,300 H.P., in W.E.S. Plan 2 conditions.)
2. Convert these probably destructive forces into a reduction of water level at the tailwater of the Barnhart Powerhouse.
3. Improve the navigation conditions at the outlet of the Gut which in W.E.S. Plan 2 fail to satisfy the specified navigation conditions.

The proposed scheme was named N.R.C. Polly's Gut modification, A.C.N.-III.

MODEL PROCEDURE

The initial conditions, as outlined in A.C.N.II/7-N.P., were:- The river bed in the tailrace excavated to 136.0 elevation, Polly's Gut in the natural state, W.E.S. Plan 2 in the South Channel, and compensating by-pass channel in the North Channel (Fig. 1).

Before starting tests on proposed modifications the water levels were very carefully measured across six sections in the Gut. These results were used as a basis of comparison for the modifications.

As expected the flow around Massena Point created a pressure rise, at the funnel-shaped shoreline of Cornwall Island, of 1.4 ft. which was reflected to the opposite shore downstream of the restricted neck of the Gut.

The first modification was the replacing of the sharp inlet corner at Massena Point with a large radius. This was done to reduce the pressure rise across the inlet of the Gut, and to remove the large separation zone which exists behind the point in natural conditions. Three radii were tested, 680 ft., 980 ft., and 1300 ft. The radius chosen for future tests was 1200 ft. With this radius the slope of the water profile was reduced by 50 percent from the original.

The improved inlet condition could not have full efficiency, however, because the water, which is two-thirds of the total discharge of the river, had to flow through a 100-degree bend to the right at the inlet, and through a 90-degree bend to the left, at the outlet of the Gut. The head needed to overcome these turns could be regained by reducing the curvature of the channel. To achieve this, a by-pass channel was installed which connected the inlet of the Gut directly to the pool in the South Channel below the Gut. To determine the cross-section of the channel various combinations of depth and width were tried.

- (a) Decreasing in width at a constant base elevation of 120.0 ft.
- (b) Decreasing in depth. (The sides of the channel were left unchanged and therefore the base width increased in the ratio of the slope of the sides, 1:2, as the depth of the channel was decreased.)

The Gut modification changed the discharge distribution around Cornwall Island; 7 percent more flowing into the South Channel. Additional cuts in the North Channel, were necessary to return to the natural distribution.

RESULTS

In natural conditions the water surface of the river between the tailrace area and gauges, 13/14 in the North Channel, and 21/22 in the South Channel, has a mean slope of 0.0003. The navigation excavation in A.C.N. II/7 lowers the water level upstream of Cornwall Island by approximately 1.0 ft., but concentrates very nearly all of the remaining drop, between the tailrace and Lake St. Francis, in the vicinity of the river junction. For example, the drop of the water level, in the 3000 ft. long Polly's Gut, increases from 2.1 ft. to 3.1 ft. at a discharge of 310,000 c.f.s. These increased energy concentrations may establish conditions which are difficult to control, and due to increasing erosion create the danger of disturbing the balanced flow distribution around the Island.

The N.R.C. Polly's Gut Modification released the concentrated heads in the Gut and North Channel, and gave a gradual slope from the Powerhouse to Lake St. Francis of 0.00014. The head which was necessary in A.C.N. II/7 to overcome the flow restriction in the Gut is now utilized, so increasing the total head available at the Powerhouse, see Fig. 2.

The work load in the Barnhart Powerhouse increases in relation to the work load in natural conditions as follows:

	<u>UNREG.</u>	<u>REG. 151</u>	<u>REG.152</u>	<u>REG.153</u>
A.C.N.II/7	1.3%	1.2%	1.3%	1.3%
A.C.N.III	<u>3.5%</u>	<u>3.5%</u>	<u>3.5%</u>	<u>3.2%</u>
Increase	2.2%	2.3%	2.2%	1.9%

To compare the two schemes, A.C.N.-II/7 and A.C.N.-III, consider the effect a 2-ft. regulation drop at Beauharnois (from Reg. EL 153.0 to EL 151.0) has at gauges A/F. Figure 3 shows quite clearly that besides the general average drop of water level (difference A) acquired with A.C.N.-III of:

1.25 ft. at 180,000 c.f.s.
 1.75 ft. at 240,000 c.f.s.
 2.30 ft. at 310,000 c.f.s.

we shall utilize better the regulation difference in A.C.N.-III, (difference B), which is obtained from the slope of the line and is:

1.40 ft. at 180,000 c.f.s.
1.00 ft. at 240,000 c.f.s.
0.55 ft. at 310,000 c.f.s.

as compared to, in A.C.N.-II/7:

1.20 ft. at 180,000 c.f.s.
0.65 ft. at 240,000 c.f.s.
0.45 ft. at 310,000 c.f.s.

So, A.C.N.-III uses at least 20 percent more of the regulation drop than A.C.N.-II/7.

The main advantage of the N.R.C. scheme is its effect on the navigation conditions in the South Channel. In the W.E.S. Plan 2, with no by-pass channel, the velocities exceed the required 4 f.p.s. where the flow from the Gut enters the navigation channel, see Figure 4. There is very great turbulence in the navigation channel below the dyke, and the velocity range, across certain points of the navigation channel, is too high, ranging from 0 to 7 f.p.s. in one place caused by a 30-degree cross-current. With the N.R.C. by-pass channel the high velocities at the outlet of the Gut are reduced, and the flow is of a more uniform nature across the channel. The velocities in the Gut are reduced thus lowering the kinetic forces acting on the concrete dyke, by as much as 60 percent, and reducing the turbulence. The concrete dyke could be replaced with an island of coarse fill which would withstand the remaining forces.

A.C.N.-III solves the important navigation and power problems in the restricted river section around Cornwall Island, although we were prevented by the St. Lawrence Seaway Authority, letter dated 23 October, 1956, from studying the following two details:

- (a) a probable reduction of the cut at the North shore opposite Polly's Gut,
- (b) a reduction of the velocity in ranges 67, 65 and 3 to the required 4 ft./sec. by additional excavation around gauge 26.