(86)

BRIEF

TO THE

INTERNATIONAL JOINT COMMISSION

ON

PROPOSED REDUCTION OF SHOAL

NEAR

TOWER ISLAND

NIAGARA RIVER

(386)

APRIL 24, 1963

The Power Authority of
the State of New York

The Hydro-Electric Power
Commission of Ontario

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REPORT ON
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OF
SHOAL NEAR TOWER ISLAND

Purpose of Brief

1. The purpose of this Brief is to request approval of construction operations to reduce the elevation of a shoal now existing near Tower Island and thus improve the ice-discharge capacity of the Chippawa-Grass Island Pool. The reduction of this shoal is considered by the Power Authority of the State of New York and The Hydro-Electric Power Commission of Ontario as an essential part of the ice-discharge plan, and is necessary to reduce the possibility of ice jamming in the Pool and upstream with the consequent danger of flooding. The reduction of this shoal will thus assist during ice runs in the maintenance of the established pool level range. It is proposed that this work be carried out during the open water season in 1963 by the construction forces of Ontario Hydro, who are at present completing the extension to the Control Structure in this area. In this Brief are given the reasons for the reduction of the shoal and engineering data with respect to its removal.

General

2. In an Order dated 15 August 1961, the International Joint Commission approved an extension to the Remedial Works in the Niagara River, specifically; a five-gate extension to the Control Structure; a downstream training wall and end weir; an upstream accelerating wall; and removal of the submerged rock weir. This approval followed submission of a request by the Power Entities and also followed recommendation

of the International Niagara Board of Control. One purpose of the Control Structure extension was to provide additional facilities to control the levels of the Grass Island Pool required following the coming into service of the Robert Moses Niagara Power Plant, but another purpose was to provide a means for the safe discharge of ice from the Pool on the Canadian side. The purpose of the other approved works was principally to provide safe ice discharge facilities. In their Order of Approval, the International Joint Commission retained jurisdiction over the subject matter of the approval. It was considered by the Power Entities that the plan proposed for safe ice passage was the best that could be developed at that time, but it was recognized that refinements to the plan might be required as a result of actual experience under ice conditions.

Experience and Actions to Date

3. Experience during the winter of 1961-62, the first winter under changed conditions, indicated that the general ice-passage plan appeared to operate with reasonable success, particularly on the Canadian side. However, with heavy runs, ice grounded and stopped in shallow areas of the Pool. These groundings were viewed with concern in that they could and did form the basis for jams which extended upstream. In the spring of 1962 a complete new sub-aqueous survey was made of the Pool and the shallow areas charted. From the survey results and from observations during the previous winter, it was decided by the Power Entities that a shoal off the Sir Adam Beck intakes should be reduced, and the ice flushing channel on the United States side widened, these areas being indicated on Drawing No. 210-b-1002. The Niagara Board and the International Joint Commission were advised of these

decisions at the April 1962 meeting of the Commission, and the Board and Commission agreed that, as these measures did not affect the Remedial Works, no specific approval by the Commission was necessary. The work was carried out and partially completed during the summer of 1962. Also, ice-breaking vessels were constructed for each Power Entity to aid in ice-discharge operations.

4. The winter of 1962-63 proved to be severe, and very large quantities of ice entered and were discharged from the Pool. It was observed that the ice-passage facilities on the Canadian side were most successful and in fact discharged the great majority of the ice during the winter. On the United States side, where the problems are much more difficult, the ice-discharge facilities were not as successful. The outlet from the Pool became blocked relatively early, and at one stage a jam existed from Tower Island along the United States shore and for the full length of the East Channel to the head of Grand Island. Fortunately, a significant discharge of Lake Erie ice did not occur during this period, but it was obvious that additional work is necessary to improve Pool outlet conditions on the United States side.

Need for Reduction
of Shoal off Tower Island

5. An ice-escape channel was provided along the United States side of the Pool and, as mentioned above, is being widened to improve its ice carrying capacity. This widening is scheduled for completion this year. Experience now has shown, however, that its effectiveness during heavy ice runs is reduced because of a shallow shoal downstream

from its exit. This shoal, shown on Drawings 210-b-1002 and 210-b-1003 is on the United States side and immediately upstream of Tower Island. In some areas the shoal extends above Elevation 560 as may be seen in the two aerial views included in this Brief, and is almost above water at low pool levels. The shoal acts as an effective barrier for heavy ice floating down the ice channel or for ice from the center of the Pool discharging on the United States side of Tower Island. The ice stopped by the shoal forms an anchor for a jam forming upstream and forces all ice from the Pool to be discharged through the Control Dam. For these reasons it is considered essential that this shoal be reduced to improve the ice-discharge capacity of the Pool.

6. From model test results described later, and from observations in the field, it appears that the principal control of levels in this area occurs downstream from the shoal. This explains the relatively low velocities and poor ice-carrying capacity across the shoal and also permits a reduction of the shoal without significantly reducing the ability of the Control Structure to control Pool levels.

Plan of Shoal Reduction

7. The position of the shoal where reduction is proposed to Elevation 555 is shown on Drawing 210-b-1002 and 210-b-1003. The limit of the excavation on the United States side is in line with a projection of the ice escape channel shore, the limit on the upstream end and Canadian side is along existing 555 contour. At the downstream end, the limit is somewhat indeterminate pending further information. While higher elevations may occur downstream, the considerable

increase in velocities in that area are believed sufficient to discharge the ice.

8. As depths are too shallow to use floating equipment, it is planned to partially encircle the area with a semi-impervious cofferdam open at the downstream end for drainage. While the area will not be dry, depths will be reduced sufficiently to permit reduction of the shoal by "in-the-dry" methods.

Effect of Shoal Removal

9. The Power Entities are conscious of the need for determining whether the proposed reduction of the shoal would have an adverse effect on the performance of the Remedial Works. Consequently, a series of model tests has been run on the Niagara Model at Ontario Hydro's laboratory at Islington. Two series of tests were made; the first to determine the effect of the completed shoal reduction; the second to determine any temporary effects during the construction and use of the cofferdam.

MODEL TESTS OF SHOAL REDUCTION

Preliminary Tests

10. In order to determine that the performance of the model had not changed in any way since the last Control Structure performance tests had been run, the conditions of flow and diversion contained in Table I of the "Brief to the Governments of Canada and the United States on Proposed Extension to Niagara River Remedial Works" dated March 15,

1961, were again set up and the results checked. For comparative purposes this table is shown again in Table I herein with the associated crest panel discharges shown in Table IA. The data obtained from this test series are contained in Table II of this Brief and on comparison it may be concluded that the model produced essentially the same results.

Re-Verification Tests

11. The 1962 field survey indicated that the model topography differed in some areas of the upstream end of the pool, but that these were relatively minor and it was considered, based on past experience with the model, that it was hydraulically unnecessary to change this area.

12. In the critical control area adjacent to Tower Island and northward to the American shore some differences were apparent which were likely to affect previously predicted Pool levels, Falls' flow split, and possibly crest discharge distribution. In particular, a depression was found to exist immediately north of Tower Island which would undoubtedly account for the difficulty experienced in a previous re-verification of the model to data supplied by the Niagara Control Board in November, 1957. In general terms, the area north and east of the end of the control structure was approximately two feet lower than before, while the area immediately upstream of the structure was approximately two feet higher than shown in the previous survey.

13. The model was revised over this fairly large area (See Drawing No. 210-b-1002) to conform to the 1962 survey,

and re-verification tests were made with the November, 1957, prototype flows and diversions. The test results are shown in Table III together with the prototype conditions. A more satisfactory similarity between model and prototype is indicated.

Model Tests Following
Revisions to 1962 Survey

14. Base Tests - Prior to determining the effects of any proposed shoal reduction it was necessary to determine the performance of the Remedial Works under conditions existing with the new topography in the vicinity of Tower Island. Accordingly, Tables I and IA of the March 15, 1961, Brief were again checked and the new performance data is contained in Tables IV and IVA. Table IV contains the model results in respect to flows and levels while Table IVA records the measured crest panel discharges. Complete crest discharge measurements were made for one condition only while for the other five conditions just the flank crest discharges were measured.

15. Test to Determine Effect of Proposed Shoal Reduction - Drawing No.210-b-1002 shows the area where the shoal reduction is proposed. With the proposed plan in the model the same series of tests and crest discharge measurements as in paragraph 14 were run and the results tabulated in Tables V and VA.

16. Candle Float Pictures - Candle float pictures were taken showing the path of ice moving down the American Ice Channel for a river flow of 200,000 cfs with 50,000 cfs over the Falls before and after the shoal reduction was made. These photographs are shown on Plate 1.

Test Results

17. Base Tests - A comparison of Tables IV and IVA of this report with Tables I and IA of the March 15, 1961, Brief shows that with the revised topography only minor changes in the original model performance of the Control Structure and other Remedial Works occurred. A very slight decrease in the predicted ability of the dam to maintain levels might be noted, but the maintenance of proper levels is still well within the capability of the 18-sluice structure. A small decrease in the flow down the American channel is indicated. On the other hand, the Horseshoe Falls' crest discharge figures show some increase in flow over the flanks.

Effect of Proposed Shoal Reduction

18. A comparison of Tables IV and IVA with Tables V and VA shows that at Falls' flows of 50,000 cfs an additional closure of one gate by one foot at low flows and by four feet at high flows is necessary to maintain the proper pool level when the shoal is reduced. Similarly at Falls' flows of 100,000 cfs the corresponding additional gate closure necessary to maintain the proper pool level varies from somewhat over one full gate, to four feet of one gate. With the 50,000 cfs Falls' flow condition the effect of the shoal reduction is very small and well within the operating capacity of the Control Structure. At Falls' flows of 100,000 cfs the effect is not considered important since many additional gates are open and available for control if necessary. These tables also show a slight increase in flow over the American Falls as a result of the shoal reduction and that the flows over the flanks of the Horseshoe Falls remains quite satisfactory and in fact are generally improved.

Candle Float Pictures

19. The candle floats, Plate I, show that the reduction of the shoal as proposed should alter the surface currents such that ice leaving the ice escape channel can proceed directly across the shoal area and into the cascades leading to the Horseshoe Falls.

Conclusions from Model Tests

20. The model tests indicate that while the proposed shoal reduction will have a small effect on the performance of the Control Structure, there still will be ample gates to provide the necessary level control and ice passage. The tests show also that there will be no adverse effect on Falls' flows. The excavation will assist in maintaining a clear channel for ice coming down the American ice channel and from the Pool.

MODEL TESTS ON EFFECT OF PROPOSED COFFERDAM

General Plan of Cofferdamming

21. In order to excavate to Elevation 555 the area shown on Drawing No. 210-b-1002 which lies downstream of the Power Authority's ice escape channel, investigations have indicated that the most economical and satisfactory method would be to cofferdam most of the area and excavate the material in the comparative dry. This would be accomplished by a cofferdam built upstream from Tower Island surrounding the area to be excavated, with a spur leg toward Goat Island for the purpose of maintaining satisfac-factory American Falls' flows. The cofferdam shown on

Drawing No. 210-b-1003 would be open-ended to allow the enclosed area to drain to a depth shallow enough to drill and muck the rock, with disposal in Canada by truck via Tower Island and the control structure. Some disposal might be made in the deep area upstream from the cofferdam.

Model Test Results

22. Model tests were conducted at a river flow of 200,000 cfs and gauge No. 5 (Material Dock) level at 562.8 (USLS datum) with the cofferdam, Drawing No. 210-b-1003, being added progressively in steps, A through I. During each step, the flow over the American Falls was determined with the following results:

Cofferdam Portion Added	American Falls' Flow - cfs	Control Structure gates open
River flow 200,000 - 100,000 Falls' flow - Gauge No. 5 at 562.8		
None	10,500	1 - 8
A	10,200	1 - 8
B	10,200	1 - 8
C	9,400	1 - 8 (No. 9 - 558.5)
D	8,300	1 - 8 (No. 9 - 555.0)
E	6,200	1 - 10
F	5,000	1 - 11
G	5,000	1 - 11 (No. 12 - 558.5)
H	6,700	1 - 12
I	8,200	1 - 12
River flow 200,000 - 50,000 Falls' flow - Gauge No. 5 at 562.8		
I	8,700	1 - 6 (No. 7 - 557.0)
River flow 170,000 - 50,000 Falls' flow - Gauge No. 5 at 561.9		
I	6,700	1 - 6 (No. 7 - 558.0)

Discussion of Results

23. The selection of the 200,000 cfs river flow for the model test is based on a reasonable prediction of this year's flow while the cofferdam is in effect, and is low because of the low supplies forcasted. When the cofferdam is completed, the American Falls' flow during the Tourist Season days will be approximately 8,000 cfs as it is the intention of the Power Entities to maintain the pool level at or near 562.8 regardless of river flow to facilitate the dredging which will be in progress elsewhere in the Pool. The American Falls' flow would, however, reduce to 6,700 cfs if the Pool level was allowed to fall to 561.9 at Gauge No. 5, proper level for 170,000 cfs river flow, in comparison to a flow of 6,300 cfs for this level when the control structure extension is complete. The flow of 8,200 cfs while the cofferdam is in place with Gauge No. 5 at 562.8 compares favourably with the flow of 10,300 cfs for this level when the control structure extension is complete, and it is believed will produce a satisfactory spectacle.

24. It should be noted, however, that during the placing of portions F and G of the proposed cofferdam, the American Falls' flow is reduced to 5,000 cfs temporarily for a few weeks which would correspond to a river flow of approximately 160,000 cfs under normal conditions, but with the addition of portions H and I increases to above 8,000 cfs where it will be normally maintained. Therefore, it is considered that the proposed cofferdam will enable the work to be executed in an efficient and economical manner without sacrificing the scenic spectacle of the Horseshoe and American Falls.

CONCLUSIONS

25. As mentioned above, the reduction of the shoal near Tower Island is considered to be a necessary measure in improving the ice-discharge capacity of the Grass Island Pool and is considered to be an essential part of the present ice-passage plan. Its reduction will assist during ice runs in the maintenance of the established pool level range. The reduction of this shoal during 1963 is considered most desirable and it is estimated that construction must start in May to ensure reduction of the shoal and removal of the cofferdam by the end of the open water season. From the engineering data presented, there may be a very temporary reduction in the American Falls' flow during the construction of the cofferdam, but the reduction is not considered serious. When completed, the shoal reduction will not impair the ability of the remedial works to maintain Pool levels within the elevations stipulated and to distribute the flows over the Falls as required by the 1950 Treaty.

April 8, 1963.

TABLE I

NIAGARA MODEL

18 SLUICE CONTROL STRUCTURE

PERFORMANCE TESTS

RIVER FLOW		170,000	170,000	200,000	200,000	240,000	240,000
Falls Flow -	Canadian	41,000	91,600	38,100	87,600	48,300	82,700
	American	9,000	8,400	12,500	12,400	17,200	17,300
	TOTAL	50,000	100,000	50,600	100,000	65,500	100,000
Diversions -	American	60,000	35,000	75,000	50,000	95,000	70,000
	Canadian	60,000	35,000	74,400	50,000	79,500	70,000
SAB		57,500	35,000	60,000	50,000	62,000	62,000
OP		2,500	-	10,700	-	10,700	8,000
TP		-	-	3,700	-	5,800	-
CN		-	-		-	1,000	-
Waterlevels -	Slaters Pt.	562.25	562.35	563.15	563.25	564.25	564.35
	Gauge 5	561.9	561.9	562.8	562.8	564.0	564.0
	Gauge 51	561.35	561.35	562.35	562.35	563.6	563.4
	Conners	562.35	562.50	563.15	563.35	564.3	564.45
	Grass Isl.	561.75	561.65	562.65	562.60	563.8	563.85
Control Structure							
Gates Closed		4 to 18	12 to 18	4 to 18	9 to 14	3 to 18	6 to 18
Gates Open		1 & 2	1 to 11	1 & 2	2 to 7	1 & 2	1 to 4
		3 at 555.0'		3 at 558.0'	#1 at 557.5		#5 at 559.5'
					#8 at 559.0'		

(Reproduction of Table I in Brief dated March 15, 1961)

TABLE 1A

NIAGARA MODEL

HORSESHOE FALLS CREST DISCHARGE

18 SLUICE CONTROL STRUCTURE

		RIVER FLOW					
	Panel	170,000	170,000	200,000	200,000	240,000	240,000
Can.	2	8)	33)	5)	27)	7)	24)
	3	13) Av 9.75	37) Av 38.5	9) Av 5.75	37) Av 34.75	12) Av 8.25	30) Av 30.0
	4	8)	37)	5)	33)	7)	29)
	5	10)	47)	5)	42)	8)	37)
	6	11	50	6	49	9	37
	7	33	85	21	82	30	71
	8	33	75	29	67	31	61
	9	45	83	41	77	45	74
	10	28	56	21	54	26	51
	11	19	59	8	54	12	44
	12	18	49	21	43	28	37
	13	23	51	29	47	37	49
	14	94	129	101	127	112	129
	15	13	30	15	29	25	29
	16	9	19	11	19	17	22
	17	10	16	12	17	15	19
	18	6)	11)	7)	12)	10)	14)
	19	8)	13)	9)	15)	15)	18)
	20	6) Av 6.2	14) Av 12.0	10) Av 8.2	15) Av 14.2	15) Av 12.8	17) Av 17.0
	21	5)	8)	6)	12)	9)	14)
U.S.	22	6)	14)	9)	17)	15)	22)
Can. Falls		40,600	91,600	37,900	87,600	48,500	82,800
Am. Falls		9,000	8,400	12,500	12,400	17,200	17,300

(Reproduction of Table II in
Brief dated March 15, 1961)

TABLE II

NH 9048

NIAGARA MODEL
18 SLUICE CONTROL STRUCTURE
PERFORMANCE TESTS
RE-VERIFICATION OF TABLE I MARCH 15/61 BRIEF

JUNE 25/62

FLOW		170-50	170-100	200-50.6	200-100	240-65.5	240-100
FALLS FLOW	CAN.	40,800	91,700	38,100	87,600	48,300	82,700
	AM.	9,200	8,300	12,500	12,400	17,200	17,300
	TOTAL	50,000	100,000	50,600	100,000	65,500	100,000
DIVERSIONS	AM.	60,000	35,000	75,000	50,000	95,000	70,000
	CAN.	60,000	35,000	74,400	50,000	79,500	70,000
	SAB.	57,500	35,000	60,000	50,000	62,000	62,000
	OP.	2,500	-	10,700	-	10,700	8,000
	TP.	-	-	3,700	-	5,800	-
	CN.	-	-	-	-	1,000	-
WSE SLATERS		562.25	562.30	563.15	563.35	564.25	564.35
#5		561.90	561.90	562.80	562.80	564.00	564.00
#51		561.35	561.35	562.35	562.35	563.65	563.4
CONNORS		562.35	562.45	563.15	563.30	564.30	564.45
GRASS		561.80	561.60	562.65	562.60	564.85	563.85
CONTROL DAM GATES CLOSED		4-18	12-18	4-18	9-18	3-18	6-18
GATES OPEN		1-2	1-10	1-2	2-7	1-2	1-4
		#3-555.0	#11-555.0	#3-558.0	#1-557.5		5-58.0
					#8-559.0		

TABLE III

July 24, 1962

NIAGARA RIVER MODEL
REVERIFICATION TEST - 1957 CONDITIONS
13 SLUICE CONTROL DAM
MODEL TOPOGRAPHY CHANGED TO CONFORM TO 1962 SURVEY

DATA	Proto Nov. 2. 1957	Model	Proto Nov. 10. 1957	Model	Proto Nov. 20. 1957	Model
River Flow	177,100	177,000	199,800	200,000	221,600	222,000
Falls Flow	68,200	68,100	89,900	90,100	109,500	109,500
Diversions	108,900	108,900	109,900	109,900	112,100	112,500
U.S. Adams	8,500	8,500	8,400	8,400	8,500	8,500
Schoellkopf	6,500	6,500	6,700	6,700	6,600	6,600
TOTAL	15,000	15,000	15,100	15,100	15,100	15,100
Canadian S.A.B.	58,600	58,600	60,600	60,600	61,500	61,900
Ontario Power	10,700	10,700	10,700	10,700	10,800	10,800
Toronto Power	14,400	14,400	13,100	13,100	14,300	14,300
Niagara Power	10,200	10,200	10,400	10,400	10,400	10,400
TOTAL	93,900	93,900	94,800	94,800	97,000	97,400
Gauges No. 5	562.09	562.15	563.14	563.15	564.26	564.35
Slaters	562.90	562.95	563.86	563.85	564.91	564.90
No. 3		561.50		563.60		563.90
No. 51	561.38	561.30	562.43	562.45	563.66	563.75
Connors	563.12	563.15	564.02	564.00	565.11	565.10
Grass Island Pool Dam	561.68	561.65	562.68	562.65	563.78	563.85
U.S. Falls	557.65	557.55	558.35	558.35	559.11	559.25
Lewiston Intake		563.10		564.00		565.00
Control Dam						
Gates Open	No. 1 - 7	No. 1 - 7	No. 1 - 6	No. 1 - 6	No. 1 - 4	No. 1 - 4
Intermediates	No. 8 - 556.0	No. 8 - 556.0			No. 5 - 13	No. 5 - 13
Gates Closed	No. 9 - 13	No. 9 - 13	No. 7 - 13	No. 7 - 13		
American Falls		7,200		11,000		17,700

NL 9074 TABLE IV July 30, 1962

NIAGARA RIVER MODEL
18 SLUICE CONTROL STRUCTURE
PERFORMANCE TESTS
MODEL TOPOGRAPHY CHANGED TO CONFORM TO SURVEY SPRING 1962

RIVER FLOW			170,000	170,000	200,000	200,000	240,000	240,000
FALLS FLOW	CAN.		41,600	93,700	38,500	89,700	48,000	84,300
	Am.		8,400	6,300	11,500	10,300	16,500	15,700
		TOTAL	50,000	100,000	50,000	100,000	64,500	100,000
DIVERSIONS	AM.		60,000	35,000	75,000	50,000	95,000	70,000
	CAN.		60,000	35,000	75,000	50,000	80,500	70,000
	SAB.		57,500	35,000	60,000	50,000	62,000	62,000
	OP		2,500	-	10,700	-	10,700	8,000
	TP		-	-	4,300	-	6,800	-
	CN		-	-	-	-	1,000	-
W.S.E.	SLATERS		562.30	562.40	563.15	563.30	564.30	564.35
	5		561.90	561.90	562.80	562.80	564.00	564.00
	51		561.25	561.30	562.15	562.15	563.60	563.35
	CONNORS		562.30	562.50	563.15	563.35	564.30	564.45
	GRASS		561.75	561.65	562.65	562.55	563.85	563.85
	U.S. FALLS		558.35	557.70	559.00	558.75	559.90	559.80
CONTROL DAM GATES OPEN			#1 - 2	#1 - 12	#1 - 2	#1 - 7	#1 - 2	#1 - 4
INTERMEDIATES			#3-556.0	-	#3-557.0	#8-556.0	-	#5-556.0
GATES CLOSED			#4 - 18	#13 - 18	#4 - 18	#9 - 18	#3 - 18	#6 - 18

NL 9074 TABLE IVA July 30/62

NIAGARA RIVER MODEL
HORSESHOE FALLS CREST DISCHARGE
18 SLUICE CONTROL STRUCTURE
MODEL TOPOGRAPHY CHANGED TO CONFORM TO SURVEY SPRING 1962

RIVER FLOW

PANELS	170		170		200		200		240		240	
2	8		32		6		30		8		26	
3	13		39		9		39		12		33	
4	10		39		8		39		8		28	
5	11	10.5 Av.	45	38.7 Av.	8	7.0 Av.	53	40.25 Av	10	9.5 Av	40	31.7 Av.
6							52					
7							74					
8							78					
9							75					
10							52					
11							59					
12							44					
13							47					
14							127					
15							29					
16							19					
17							19					
18	8		12		8		11		12		13	
19	10		17		12		15		17		18	
20	8		14		9		13		13		18	
21	6		11		7		10		10		13	
22	7	7.8 Av.	14	13.6 Av.	8	8.8 Av.	15	12.8 Av.	13	13.0 Av.	17	15.8 Av.
Can. Falls	41,600		93,700		38,500		89,700		48,000		84,300	
Am. Falls	8,400		6,300		11,500		10,300		16,500		15,700	
TOTAL	50,000		100,000		50,000		100,000		64,500		100,000	

TABLE V

NIAGARA RIVER MODEL
18 SLUICE CONTROL STRUCTURE
555.0 EXCAVATED AREA UPSTREAM FROM TOWER ISLAND

River Flow		170,000	170,000	200,000	200,000	240,000	240,000
Falls Flow	Canadian	41,200	92,500	38,100	88,600	48,200	83,200
	American	8,800	7,500	11,900	11,400	17,200	16,800
	Total	50,000	100,000	50,000	100,000	65,400	100,000
Diversions	American	60,000	35,000	75,000	50,000	95,000	70,000
	Canadian	60,000	35,000	75,000	50,000	79,600	70,000
	Sir Adam Beck	57,500	35,000	60,000	50,000	62,000	62,000
	Ont. Power	2,500	-	10,000	-	9,800	8,000
	Tor. Power	-	-	5,000	-	6,800	-
	Can. Niagara	-	-	-	-	1,000	-
W.S.E.	Slaters	562.25	562.30	563.15	563.20	564.30	564.35
	5	561.90	561.90	562.80	562.80	564.00	564.00
	51	561.40	561.35	562.35	562.25	563.75	563.40
	S.A.B. Intakes	561.70	561.60	562.70	562.50	563.90	563.80
	Acc. Wall	562.00	561.40	562.75	562.60	564.10	564.10
	Ont. Power 'B'	556.55	558.00	553.95	558.50	553.80	557.20
	Connors	562.25	562.45	563.05	563.25	564.30	564.50
	Grass	561.75	561.60	562.65	562.55	563.85	563.85
	U.S. Falls	558.45	558.20	559.20	559.05	560.00	559.90
Control Dam	Gates Open	1 and 2	1 - 10	1 and 2	1 - 6	No. 1	1 - 4
	Intermediates	3 - 557.0	11 - 558.0	3 - 560.5	7 - 556.0	2 - 557.0	5 - 560.0
	Gates closed	4 - 18	12 - 18	4 - 18	8 - 18	3 - 18	6 - 18

NL 9083

March 26, 1963

TABLE VA

NIAGARA RIVER MODEL
HORSESHOE FALLS CREST DISCHARGE
18 SLUICE CONTROL STRUCTURE
555.0 EXCAVATED AREA UPSTREAM TOWER ISLAND

		River Flow					
	Panels	170	170	200	200	240	240
Can.	2	9	34	6	30	7	25
	3	13	40	9	38	11	34
	4	11	42	7	36	8	30
	5	11	49	8	34	9	41
		11.0 Av.	41.25 Av.	7.5 Av.	34.5 Av.	8.75 Av.	32.5 Av.
	6				31		
	7				72		
	8				81		
	9				76		
	10				54		
	11				54		
	12				40		
	13				48		
	14				144		
	15				31		
	16				20		
	17				17		
	18	11	17	12	14	13	17
	19	10	18	13	17	14	19
	20	9	17	12	15	13	16
	21	8	13	9	14	8	14
G.I.	22	9	20	10	20	13	18
		9.4 Av.	17.0 Av.	11.2 Av.	16.0 Av.	12.2 Av.	16.8 Av.
	Can. Falls	41,200	92,500	38,100	88,600	48,200	83,200
	Am. Falls	8,800	7,500	11,900	11,400	17,200	16,800
	Total	50,000	100,000	50,000	100,000	65,400	100,000

March 26, 1963

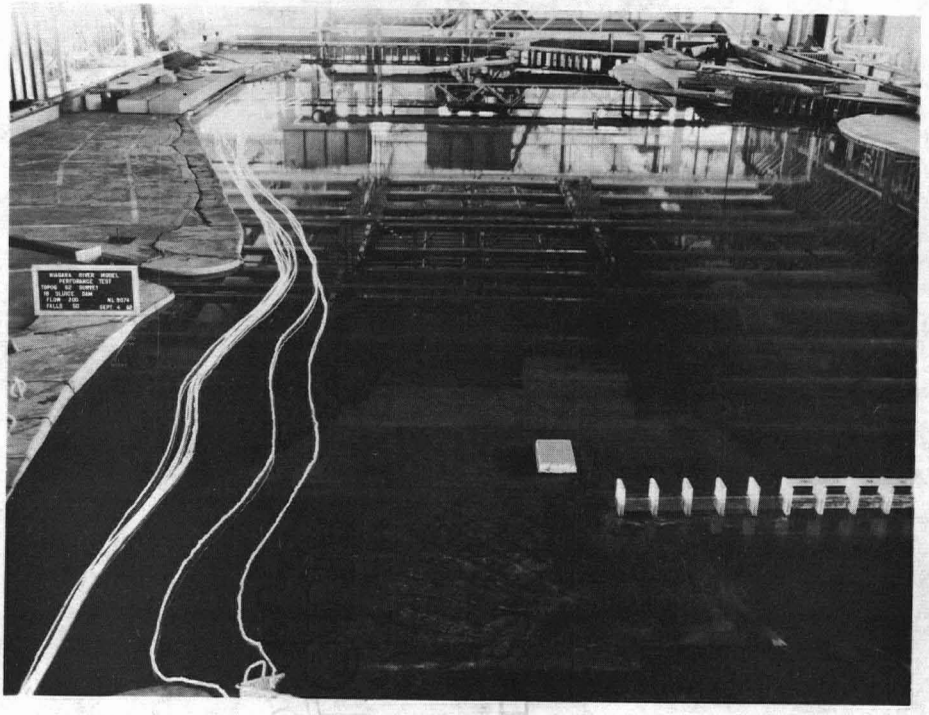

Fig. 1
SURFACE FLOW PATH BEFORE EXCAVATION
RIVER FLOW 200,000 cfs

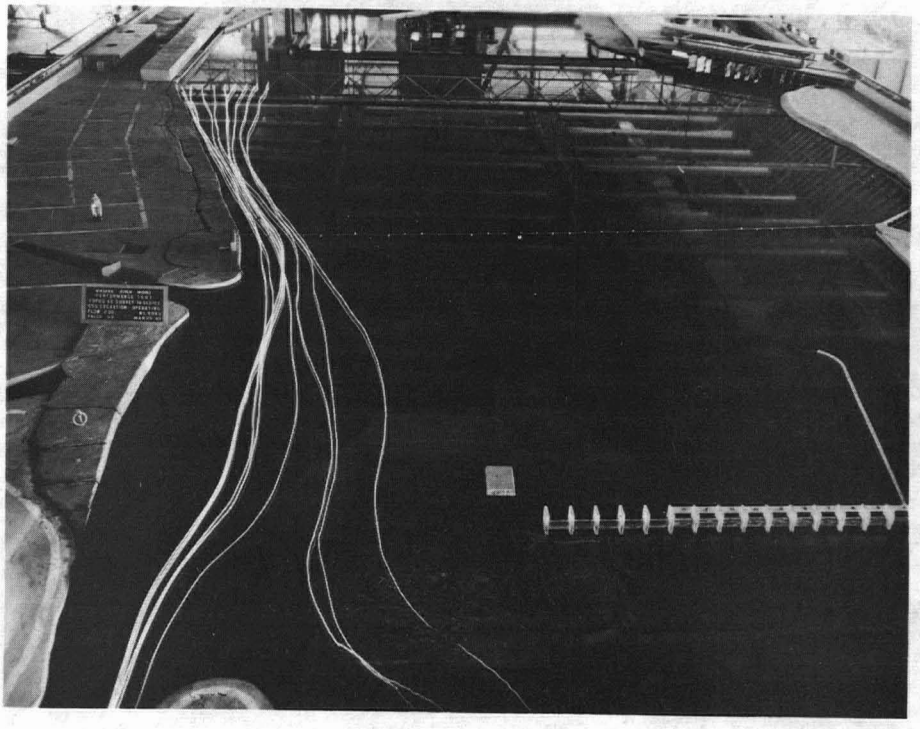

Fig. 2
SURFACE FLOW PATH AFTER EXCAVATION
RIVER FLOW 200,000 cfs

OBLIQUE AERIAL PHOTOGRAPH OF SHOAL AREA - MARCH 23, 1963

VIEW LOOKING DOWNSTREAM TOWARD GOAT ISLAND