ALDEN RESEARCH LABORATORIES

INDIAN POINT COOLING WATER STUDIES

MODEL NO. 2

CONSOLIDATED EDISON COMPANY
OF NEW YORK

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WORCESTER POLYTECHNIC INSTITUTE
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INDIAN POINT MODEL NO.2 COOLING WATER STUDIES

for

CONSOLIDATED EDISON COMPANY

NEW YORK, N. Y.

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ALDEN RESEARCH LABORATORIES

WORCESTER POLYTECHNIC INSTITUTE

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INDIAN POINT MODEL NO. 2 COOLING WATER STUDIES

1. INTRODUCTION

A hydraulic model was designed and constructed for the Consolidated Edison Company of New York at the Alden Research Laboratories of Worcester Polytechnic Institute during the Winter and Spring of 1968. The model was constructed in an existing building in an area which had previously been the site of the Indian Point Model No. 1. The No. 2 model was designed to reproduce a section of the Hudson River from Verplanck Point about 9000 feet downstream from the Indian Point Plant to Roa Hook about 9000 feet upstream from the Plant. A horizontal scale of 1:250 and a vertical scale of 1:60 were selected. The model was designed to simulate the cooling water flow conditions pertaining to generating units No. 1 and No. 2 and those pertaining to generating units Nos. 1, 2 and 3 in which case a changed configuration of the outfall applied.

Since the tidal action of the Hudson River is a dominant hydraulic factor in determining the flow pattern as well as the dispersion of released cooling water the model was designed with automatic tide controls.

The so-called Moth Ball Fleet consisting of some 160 World War II cargo ships, anchored along the western side of the river, opposite the Indian Point Plant, was considered to influence the river hydraulics and was therefore incorporated in the model.

Although of secondary importance in terms of heat effect, the Rockland-Orange Company's Lovett plant situated on the western shore of Hudson River was included in the model.

In order to assure satisfactory hydrodynamic similitude between model and prototype rather comprehensive field measurements were planned by the Alden Research Laboratories and Consolidated Edison Company. The field studies, based on aerial mapping of drogues, were carried out on two occasions, August 14 and September 20, 1968. The model was adjusted on the basis of field data.

Changes in the New York State regulations stating the limiting temperature conditions for the River required radical changes in the design of the cooling water outfall structures on two different occasions during the course of testing. The temperature requirements pertaining to the near vicinity of the outfall were such that a submerged outfall proved necessary in order to accomplish sufficient initial dilution of the cooling water. In order to determine the design and dimensions of adequate outfall structures it was necessary to conduct tests in an undistorted scale model. Such a model was constructed to scale 1:50 and comprehensive testing was carried out with two purposes: 1) to guide Consolidated Edison Company in their design of the outfall structure so as to meet the given temperature requirements; 2) to establish a set of boundary conditions to be imposed on the main model. The results of these tests were reported in a progress report of August, 1968 and, due to renewed changes in state regulations, which invalidated the application of these test results, a progress report of October 1968. Additional tests were carried out in the small model in March of 1969 and results presented in a progress report of April, 1969. Since the outfall test results are essential both in regard to the design of the prototype outfall structure and also to the testing of the main model a summary of these tests and their results are presented herein.

The final testing of the main model was carried out between November 4 and December 6, 1968 and the results of these tests are presented in this report.

2. MODEL DESIGN

2.1 Model Topography

Reproduction of the river bed topography was based on essentially two sources:

A 1:24000 map which shows depth contour lines at 6, 12, 18 and 30 feet below mean low water and in addition a number of point soundings and the Coast and Geodetic Survey map No. 282 to scale 1:40000 which gives a great number of point soundings and information about dredgings. Templates were made based on the above information and placed on the model foundation concrete slab according to an adopted coordinate system, see Photo No. 1. The templates were back filled with sand which was compacted to within about 2 inches from the template edge. The remaining 2 inches were filled with concrete, molded to the shape of the river topography using the templates as guides, see Photo No. 2. Two foot high 4" concrete walls, cast on the concrete slab, provided with the slab a water tight enclosure for the model.

The area containing the cooling water intakes and the outfall channel was molded in fiberglass in order to facilitate changing of these structures to model the configuration pertaining to different construction stages. Photo No. 3 shows the intake-discharge configuration for Units 1, 2 and 3 with connecting piping while Photo No. 4 shows the fiberglass part representing the outfall for Units 1 and 2. Figure 1 shows the general arrangement of the model including the model topography.

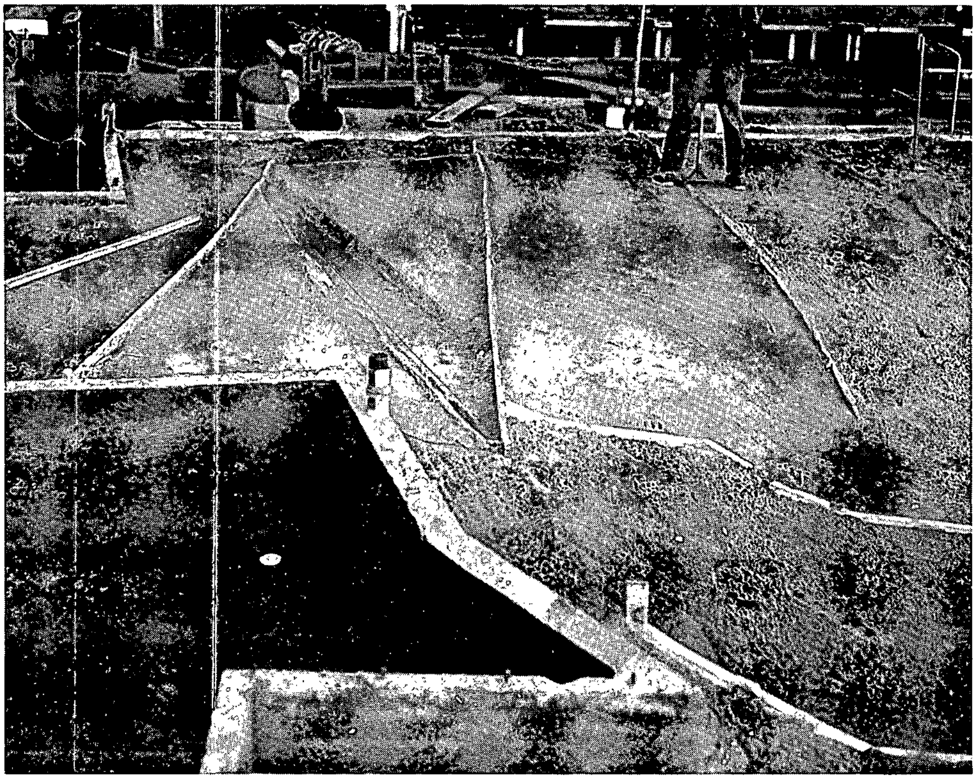


PHOTO NO. 1 SAND FILL BEING COMPACTED

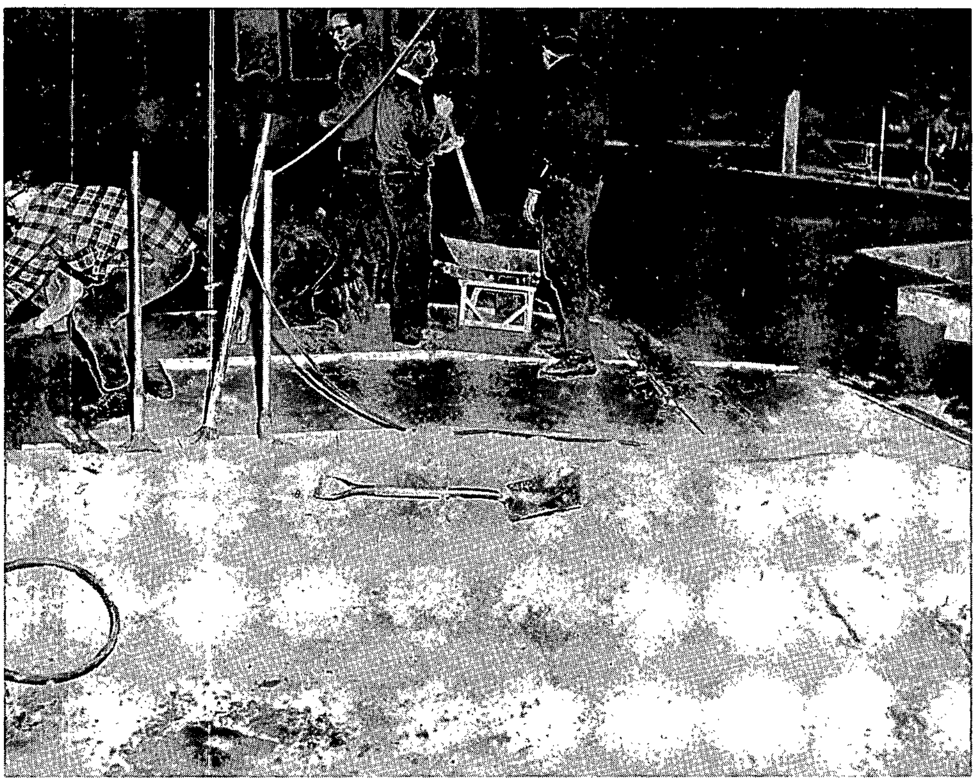


PHOTO NO. 2 CONCRETING THE TOPOGRAPHY

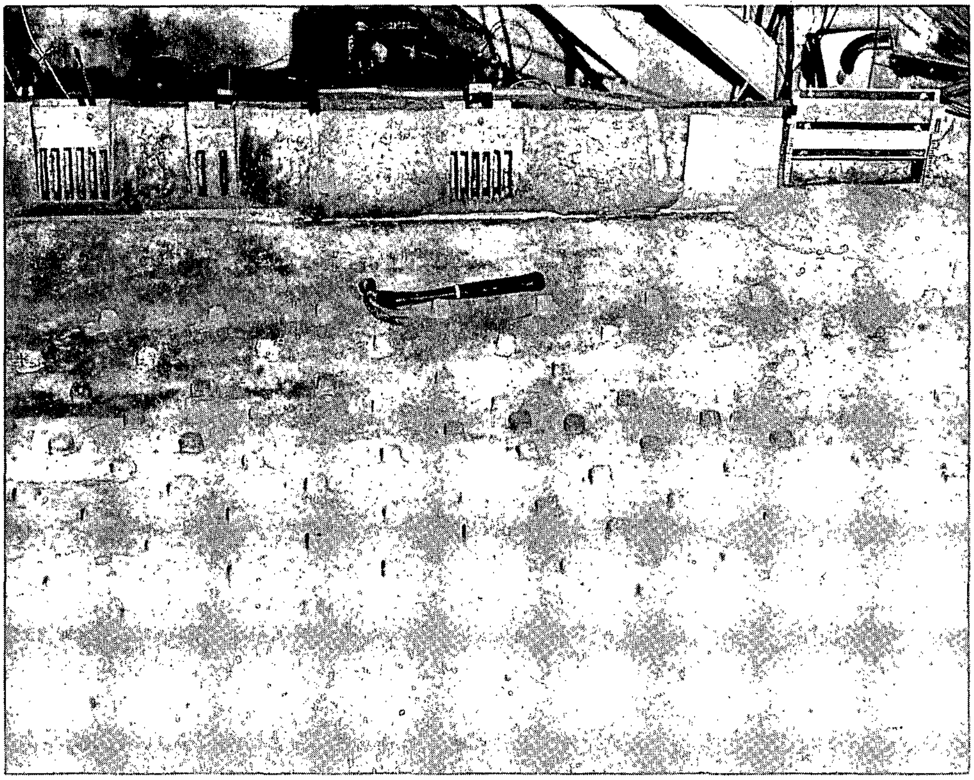


PHOTO NO. 3 INTAKES AND DISCHARGE CHANNEL, UNITS 1 + 2 + 3

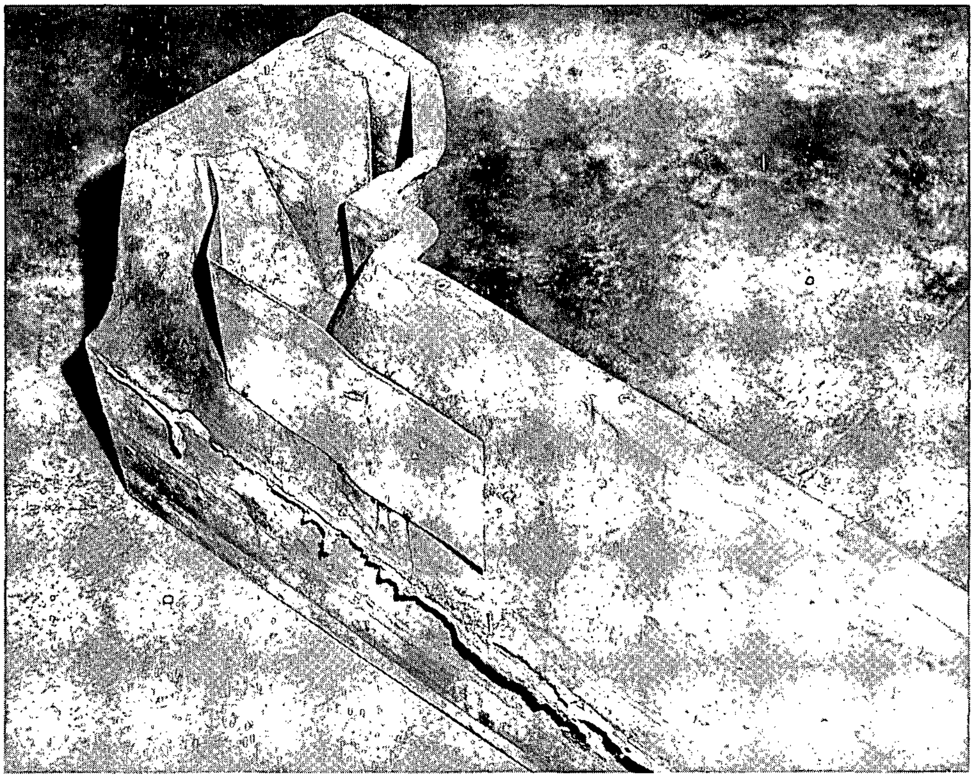


PHOTO NO. 4 DISCHARGE CHANNEL, UNITS 1 + 2

2.2 Water Supply, Tide Controls

The river flow at Indian Point is strongly dependent on the tide action of the Atlantic Ocean. A tide cycle at Indian Point comprises a flood period with an average duration of about 6 hours and an ebb period of about 6.5 hours, flood plus ebb thus making a tide cycle duration of approximately 12.5 hours. The flow associated with the tide action varies from 0 at slack tide to approximately 250,-000 cfs. upstream flow at peak flood, back to 0 flow at slack before ebb and approximately 250,000 cfs downstream flow at peak ebb. The tidal flow varies due to variation in the tide as a function of mutual position of moon and sun, wind and barometric conditions. These variations would, in general, be in the order of 20% but may at times be twice this value.

Superimposed on the tidal flow is the Hudson River fresh water flow which varies from about 4000 cfs. associated with a severe drought to in the order of 40,000 cfs due to a high spring run-off.

In order to model the flow variation over a tide cycle control apparatus was designed and fabricated. The tide controls constituted two sets of specially de-signed discharge valves and overflow weirs, one set for each end of the model. Valves and gates were operated by cams, mechanically driven at a speed such that one revolution was equal to the period of a model tide cycle. Photo 5 shows the downstream control apparatus with its overflow weir and the constant head tank for the discharge valve

Water for the model was supplied from a 20 HP propeller pump placed in a sump outside the model, see Figure 1. 12" piping connected the pump to each of the constant head tanks. The function of the head tanks was to minimize variations in flow to the tide valve due to fluctuations of pump discharge. In this way a flow with variations of less than 1% was supplied to the tide valves. The tide valves directed the proper amount of flow, at any instant, to the model while the excess was directed back to the sump.

The tide machine cam design was based on data obtained from "Tides and Currents in Hudson River" by Paul Schureman, U. S. Coast and Geodetic Survey.

Heated water for simulating the cooling water effluent was supplied from a 50 HP boiler. The pipe line delivering the water to the model outfall channel was equipped with a calibrated flow meter and valves for regulating the flow rate. A cold water line supplied water upstream of the meter for adjusting the temperature of the effluent.

Flow from the cooling water intakes was withdrawn by a pump with pipes, containing flow meters and valves, leading from the intakes to the suction side of the pump. Thus the flow from each individual intake could be adjusted and metered.

2.3 Instrumentation

In order to measure temperatures at various points in the model and of water entering the model and leaving it, a system of thermocouples connected to four 24-channel recorders was adopted. The recorders (Esterline Angus) were operated in parallel, each recorder printing the temperature reading from a thermocouple every 2 seconds. With 24 thermocouples per recorder a complete scan of 96 thermocouples would thus be carried out in 48 seconds. Simultaneously a data logger digitalized the recorder outputs and fed this information to an IBM computer tape for data processing. After completing one scan the recorders would automatically

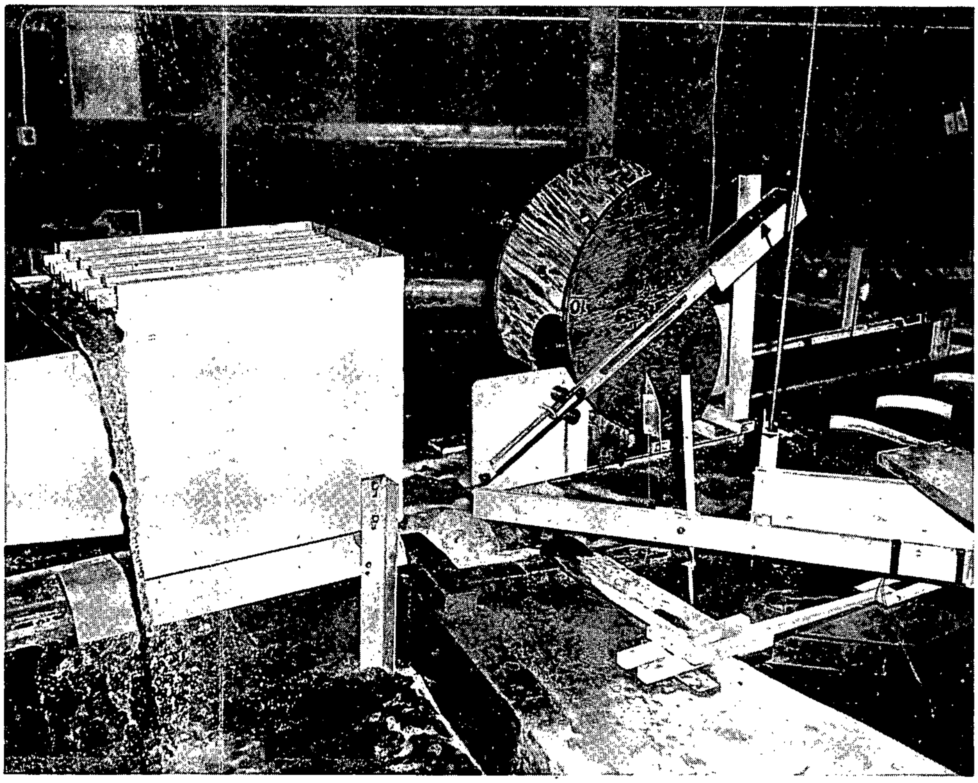


PHOTO NO. 5 HEAD TANK, TIDE MACHINE, DISCHARGE GATE

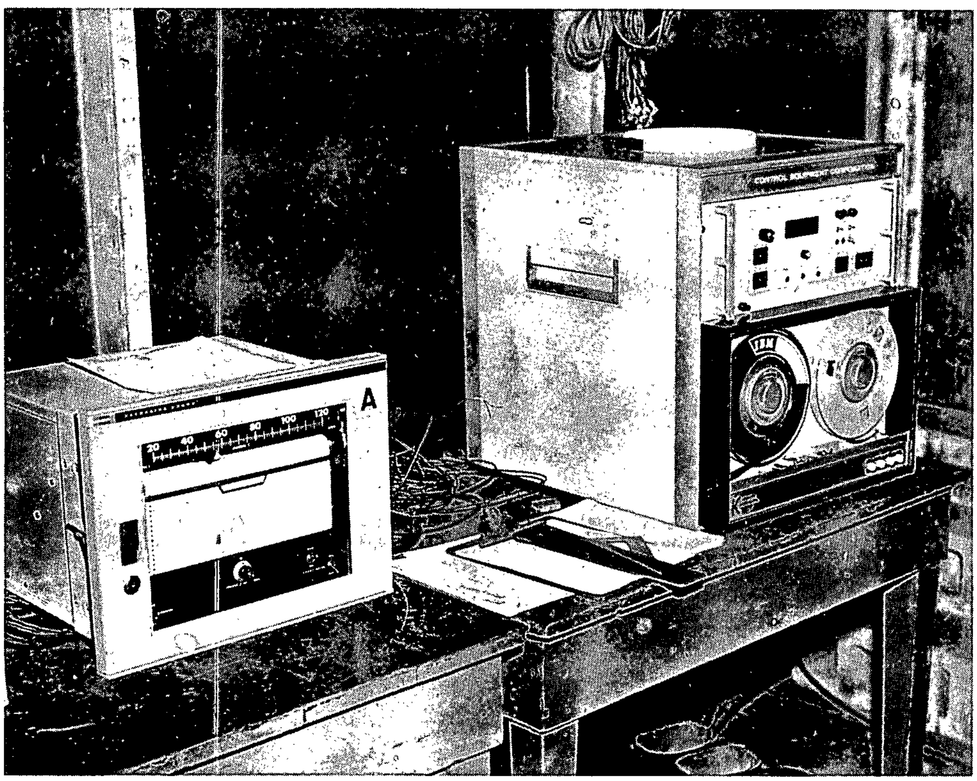


PHOTO NO. 6 RECORDERS AND DATA LOGGER

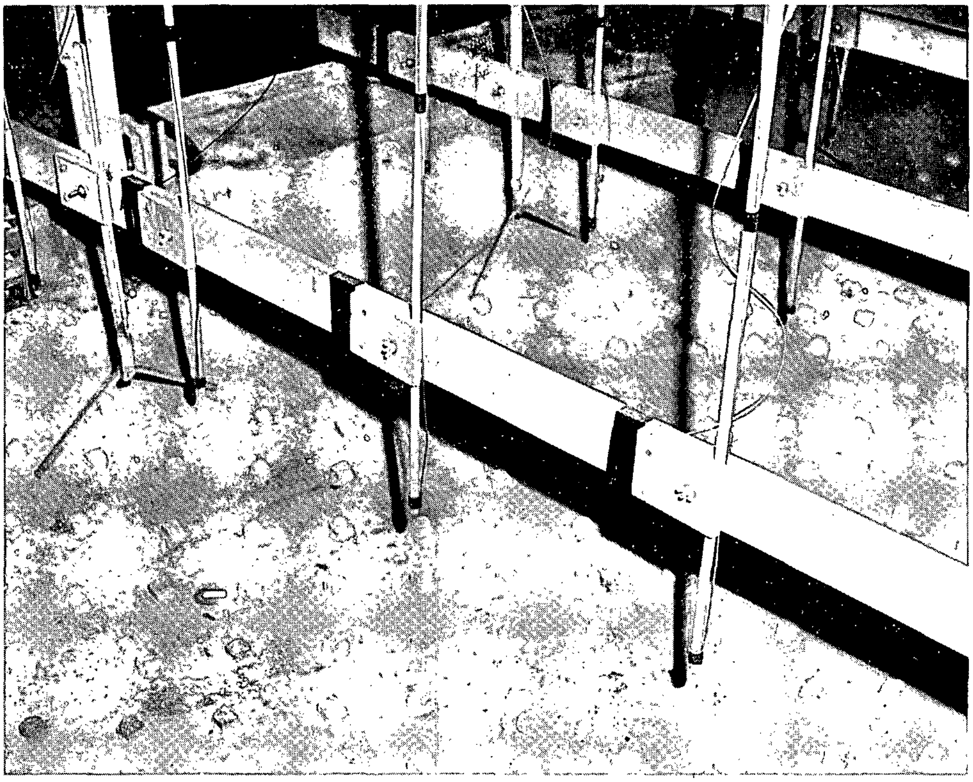


PHOTO NO. 7 THERMOCOUPLE MOUNTING

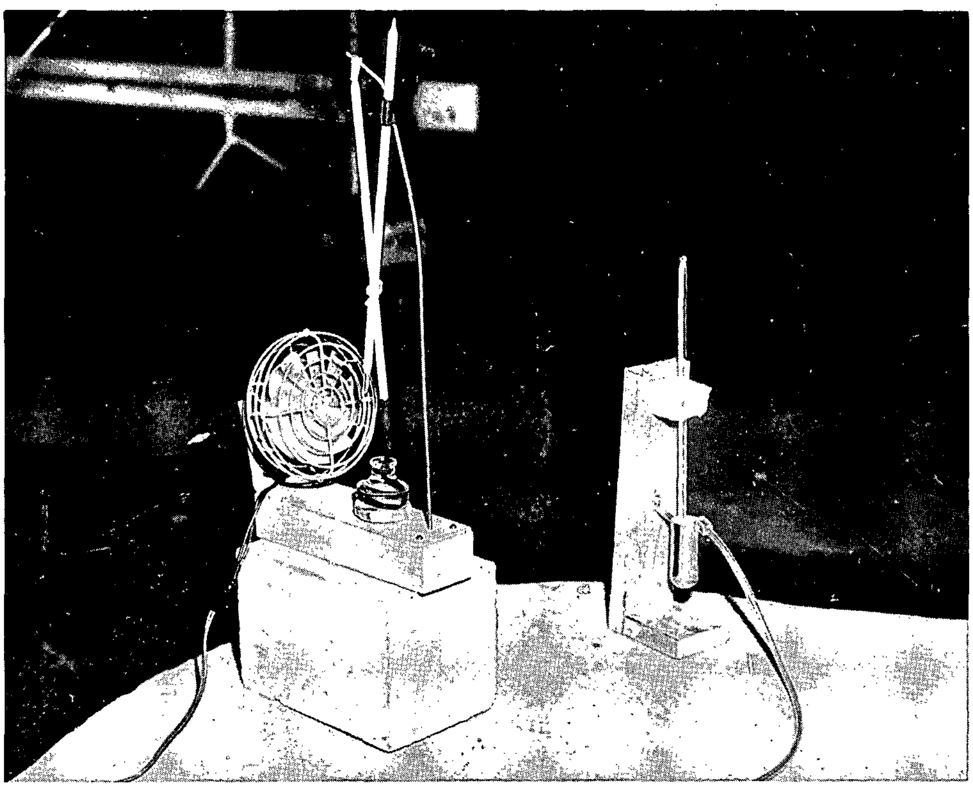


PHOTO NO. 8 DRY BULB - WET BULB INSTRUMENT,
DEW POINT INSTRUMENT

start a new scan. Photo 6 shows one of the recorders and the data logger.

Fixed thermocouples were mounted according to Table I

Position	Number of Thermocouples
Intake Unit No. 1	2) one close to the upper edge
" " 2	2)- of the intake opening, one
" " 3	2) near the bottom
Discharge Channel	1
Air Temperature upstream end of "Moth Ball Fleet"	1
Discharge to and from model, downstream end	2
upstream end	2
Thermos bottle	4
	16

TABLE I POSITION OF FIXED THERMOCOUPLES

The remaining 80 thermocouples were distributed withint the model, supported on wooden dowels as shown on Photo No. 7. The boards were movable in horizontal directions and the dowels could be adjusted as to elevation.

As indicated by Table 1, 4 thermocouples were mounted in a thermos bottle. In this way a check was provided on recorder drift. In addition to the 96 recorder registered thermocouples a portable thermistor apparatus was used providing 23 additional temperature probes. The thermistor instrument was manually operated as to switching between probes as well as read-out.

In order to record air temperature and humidity a dry bulb-wet bulb instrument was used, see Photo No. 8. This instrument was calibrated to a dew point instrument in order to achieve the correct compensating air stream provided by a small fan.

Timing with respect to the tide cycle was based on the tide machine cam motion. A set of electrical switches placed at equal time intervals activated a bulb which provided time signals. A zero time was arbitrarily chosen as the time when water started flowing into the model at the downstream end. This would essentially correspond to slack before flood at Verplanck Point.

The velocity distribution in the model was measured by a photographic method. A camera was mounted vertically above the area to be investigated. The camera was equipped with a slowly rotating disk below the lens with "spokes" which intermittently interrupted the exposure. Candles on styrofoam floats supplied with sheet metal cruciforms, adjustable as to depth, were traced by the camera. The candle paths so photographed would show time marks due to the interrupter and would thus yield information both about velocity magnitude and velocity direction. Photo No. 9 shows as an example a photograph obtained this way.

3. MODEL CRITERIA

3.1 Model Similitude Relations

It is the purpose of the model to simulate the hydraulic behaviour of the Hudson River within the modeled area. The dominating forces, governing the flow distribution, are gravity forces and inertia forces. The gravity forces include so-called buoyancy forces caused by differences in specific weight. It is therefore essential that the ratio between inertia and gravity forces be maintained equal in the prototype and the model. The ratio between these forces can be expressed as

$\frac{F_i}{F_G} = \frac{V^2}{gL}$ where F_i stands for inertia force, F_G for gravity force, V is the velocity at a given point in the flow and L is a characteristic length at that point, generally the depth of flow. The square root of this ratio is generally called the Froude number and the model criteria then can be expressed as the requirement that the Froude number for any point in the model be equal to the Froude number of the corresponding point in the prototype.

With this criteria and the chosen length and depth ratios of the model the dynamic and kinematic scale ratios between model and prototype can be computed. These ratios are given in Table 2.

It should be noted that modeling of specific weight according to the Froude law requires that the ratio between prototype specific weight and model specific weight be unity. When specific weight differences are caused by temperature differences, this requirement will be fulfilled by modeling the same temperature in the model as would occur in the prototype, i.e., a one-to-one temperature scaling.

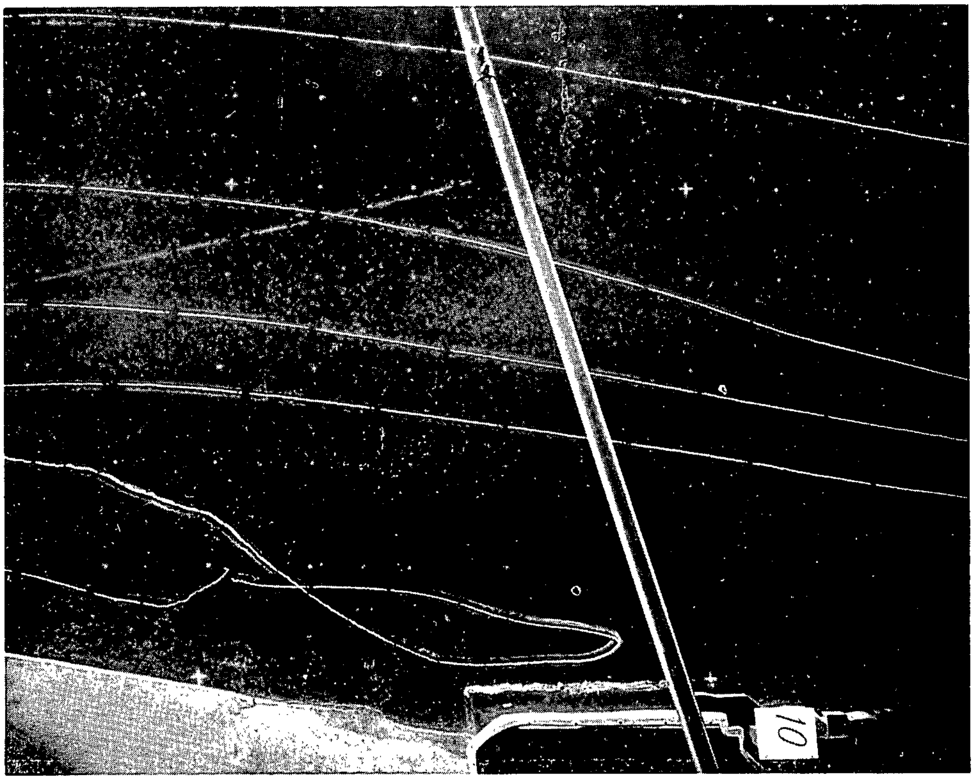


PHOTO NO. 9 VELOCITY MEASUREMENTS. CANDLE PATH LINES

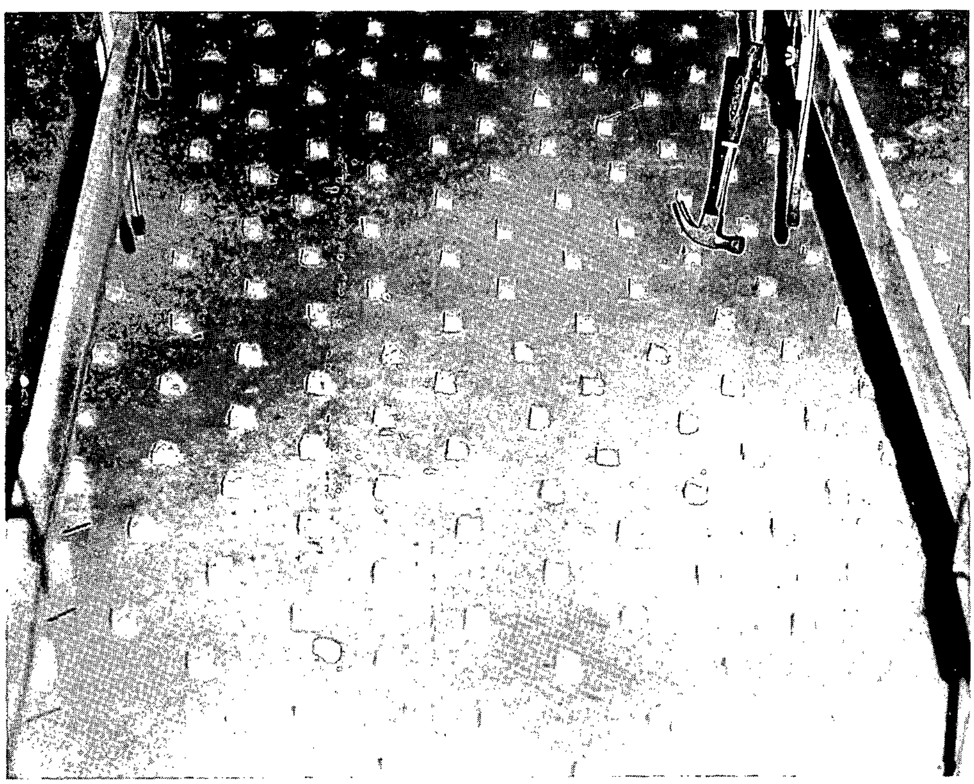


PHOTO NO. 10 ARTIFICIAL ROUGHNESS

RELATIONS BETWEEN PROTOTYPE AND MODEL PROPERTIES

		INDIAN POINT II MODEL	PROTOTYPE
GEOMETRIC	Length	1 Foot	250 Feet
	Width	1 Foot	250 Feet
	Depth	1 Foot	60 Feet
	Volume	1 $Foot^3$	375,000 $Feet^3$
KINEMATIC	Time	1 Second	32.2 Seconds
	Velocity	1 FPS	7.74 FPS
	Flow Rate	1 CFS	116,000 CFS
DYNAMIC	Pressure	1 PSI	60 PSI
	Gravity Force	1 Pound	375,000 Pounds
TEMPERATURE		1°F	1°F

The Kinematic-Dynamic-and Temperature Ratios are based on Froude Scaling i.e. Gravity and Inertia Forces are considered dominant forces.

TABLE II

Since the specific weight of water varies with temperature in a non-linear way the one-to-one density ratio can be modeled also when the model ambient temperature is different from the river ambient temperature. Figure 2 illustrates this. An ambient temperature for the river of 78F was assumed as a basis for the diagram. As an example, if the model ambient temperature is 60F the model temperature differential should be 20.5F in order to properly model a prototype differential of 15F.

The primary concern, thus, is in modeling the correct specific weight ratios and therefore when a "distorted" temperature of the warm effluent is used in the model the model effluent may be thought of merely as a tracer, having the true specific weight. This "tracer" has the advantage of being conveniently detected and also the hydrodynamic advantage of possessing the correct diffusion properties. When temperature differences in the model are in excess of those of the prototype a proper reduction must be made when test results are presented in terms of predicted prototype temperatures.

Specific weight differences in the prototype may also be due to variable salinity. The lower part of Hudson River is a typical estuary with salt water being forced upstream from the Atlantic Ocean due to the tidal action and partly due to the higher specific weight of the salt water which causes a "density flow" in the upstream direction. However at Indian Point density measurements presented in "Tides and Currents in the Hudson River" indicate that the specific gravity at Verplanck Point was 1.0021 as an average of 8 measurements taken during a survey in September, 1929 and that the maximum specific gravity difference was 0.004 with depth. This difference corresponds to a temperature difference of less than 3F at an ambient temperature of 78F. More recent measurements of salinity have indicated a maximum salinity of approximately 5 parts per thousand (Dr. Gwyneth Howells) with no variation with depth. A salinity of 5 ppth corresponds to a specific gravity of 1.007. It should be noted in this connection that salinity varies with the time of the year, being a minimum at the time of maximum fresh water run-off and a maximum at the end of the summer or in connection with low fresh water flows.

In view of the uniform density and low absolute salinity at Indian Point it was felt that modeling of temperature induced specific weight differentials would yield an adequate representation of prototype conditions.

Also in view of the uniform density and low salinity it seems reasonable to assume that the dispersion properties in the vicinity of Indian Point are due mainly to turbulent diffusion and to the non-steady flow pattern associated with the tidal flow.

The turbulent diffusion is proportional to the kinematic eddy viscosity which in turn is a function of the Reynolds number of the flow. The Reynolds number ($R_e = \frac{4 V y m}{\nu}$) is very high (about 3×10^7) at ebb and flood strength and reduces, theoretically, to 0 at slack tides.

The non-steady flow behaviour is particularly marked in conjunction with slack tides. For instance, it was observed that flood occurs along the Indian Point shore a considerable period of time prior to flood at mid River. This indicates that a shear zone exists in this area which may account for a considerable increase in dispersion. Such large scale dispersion caused by non-steady flow, is mainly due to non-uniform river geometry.

From a model point of view, since the diffusion coefficient is a function of eddy viscosity it is important that model Reynolds numbers are large. This was accomplished by distorting the model. Further, in order to maintain a high turbulence level, artificial roughness was added to the model bottom. See Photo No. 10. The roughness magnitude was computed based on an assumed Manning n-value of 0.02 for the Hudson River. (No actual data of river roughness is available, therefore the chosen value was a conservative estimate based on Open Channel considerations.) The distortion factor, depth ratio/length ratio = 4.16, determines the equivalent roughness of the model. With the applied roughness the model maintained rough turbulent flow in major portions of the bed for most of the tide cycle period.

3.2 Velocity Distribution - Field Measurements

The velocity distribution in the model was measured using the technique described in 2.3 "Instrumentation". At the time when the tide machinery was designed and the model was put in operation the only available current data were from "Tides and Currents in Hudson River" by Paul Schureman, U. S. C. and G. S. Figure 3 shows the stage versus time and velocity versus time based on these data. Although it is indicated in the above publication that average conditions were attempted based on surveys carried out between 1854 and 1932 the ratio between flood strength and ebb strength seems to indicate a condition with a spring run-off of about 30,000 cfs.

Figure 3 shows comparisons between the stage and current data from the above source and model data based on measurements. It is seen that the midstream velocity magnitudes agree well with the prototype data. The apparent lag in time is due to the arbitrarily chosen "0 time". T = 0 was defined as the time when the downstream discharge valve started opening, an operation which was well defined and easily recognizable. Some time ellapses in which the downstream momentum is counteracted by the inflow before slack tide can occur.

The stage curves, Figure 3, are referred to a datum so chosen that the curves become symmetrical. The average range at Indian Point is approximately 3 feet with high tide approximately 2 feet above MSL and low tide 1 foot below MSL. The model tide range was generally a few percent higher than that corresponding to the prototype range and the model stage produced a somewhat "fuller" curve than the prototype, as indicated in Figure 3. It is noted that in terms of flow pattern the range has insignificant effect.

Figure 4 shows a comparison between pathlines obtained by aerial photography in the field and pathlines photographically obtained from the model off Indian Point. The agreement was found acceptable for model operation.

Detailed comparison was made between flow patterns in the prototype and the model in certain areas. A specific feature of the tide that was found to have rather a significant effect on temperature distribution was the turn about of the flow along the east shore prior to slack at midstream. The field tests indicated, as shown on Figure 4, that floats along the east shore followed a velocity versus time curve approximately one hour prior to the curve for midstream velocities. The model results were in good agreement herewith.

Figure 4 also gives a comparison between midstream velocities measured at the field tests carried out August 14, 1968 and September 20, 1968 and the data obtained from "Tides and Currents in Hudson River." It is seen that for both the field tests the velocity magnitudes were found to be considerably higher than indicated in "Tides and Currents". The tide stage of August 14 was recorded and was found to yield a range of 3.15 feet as compared to 2.9 feet for an average range. This would explain some of the differences in velocity magnitudes. For the tide of September 20 only part of the stage curve was recorded. The recorded portion had a considerably greater slope than the average stage curve indicating that also for this day the range was above normal.

As a conclusion the field tests seemed to indicate that the velocities in the Indian Point section of the Hudson River are generally higher than indicated by the midstream velocities given in "Tides and Currents in Hudson River." Since the flow rate of the model was based on the latter data the model would tend to yield conservative results with respect to cooling water dispersion.

3.3 Heat Transfer Conditions

An important factor in the heat balance both in the prototype and in the model is the heat transfer from the water surface. Since the model was sheltered by a building the solar radiation was largely reduced so that this contribution to the heat transfer may be neglected. The heat transfer then depends on the temperature difference between the water surface and the ambient air, the relative humidity and the wind speed. The latter may be taken as zero due to the building.

Heat transfer coefficients were measured two different ways as part of the test program. In one test the temperature distribution in a stratified, still body of water was measured over a period of time. The water was enclosed in a 25 $foot^2$ wooden frame separating the test volume from the rest of the model. For this condition the temperature reduction within the test volume was due to heat transfer to the air and conduction, essentially molecular diffusion, to the underlying, colder water. The latter part could be accounted for on basis of the temperature measurements.

These measurements produced quite consistent results indicating a heat transfer coefficient of $K = 6.0 \frac{BTU}{ft^2 \text{ hour } °F}$.

The second method was based on operating the whole model with a constant heat input and determining the equilibrium condition at which the heat input was balanced by the heat given off from the water surface of the model and the sump. This method was considered as less accurate for the following reasons. The heat input included the power of the 20 HP pump. It was known from electrical measurements that the pump motor operated at approximately full load, therefore, the nominal motor power was converted to BTU/sec. Whether this amount of heat was actually received by the water could not be checked. Also the heat input from the model outfall structure would produce areas in the model with higher temperatures than the average water temperature and thus with a higher rate of heat transfer.

Three tests of this type were performed. (Reported in letters of October 23 and December 2, 1968 to Consolidated Edison) Test No. 1 was performed with a heat input corresponding to operation of units 1, 2 and 3 (4670 cfs, $\Delta T = 16\%$) and gave as a result $K = 10.1 \frac{BTU}{ft^2 \text{ hour } °F}$. In test No. 2 the heat input was equivalent to operating units 1 and 2 at 13.7F. This test indicated $K = 8.8 \frac{BTU}{ft^2 \text{ hour } °F}$. For Test No. 3 the pump with its 20 HP motor was the only source of heat input. This test indicated $K = 4.0 \frac{BTU}{ft^2 \text{ hour } °F}$. This result seems to indicate that the heat input estimated for the pump was on the high side.

The experimental determination of heat transfer coefficients mentioned is part of a continuing effort at Alden Research Laboratories to improve the knowledge in this area. Heat transfer coefficients have been measured in connection with several other cooling water studies, a Master's thesis with this subject was completed several years ago and further tests have been planned.

3.4 Temperature Conditions for the Model as a Whole

When the model and sump was filled with water and put in operation it may generally be assumed that the water temperature was at an equilibrium state determined by the surroundings. As soon as the pump was turned on and the cooling water effluent adjusted to its proper temperature the heating of the model water would take place. Since the heat loss with the above conditions would be zero initially, the rate of temperature rise would be directly proportional to the heat input. As an example it may be mentioned that the model temperature rise based on operation of units 1, 2 and 3 theoretically should be 1.4F per hour. A rate of rise of 1.3F per hour was measured in good agreement herewith.

The initial condition mentioned yields the maximum possible rate of temperature rise. The extreme condition in the opposite direction would be obtained at the point where the overall heat loss from the model and the sump would equal the heat input. Neither of these conditions would generally prevail during a test.

Several tide cycles, each of approximately 23 minutes duration, generally elapsed while instrumentation was adjusted and preparations were completed for the first test of the day. This would exclude the initial condition of maximum rate of temperature rise. On the other hand to reach the condition of equal heat input and heat loss was impractical since this was a time consuming operation. The heat transfer test with 3 units required 12 hours continuous operation and steady state was then obtained due to an air temperature considerably lower than the ambient water temperature.

The effect of increasing model and sump water temperature would be to reduce the accuracy of ambient water temperature determination. The ambient water temperature was measured by two probes in the flow supplied to the model, i.e., two at the downstream end during the flood tide and two at the upstream end during the ebb tide. Therefore at a given time water at Indian Point would have been discharged into the model at a different ambient temperature than that measured by the ambient probes at that time. An estimate of this error may be established on the basis of the heat transfer tests and the residence time. If from the heat transfer test the rate of temperature rise is taken as 1.3F per hour and the residence time is taken as half a tide cycle or 12 minutes, the resulting error would be $\frac{1.3}{60} \times 12 = 0.26$F. This is in the order of the accuracy of the temperature determination and seems therefore to be without significance.

3.5 Significance of Model Length as Related to Heat Accumulation

The tidal flow is cyclic but due to the fresh water flow the flow versus time behaviour is not symmetric, the duration of flood flow is somewhat shorter than that of ebb flow. Therefore a water particle released at Indian Point at slack before flood will travel a certain distance upstream, turn back downstream at slack before ebb and in its downstream movement pass by Indian Point. The distance downstream from Indian Point where it again turns upstream at slack before flood is the net downstream movement which varies mainly as a function of the rate of fresh water flow. The net downstream movement may be estimated at about 1100 feet at a minimum fresh water flow of 4000 cfs and 11,000 feet at a high spring flood dependent fresh water flow of 40,000 cfs.

A constant release of a conservative substance at Indian Point would produce the following, somewhat simplified, but yet pertinent, picture. Starting at slack before flood, accumulation would occur in an area outside the outfall. The "island" of substance-containing water would start moving upstream with the flood flow. The continuously released substance would immediately be carried with the flow in the upstream direction, occupying an area mainly determined by the flow pattern of the river flow. At slack before ebb the original "island" would be formed at Indian Point and at slack a new "island" would form at Indian Point. Thus three "islands" would be moving upstream during the second tide cycle, two of which were separated by the distance of the net downstream movement. At slack before ebb the third "island" would miss Indian Point by this distance. Theoretically after a number of tide cycles a "necklace" of "islands", chained together by substance containing water of varying concentration and with equidistance spacing equal to the net downstream movement would occur in the River.. Longitudinal and lateral dispersion would have changed the initial boundaries and reduced the concentration tending to produce a more uniform distribution of the substance.

The ultimate condition indicated above would not develop in the Indian Point II Model because of its limited length. In fact an "island" produced at slack tide, both before flood and before ebb, would be discharged past the weirs of the model ends. The distance from Indian Point to the sections represented by the weirs was approximately 9000 feet while the movement between slack tides is in the order of 20,000 to 30,000 feet.

Therefore the model results yield information about the effect of a continuous release of cooling water from Indian Point within the modeled area for one tide cycle. The effect of build up of heat over a period of time, corresponding to several tide cycles, was not modeled. The water leaving the model past the weirs was received by the sump where vigorous mixing was accomplished by the 20 HP supply pump. Therefore the sump temperature would rise with time, i.e., the model ambient temperature would increase over a series of model tide cycles. However, the ambient temperature was continuously measured at the inflow sections of the model and isotherms based on these temperature measurements.

In conclusion it should be mentioned that heated cooling water is not a conservative substance. The heat balance of the river is strongly dependent on heat dissipation to the atmosphere. The heat dissipation is determined by the climatic conditions defining a heat transfer coefficient and the surface temperature of the river. For given climatic conditions the heat dissipation would increase with increasing surface temperature and would therefore be maximum for areas affected by the above mentioned "islands".

4. UNDISTORTED SUB-MODEL 1:50 OF THE COOLING WATER OUTFALL STRUCTURE

4.1 Introduction

A number of open channel type outfall configurations were tested in the Indian Point II model. During the course of these studies it was found desirable to discharge the cooling water from submerged outfall openings in order to meet more rigorous temperature requirements for the Hudson River. Preliminary studies in the Indian Point II model, which has a distortion of 4.16, indicated that the testing of submerged outlets would yield local results not corresponding to equivalent prototype outlets. The reason was that a jet formed by an outlet, is a specific hydraulic phenomenon, which develops without regard to the model distortion. A free jet, issuing into an infinite ambient recipient, has an angle of divergence of about 11.3°. Therefore in the distorted model the spread of the jet would appear to occur at too low a rate. The cooling water jet would entrain excessive ambient water at the point where the river surface was reached and would therefore indicate a resulting temperature on the low side. Since the results thus would be on the optimistic side, rather than on the conservative side, it was decided to carry out the detailed investigation of the outfall configuration in an undistorted model. The aim of these tests was twofold: 1) To determine the geometry of the outfalls so as to meet specified requirements with respect to river surface temperatures; 2) To determine the boundary condition to be imposed on the distorted model so as to obtain correct results from this model outside the area directly affected by the outfalls.

Tests in the undistorted model were carried out in August of 1968 (Progress Report August 1968) in October 1968 (Progress Report October 1968) and in March of 1969 (Progress Report April 1969). A summary of these tests is presented herein. In order to evaluate the effectiveness of a particular outfall configuration an efficiency parameter is defined as the ratio between the highest surface temperature observed in the vicinity of the outfall and the temperature of the cooling water. Both these temperatures refer to the ambient temperature of the modeled river water.

4.2 The Model

It was decided to construct the undistorted outfall model utilizing the heat capacity of the boiler supplying the distorted model. Part of the sump area for the distorted model was found to be a convenient site for the undistorted model, providing river ambient water for the model without any extra effort in terms of piping, installing of pump capacity, etc. Based on the above conditions a model scale ratio of 1:50 was chosen. Photo No. 11 shows the model discharge channel with six 4-foot high openings as viewed from the river. The river bottom topography was modeled on the basis of the data used for the distorted model. The lateral slope of the river bottom outside the outfall is relatively gentle and constitutes an almost plane sloping surface within the nearest 300 to 400 feet off shore. Therefore the increased submergence of the outfalls could be modeled by increasing the depth of water in the model rather than by actually excavating to greater depth of the outfall. This saved considerable time in testing and also gave the advantage of more direct comparison of different amounts of submergence.

Part of the discharge channel and the sheet piling along the river shore, containing the outfall openings, was modeled in sheet metal to an elevation such that a water depth in the discharge channel of up to 32 feet could be modeled. A regulating gate was installed at the downstream end of the model to regulate the depth of water. A 4" warm water pipeline containing an orifice meter and valves for adjusting the temperature as well as the flow rate was installed.

The model was equipped with 22 thermocouples connected to one of the recorders of the distorted model, see Photo No. 12. These were placed with reference to a grid system for which N60 and the grant of water line were base lines. For detailed measurements a thermistor set with 12 probes was used, providing more flexibility than the more stationary thermocouples.

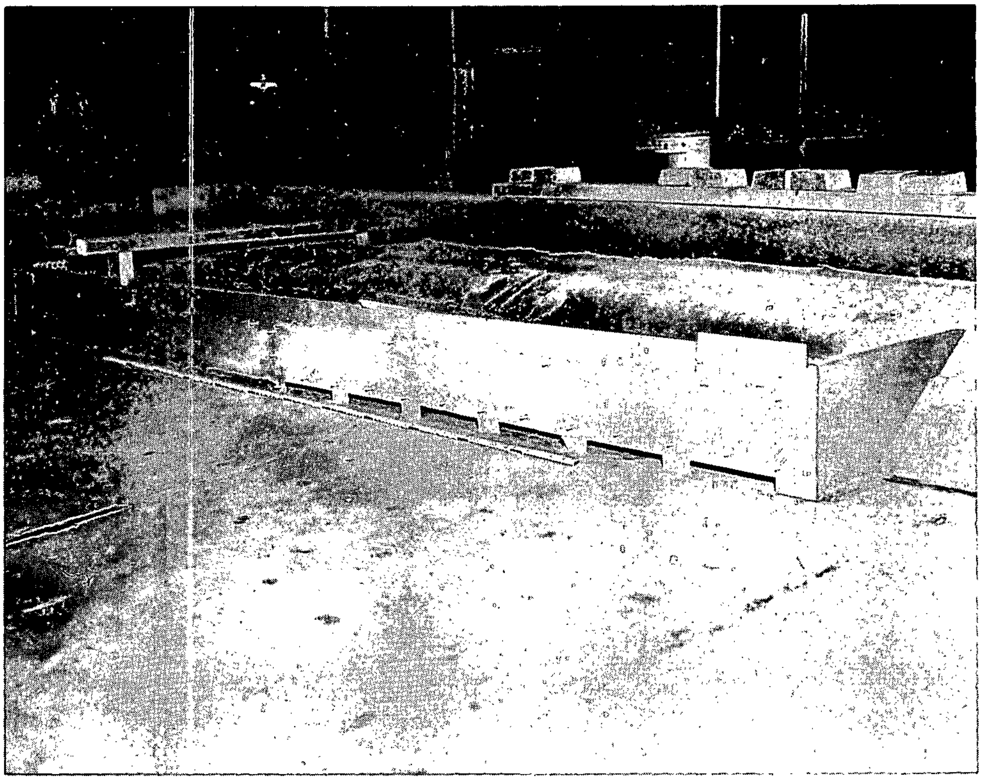


PHOTO NO. 11 UNDISTORTED MODEL. SIX 4 FOOT HIGH OPENINGS

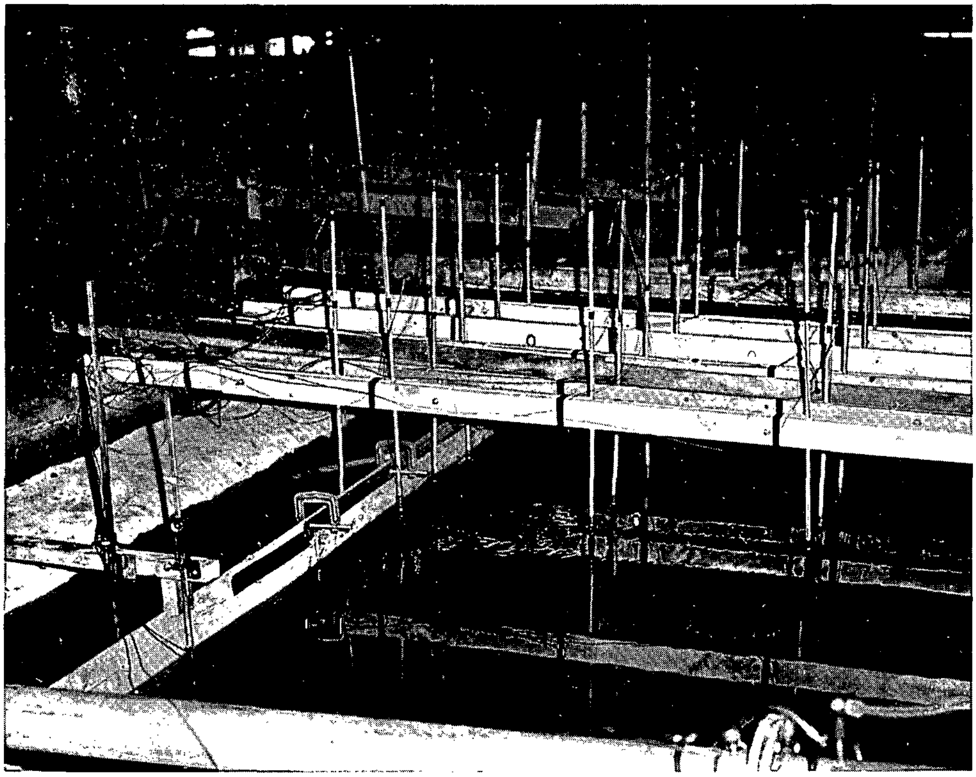


PHOTO NO. 12 UNDISTORTED MODEL IN OPERATION

4.3 Test Results

The outfall configurations tested and reported herein are summarized in the following Table III and detailed results are presented in Figures 5 - 14:

Test Data	Length of Outfall Structure	Depth of Channel Below MSL	Number of Openings	Dimensions of Openings	Water Level Difference Between Channel and River	Effluent Temperature ΔT_E Above River Ambient	Ratio of Max. Observed Surface Temp. ΔT_S to ΔT_E	Figure Number for Details
	feet	feet		feet	F	F		
March 1969	340	20	17	2.4 x 15	1.5	13.8	0.48	5
March 1969	240	20	12	4 x 15	1.5	14.0	0.50	6
Aug. 1969	240	20	6	4 x 30	1.5	17	0.53	7
March 1969	340	20	17	2.8 x 15	1.25	13.9	0.54	8
Oct. 1968	240	20	6	8 x 30	0.3	17	0.59	9
March 1969	240	20	12	6.5 x 15	0.5	13.7	0.61	10
Oct. 1968	240	20	6	7 x 30	0.4	17	0.67	11
March 1969	340	20	224	2.5 DIA.	0.6	12.9	0.67	12
Oct. 1968	240	25	6	7 x 30	0.4	17	0.70	13
Oct. 1968	240	30	6	7 x 30	0.4	17	0.65	14

TABLE III DATA OF TESTED OUTFALL CONFIGURATIONS

In general the tests results have been arranged as to decreasing efficiency. It is noted that the smaller the ratio between maximum observed river temperature and effluent temperature the more effective is the outfall structure in providing dilution.

The general trend indicated by the table values is that dilution primarily increased with discharge velocity. It is also seen that within the range tested the length of the outfall structure does not have a significant influence on the dilution. Submergence of the outfall openings does have an effect on dilution, increasing submergence improves the dilution, however, this effect is not as marked as that due to exit velocity.

It should be noted that the efficiency values shown for the tests of August and October, 1968 are not as accurate as those shown for the tests performed in March, 1969. For two reasons the latter are more accurate. The ambient temperature was more stable due to more uniform temperature of the water and the flow pattern of the water representing river flow was improved by better designed guide vanes in the upstream part of the model.

One of the tests seems to fall outside of the general efficiency pattern namely the test with six 8 by 30 foot openings, Figure 9. It is felt that the relatively favorable efficiency value indicated for this test is in error. A probable explanation is that the highest surface temperature escaped measurement due to the particular flow pattern produced by this outfall configuration.

The test with 224 circular openings, 2.5' diameter in two rows, spaced 3 feet center to center distance both horizontally and vertically, indicates a relatively low efficiency. Despite the higher exit velocity this design is equivalent to 6 openings 7 by 30 feet in terms of dilution.

The effective exit velocity is indicated by the water level difference between the outfall channel and the river. The exit velocity is approximately equal to $\sqrt{2gh}$ where h is the water level difference, g is the gravity constant. The exit velocity determined this way is higher than the nominal velocity computed as $\frac{Q}{A}$ where Q is the effluent flow rate and A is the total area of the outfall openings. The reason is that the flow is contracted by passing through the sharp cornered openings. A coefficient of contraction was computed for several of the tests and found to have a value of between 0.6 and 0.7. It was found that the coefficient increased slightly with the longer outfall structure presumably due to the relatively lower channel velocities. This is reflected in the fact that the height of the openings could be somewhat reduced without exceeding a water level difference of 1.5 feet between channel and river. The nominal area with the 240 foot long channel was 720 feet^2 while the nominal area with the 340 foot channel was 612 feet^2 for 1.5 feet water level difference. The 720 foot^2 opening area yields an opening height of 2.8 feet with the 340 foot long channel. A test with these conditions was performed, see Figure 8.

Tests were performed to determine the effect on water level difference of adjustable openings at the downstream end of the outfall channel. These tests were conducted with the outfall configuration consisting of a 340 foot long structure containing 17 openings 2.4 feet high and with 5 foot partitions between the openings. Figure 15 shows the results. It is seen that the "head loss" decreased rapidly when the last opening was extended up to the water surface, one free opening reduced the water level difference by 50%. A plot on semilogarithmic paper indicated that the gain in "head loss" varied exponentially with the number of free openings. It is seen from Figure 15 that the additional gain, when more than 3 openings were free, was insignificant.

4.4 Conclusions of Sub-Model Tests

Model tests in an undistorted model of ratio 1:50 simulating a variety of outfall configurations indicated that an initial reduction of the effluent cooling water temperature of approximately 50% may be achieved in one of several ways:

1) a 340 foot long structure with 17 openings 2.4' x 15' reduced the maximum surface temperature to 48% of the effluent temperature
2) a 240 foot long structure, 12 openings 4' x 15'; reduction to 50%
3) a 240 foot long structure, 6 openings 4' x 30'; reduction to 53%
4) a 340 foot long structure, 17 openings 2.8' x 30'; reduction to 54%

While structures 1), 2) and 3) produced a water level difference between the channel and the river of 1.5 feet, structure 4) caused a difference of 1.25 feet.

It was found that the water level difference between channel and river may be reduced by 50% by extending the furthermost downstream opening of structure 1) to the water surface. The gain with additional free openings decreased exponentially. Adjustable outfall openings would be used at times when the need for initial dilution is reduced.

It is interesting to note that the rather well developed theoretical approach to the dilution problem applied to the flow conditions of structure 1) indicates a temperature reduction to approximately 25% of the effluent temperature. The theoretical approach assumes an infinite depth above and below the outfall "slot" and is therefore not applicable to the boundary conditions of this outfall. The model results indicating only about 50% reduction reflect the reduced entrainment of ambient water due to the boundary conditions.

5. TEST RESULTS, MAIN MODEL

5.1 General

When the testing of the undistorted model was completed and an outfall configuration was selected based on these tests, satisfying the temperature requirements prevailing at that time, an extensive series of tests were conducted in the main model. These tests were carried out between November 4 and December 6, 1968. The adopted outfall configuration consisted of six 7 foot high, 30 foot wide openings with 10 food wide separations. The upstream opening was placed 500 feet downstream from the intake for Unit No. 3. The bottom of the openings was flush with the channel bottom at elevation -20 feet with reference to MSL.

The main model outfall structure was mounted with an adjustable gate. The gate position was determined by trial and error so as to produce the same temperature increase at a distance corresponding to 200 feet from the outfall as determined in the undistorted model. The model results presented in the following are, strictly speaking, applicable to this outfall configuration only. However the results of the undistorted model tests presented in Section 4 indicate that a number of outfall configurations yielded temperature patterns quite similar to those for the tested outfall. Therefore, with the aid of Section 4 the following tests results may be used to extend the application to other outfall structures.

It should be noted that an outfall configuration with higher "efficiency" than that of the tested configuration would yield generally lower temperature elevations. Therefore the following test results may be interpreted as conservative distributions, i.e., temperatures on the high side, for such an outfall.

The main model tests consisted of 79 recorded tide cycles, representing a series of different conditions. Excluding probe positions as a variable the prime variables were as indicated in the following table:

TEST SERIES	NUMBER OF UNITS	AMBIENT RIVER TEMPERATURE	DISCHARGE TEMPERATURE
310 - 325	1 + 2 + 3	48 - 53 F	17 - 19 F
501 - 531	"	41 - 49 F	17 - 19 F
532 - 551	"	42 - 54 F	33 - 35 F
600 - 611	1 + 2 + 3	40 F	26 - 28 F
410 - 418	1 + 2	45 - 55 F	16 - 18 F
420 - 421	1 + 2	49 F	32 F

TABLE IV. TESTS CONDUCTED AND APPROXIMATE CONDITIONS

Within the test series indicated in Table 4 the thermocouple positions were varied both horizontally and with respect to depth.

For each tide cycle 28 scans were recorded covering all 96 probes. One scan would produce data for plotting the isotherms within the modeled area of the river and the time for sampling the data was approximately 0.4 hours (prototype). In plotting the data the mid-point of the time interval was chosen to represent the "instant" of the isotherm pattern.

A great number of isotherm patterns were plotted for comparison and evaluation of the cooling water temperature effect. For presentation in this report were chosen eight "instants" in the tide cycle as representative for the development with time of the cooling water pattern over a tide cycle.

The position of probes was varied both horizontally and with respect to depth. Comparison between data taken at two different sets of horizontal positions showed that one set was adequate for determining the isotherm pattern. It also showed that superposition of data from two positions required extensive treatment of the data to match the two sets. The reason was primarily that the isotherm location varied rapidly with time. Therefore the scanning of two tide cycles would have to be started at almost exactly the same time in the cycle to produce compatible data.

The depth of the thermocouples were varied between 0 (water surface) and the bottom, generally in steps of 6 feet from the surface down to 24 feet depth and in greater increments below 24 feet depth. 0 depth was by definition 1/4 inch (model) below the surface at low tide. In terms of prototype this meant at low tide 20" below the water surface or, at high tide 4 feet 8' below the water surface.

The isotherms presented in Figures 16 - 101 are all converted to a temperature rise of the cooling water of 16.4F with 3 units and 14.0F with operation of Units 1 and 2. The conversion was performed according to the description in 3.1 "Model Similitude Relations".

5.2 Test Results Reported

The isotherm patterns selected to represent the test results are presented on Figures 16 - 101. These Figures may be grouped according to the following Table 5.

TEST NO.	UNITS	ΔT	T_{AMB} F	DEPTH	FIGURE NO.
522	1+2+3	16.4	44	0	16 - 23
525	"	"	50	6	24 - 31
527	"	"	51	12	32 - 38
528A	"	"	46	18	39 - 46
529A	"	"	51	24	47 - 54
533	"	"	80	0	55 - 62
534	"	"	80	6	63 - 69
542	"	"	80	24	70 - 77
410	1+2	14.0	65	0	78 - 85
416	"	"	56	6	86 - 93
420	"	14.0	80	0	94 - 101

TABLE V. TEST NUMBER AND DATA RELATED TO FIGURE NUMBER

Each group of Figures represents a tide cycle with a given depth of the probes and 8 different times in the cycle. The general development of the isotherm patterns with time is quite independent of the temperature, the number of units operating and the depth. Thus a description is given below for only one test, i.e. one tide cycle.

5.3 Tests with Units Nos. 1 + 2 + 3

Test 522 represents surface isotherms for 3 units discharging 4670 cfs of cooling water with a temperature rise of 16.4F above an ambient river temperature of 44F.

Figure 16 shows the isotherms at t = 1 hour. At this time there was a slight upstream flow in the river and the cooling water accumulated during slack tide has started moving upstream. The accumulation of cooling water was accentuated by the upstream flow along the east shore starting in the order of one hour prior to slack at mid-river. The highest surface temperature increase was 8F.

Figure 17, t = 2 hours, shows the cooling water moving upstream. It is noted that the area of the maximum surface temperature has been reduced as compared to t = 1 hour.

Figure 18, t = 3.7 hours, indicates that the areas of representing 1F, 2F and 4F temperature rise have been greatly reduced and that the maximum surface temperature decreased from 8F to between 4F and 6F. The reason for the overall reduction of heated surface area is the higher river velocities with resulting increased transport capacity and more efficient mixing. The decrease of the maximum surface temperature is partly due to the down-river component of the effluent velocity, which, when the cooling water enters the upstream river flow, aggravates the mixing. It is seen that for the ebb part of the tide cycle the 8F maximum surface temperature was consistent.

Figure 19, t = 4.6 hours, shows some "swelling" of the heated areas indicating that the flood velocities had decreased. At this time slack along the east shore is due shortly as indicated by the position of the 4F isotherm.

Figure 20, t = 6.2 hours shows the cooling water accumulated during slack before ebb moving downstream. By comparison to Figure 16 it is seen that the accumulation was less extensive than at slack before flood. The maximum surface temperature again increased to 8F.

Figure 21, t = 7.9 hours, is near ebb strength. The cooling water now was carried downstream along the east shore. The 1F isotherm was carried past the tide gate.

Figure 22, t = 9.7 hours, subsequent to ebb strength, shows a reduction of the area encompassed by the 4F isotherm as compared to the conditions at 7.9 hours. This indicates the greater rate of mixing with higher river velocities.

Figure 23, t = 11.4 hours, is towards the end of the ebb tide. The affected area increased with the reduced flow velocities and the position of the 4F isotherms was shifted outwards from the shore indicating the turnabout of the flow near the east shore. This isotherm pattern transformed itself into that shown on Figure 16, thus completing a tide cycle.

The temperature conditions for test No. 522, an ambient river temperature of 44F, produced a minimum density differential between cooling water and river water. (Ambient temperatures below 40F would further reduce the density differential, however such conditions are extremely difficult to model and this was not attempted.) It is therefore interesting to compare the results of this test to those of test No. 533 where the ambient temperature was 80F. This represents the extreme case in terms of a high density differential. Figures 55 to 62 show that areas affected by the cooling water were generally greater and also show a tendency towards generally higher surface temperatures. Where in test No. 522 the prevalent surface temperature was 1F, test No. 533 indicates occasionally a 2°F area.

These trends are due to the grater buoyancy of the cooling water in test No. 533 which tends to bring the sub-surface discharge to the surface. Accordingly, test No. 533 should indicate less effect of heat at the lower elevations. A comparison between tests No. 529A, Figures 47 - 54, and No. 542, Figures 70 - 77, both for 24 feet depth, the former with an ambient temperature of 51F, the latter of 80F, bears this out.

It is interesting to note that the potential energy with respect to the water surface of the cooling water at its exit, based on the density differential, is equivalent to the energy loss of the river water flowing a distance of more than 1 mile at 2 fps. Therefore an effect in terms of added spreading would be expected with the higher ambient temperature, i.e., the higher density differential.

Returning to the tests with an ambient temperature of about 50F it is noted that the areas bounded by isotherms of given magnitude decrease with depth in the river. At 24 feet depth the effect was insignificant and tests at 30 feet depth indicated generally no heat effect at all. Results from tests at 6, 12, 18 and 24 feet depth are shown on Figures 24 to 54. The general development with time follows closely the description given above for test No. 522.

5.4 Tests with Units 1 + 2

Three tests with discharge from units No. 1 and No. 2 are included. Results for test No. 410 are shown on Figures 78 - 85 indicating surface isotherms for 2670 cfs cooling water at 14F above an ambient river temperature of 65F. The behaviour of the isotherm pattern with time was similar to that for the three unit discharge. A comparison to test No. 522, three units, shows that the areas affected and the temperature rise produced by the two unit operation was almost as extensive as that for three units. There are two reasons for this. The two unit flow was discharged through the same outfall structure as used with three units. Therefore the discharge or jet velocity with two units was about 43% less than with three units and accordingly the initial mixing was considerably reduced. Also the higher ambient temperature in test No. 410 would increase the spread of the cooling water.

Test No. 416 is shown on Figures 86 to 93. The isotherms are for 6 feet depth and an ambient temperature of 56F.

Test No. 420 was with two units operating and an ambient temperature of 80F. Comparison of the isotherms produced by this test with those from test No. 533, three units operating and 80F ambient temperature, again shows the effect of the reduced initial mixing with two units operating. Surface areas affected and temperature elevations were almost as extensive as for operation with three units.

5.5 Recirculation

The tendency towards recirculation of heated cooling water was determined from a number of tests. Figures 102 and 103 show the measured recirculation for units 1, 2 and 3 operating at a 17F temperature rise. Figure 102 is for an ambient river temperature of 50F while Figure 103 shows the recirculation with 79F ambient temperature. It is seen that the recirculation was but slightly dependent on ambient river temperature. The increase in intake temperature was marked at the beginning of the flood tide in connection with the build-up of cooling water in the vicinity of the plant as described in Section 5.3. It is seen that the upper part of the intakes receive somewhat warmer water than the lower parts. The effective recirculation did not amount to more than in the order of 1F and only for some hours out of the 12.5 hour tide cycle.

Figure 104 shows the recirculation measured with units 1 and 2 operating. The recirculation was less than with 3 units and amounted to less than 1F for about 5 hours.

FIG. 1

INDIAN POINT II MODEL

GENERAL ARRANGEMENT

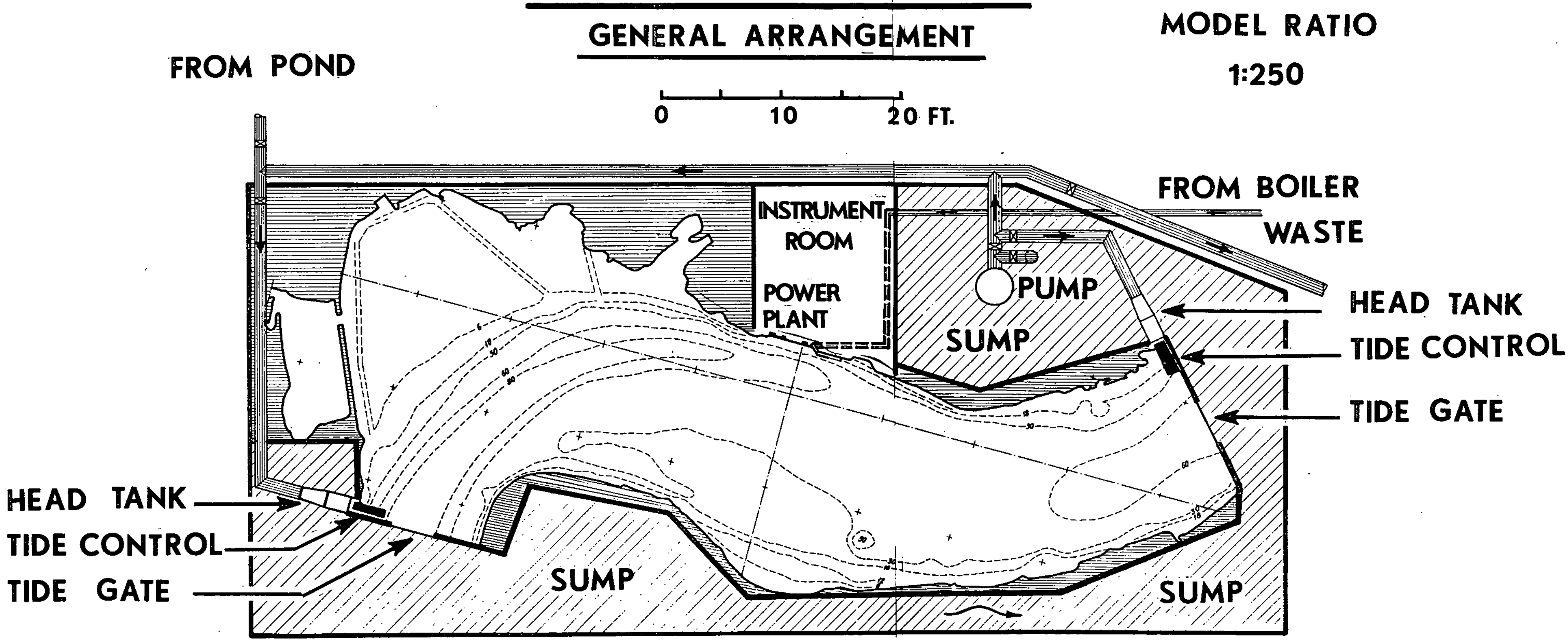
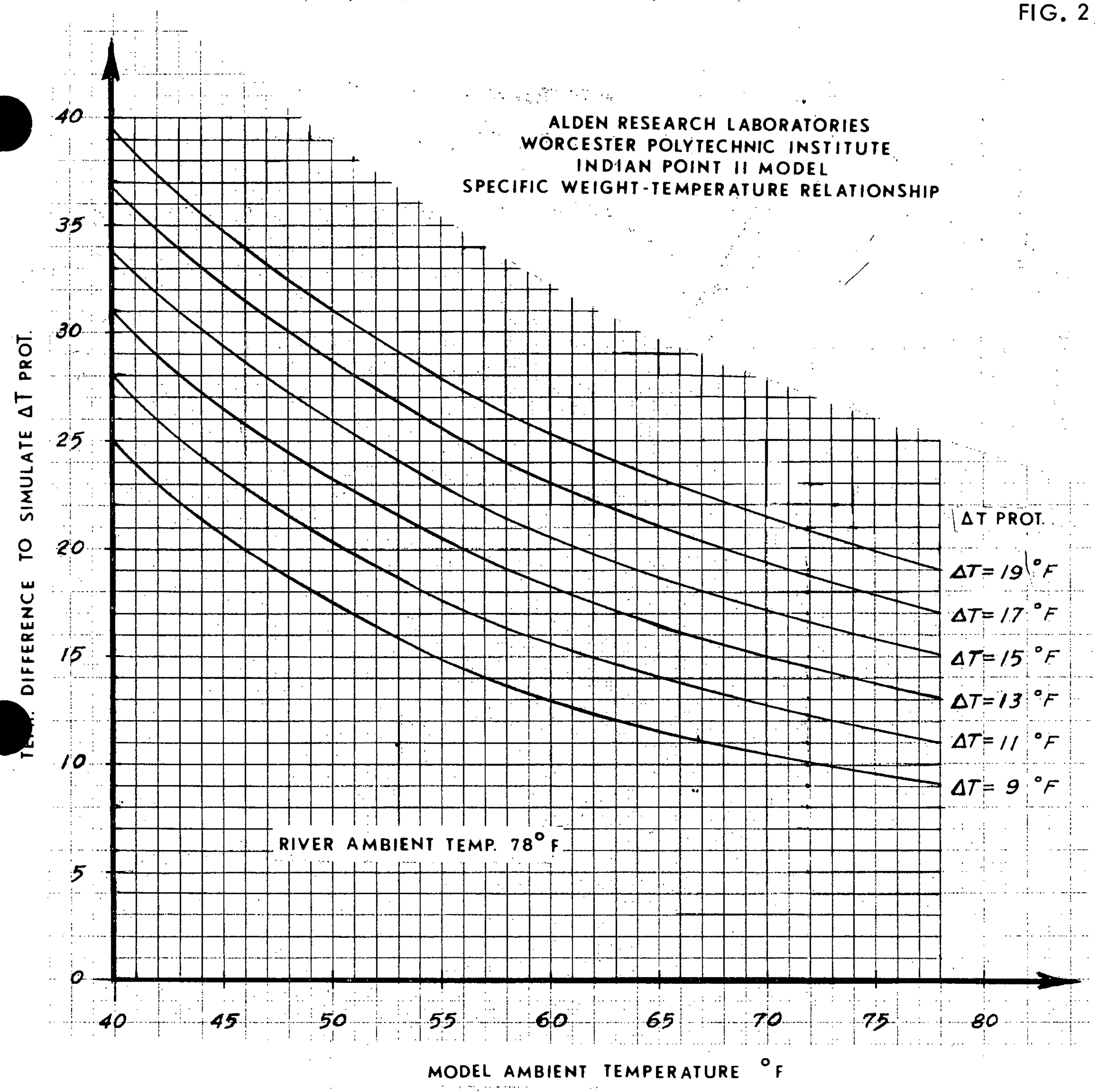


FIG. 2



ALDEN RESEARCH LABORATORIES
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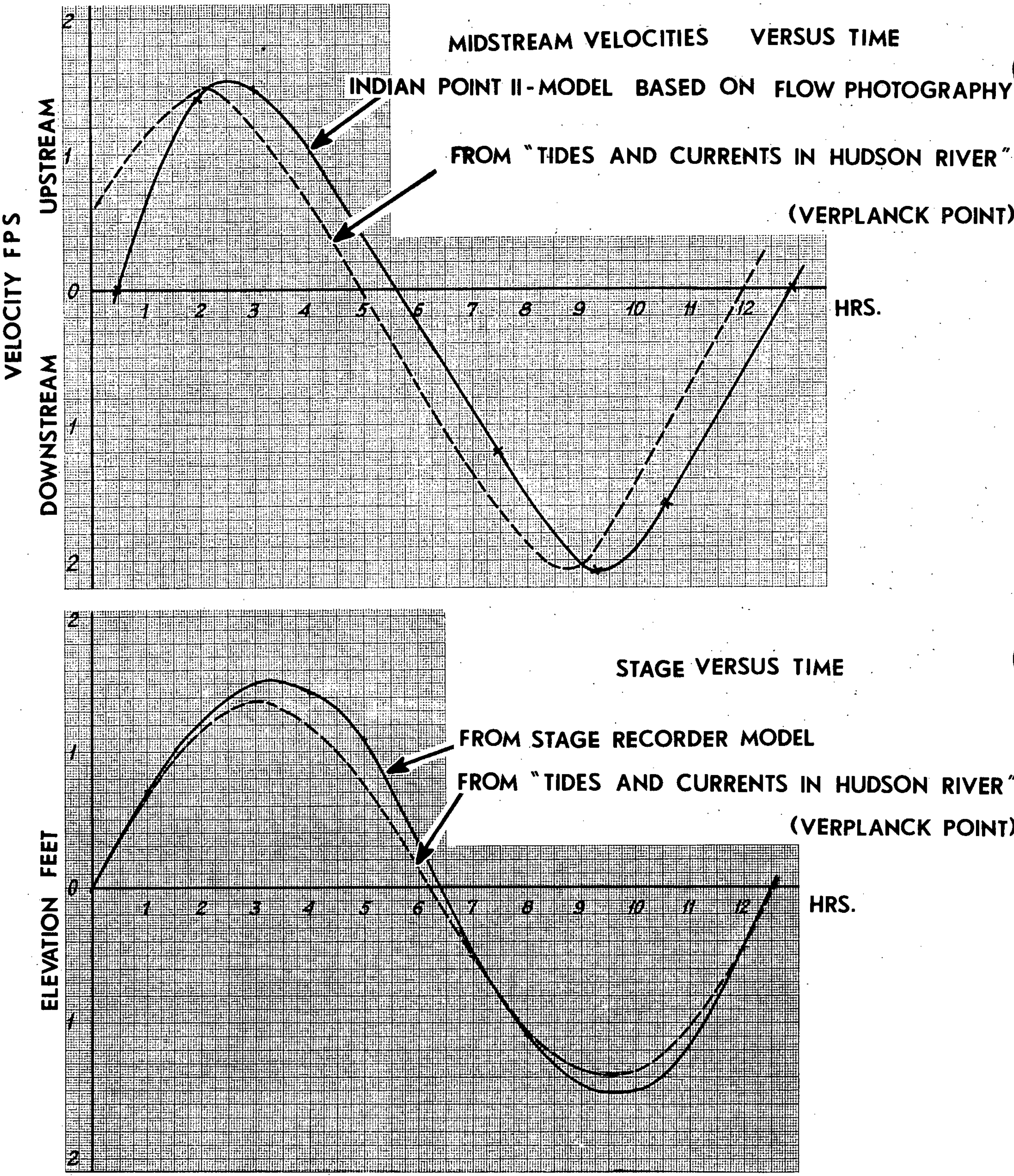
INDIAN POINT II MODEL
SPECIFIC WEIGHT-TEMPERATURE RELATIONSHIP
TEMP. DIFFERENCE TO SIMULATE ΔT PROT.
ΔT PROT.
ΔT= 19 °F
ΔT= 17 °F
ΔT= 15 °F
ΔT= 13 °F
ΔT= 11 °F
ΔT= 9 °F
RIVER AMBIENT TEMP. 78° F
0
5
10
15
20
25
30
35
40
40
45
50
55
60
65
70
75
80
MODEL AMBIENT TEMPERATURE °F

FIG. 3

COMPARISON MODEL TO PROTOTYPE



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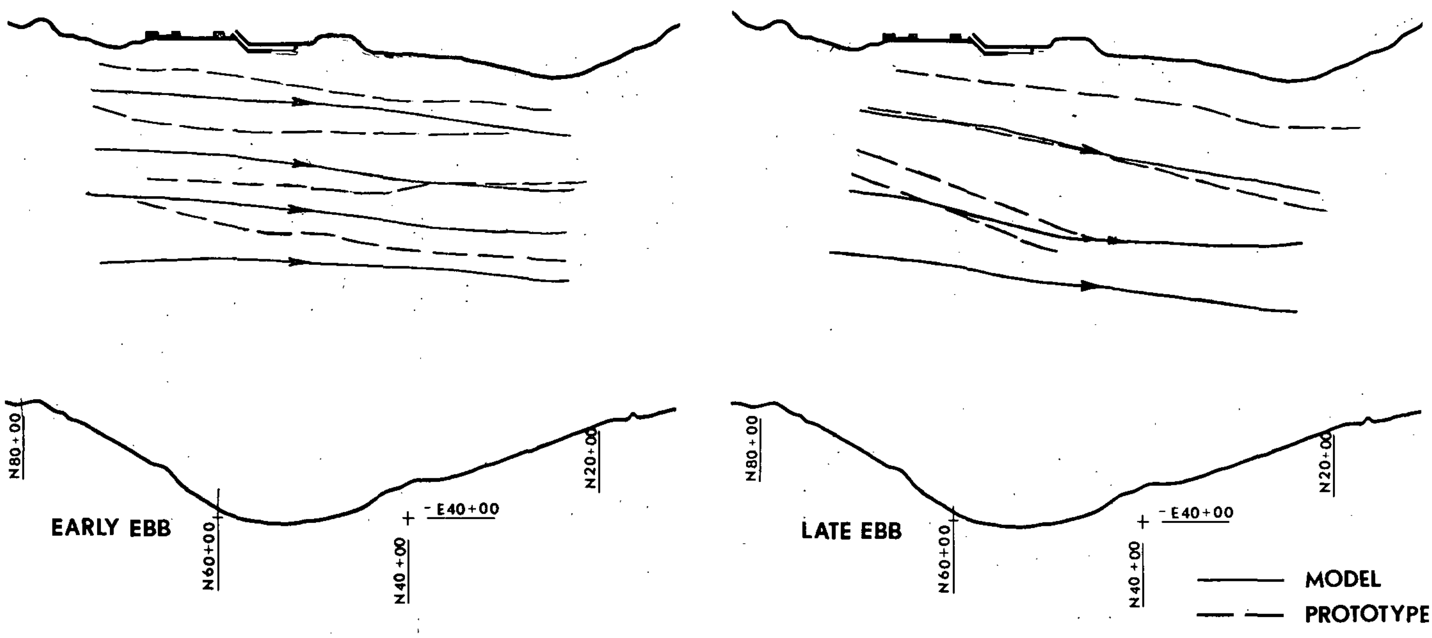
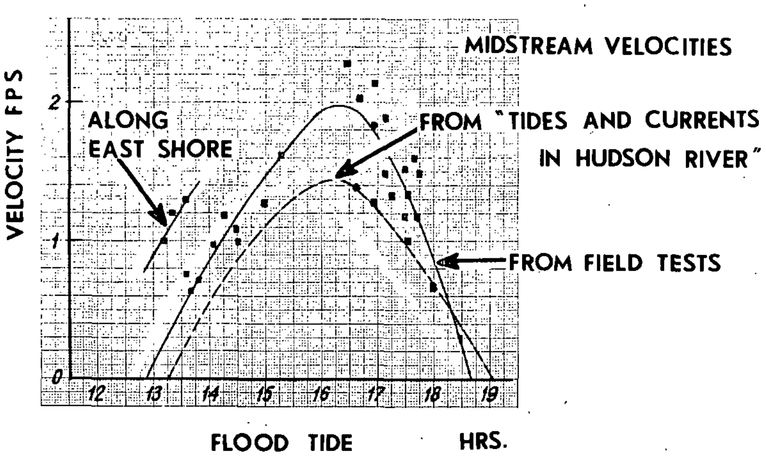
COMPARISON BETWEEN PATH LINES OFF INDIAN POINT





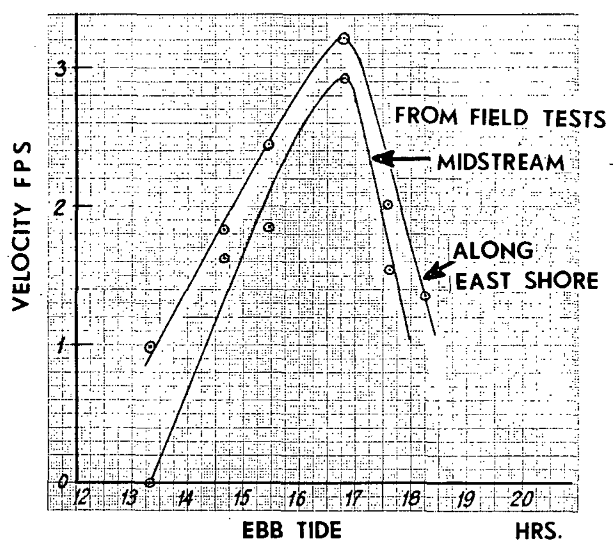


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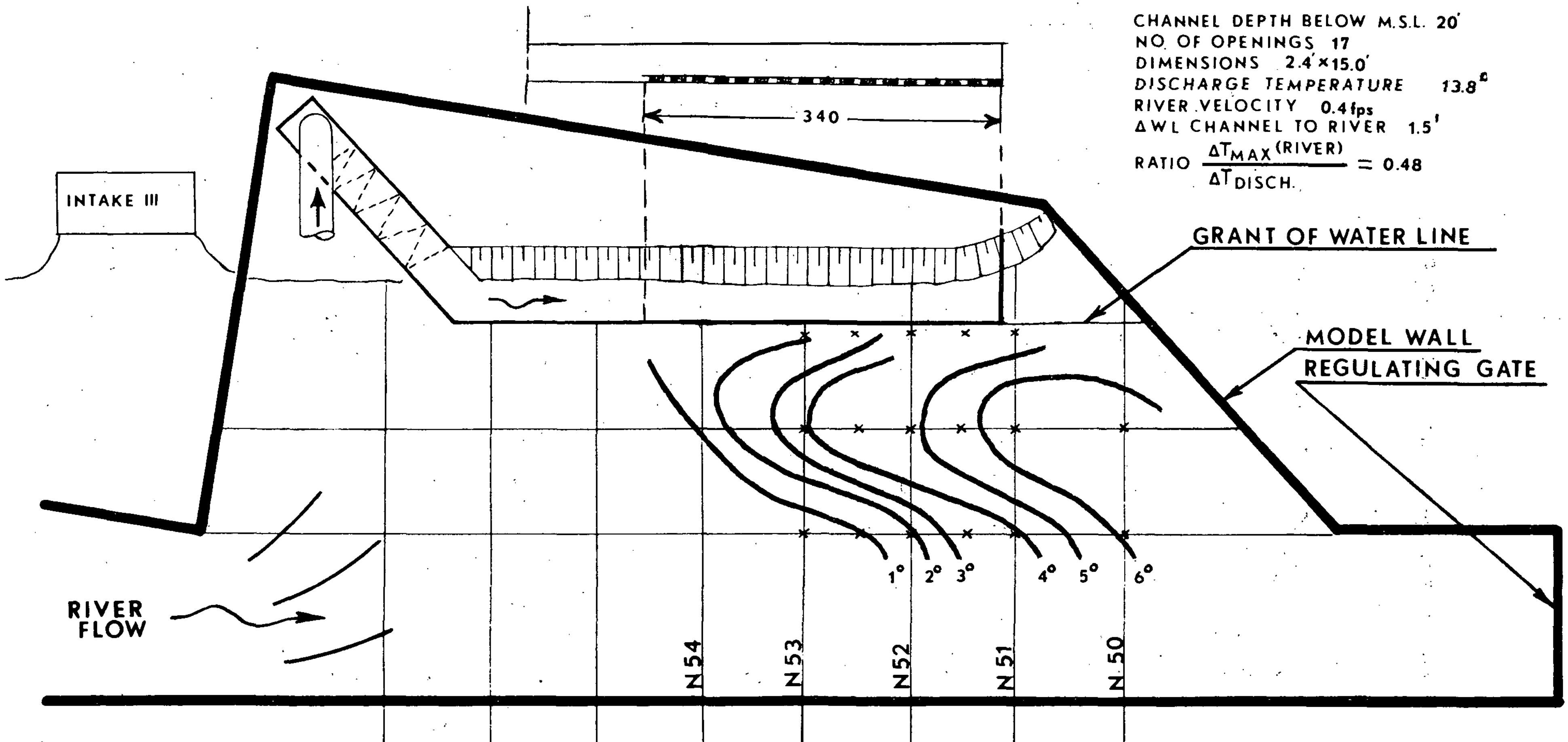
FIG. 5

OUTFALL CONFIGURATION



GUIDE VANES

x PROBE POSITION

ALDEN RESEARCH LABORATORIES
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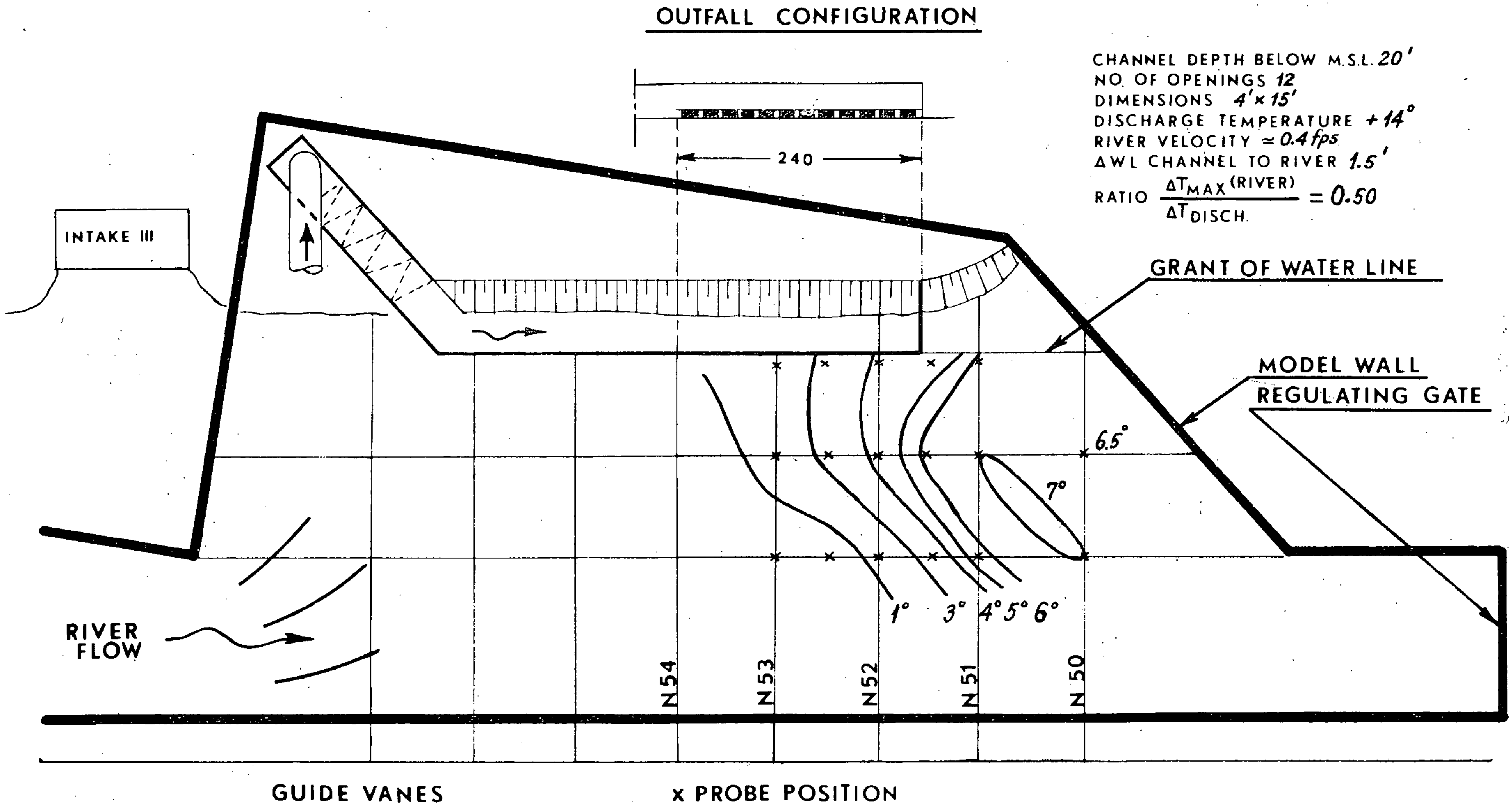
INDIAN POINT II SUB-MODEL
MODEL SCALE 1:50 (UNDISTORTED)
SURFACE ISOTHERMS
TEST DATE MAR '69



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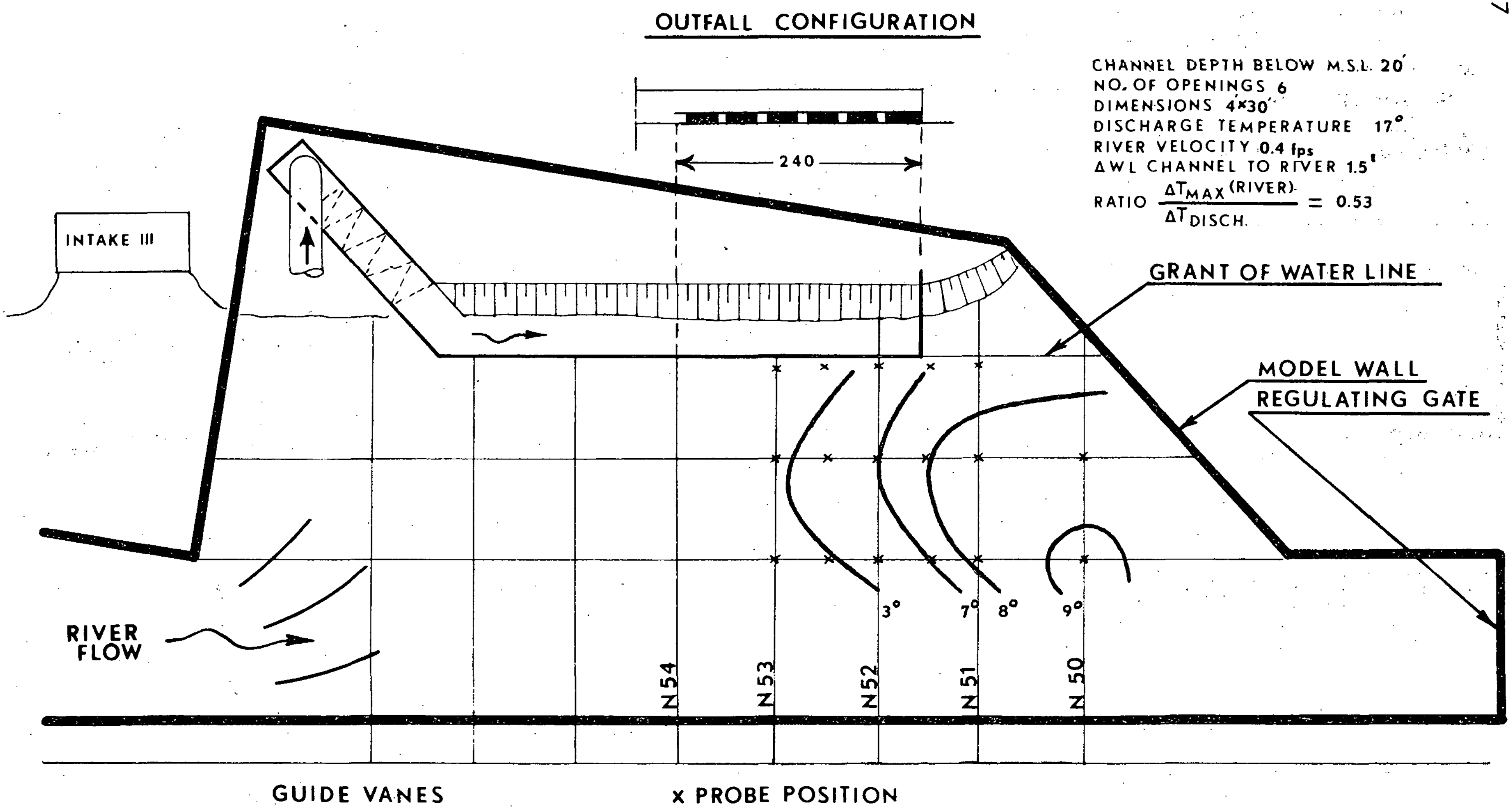
INDIAN POINT II SUB-MODEL
MODEL SCALE 1:50 (UNDISTORTED)
SURFACE ISOTHERMS
TEST DATE MAR '69

FIG. 6

FIG. 7



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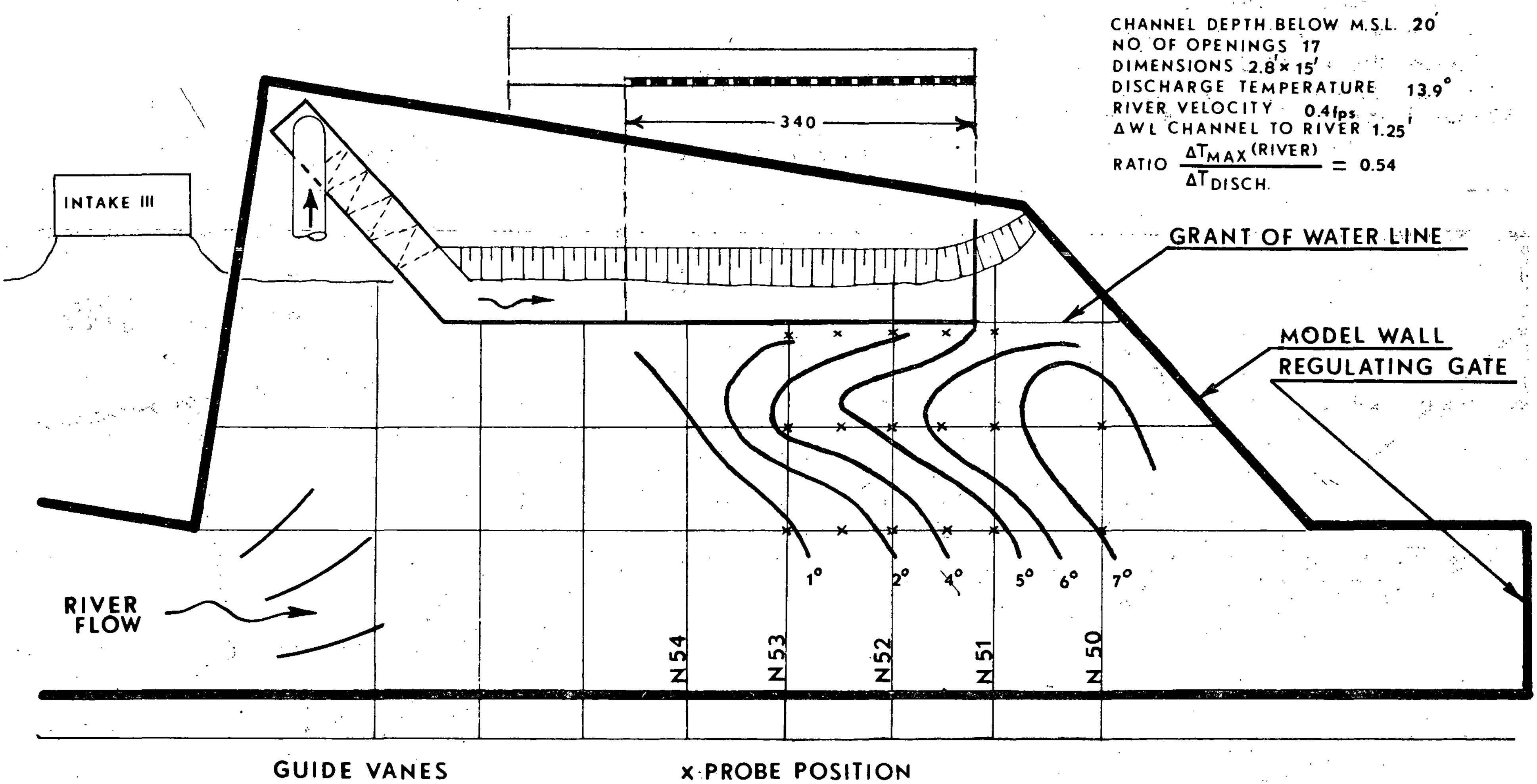
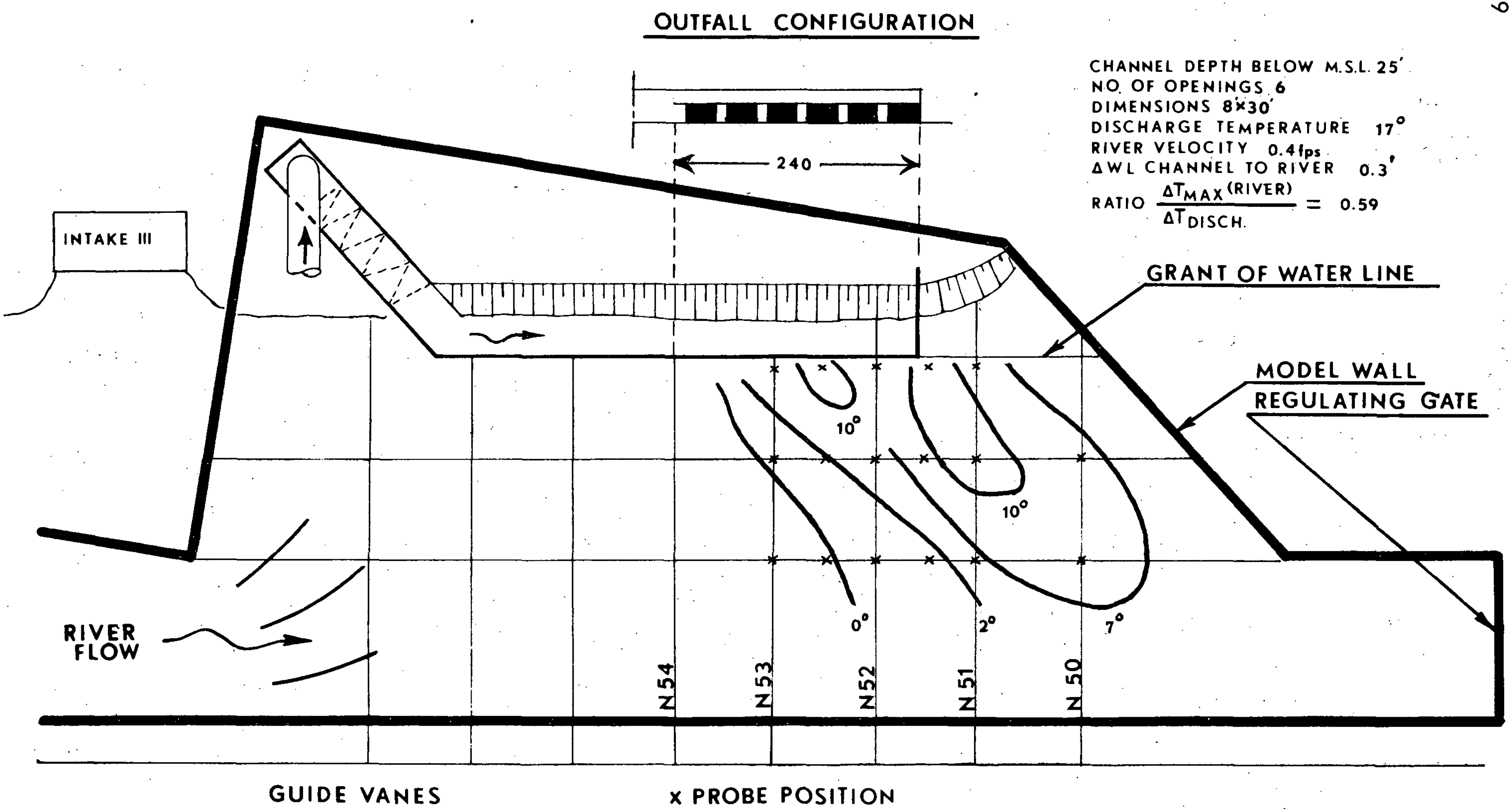
WORCESTER POLYTECHNIC INSTITUTE
INDIAN POINT II SUB-MODEL
MODEL SCALE 1:50 (UNDISTORTED)
SURFACE ISOTHERMS
TEST DATE AUG. '68

OUTFALL CONFIGURATION



ALDEN RESEARCH LABORATORIES
WORCESTER POLYTECHNIC INSTITUTE
INDIAN POINT II SUB-MODEL
MODEL SCALE 1:50 (UNDISTORTED)
SURFACE ISOTHERMS
TEST DATE MAR '69

FIG. 8



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INDIAN POINT II SUB-MODEL
MODEL SCALE 1:50 (UNDISTORTED)
SURFACE ISOTHERMS
TEST DATE OCT. '68

FIG. 9

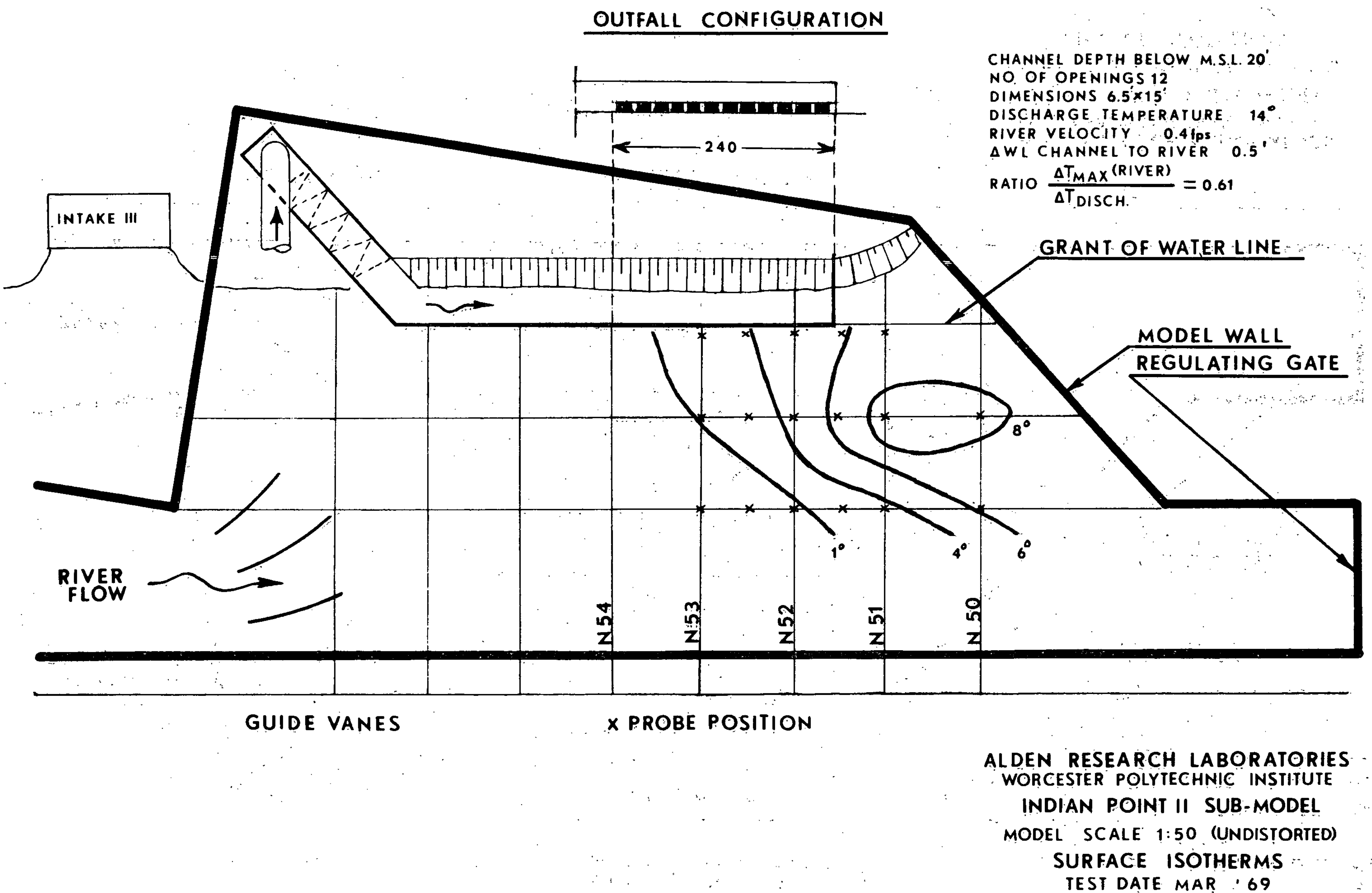
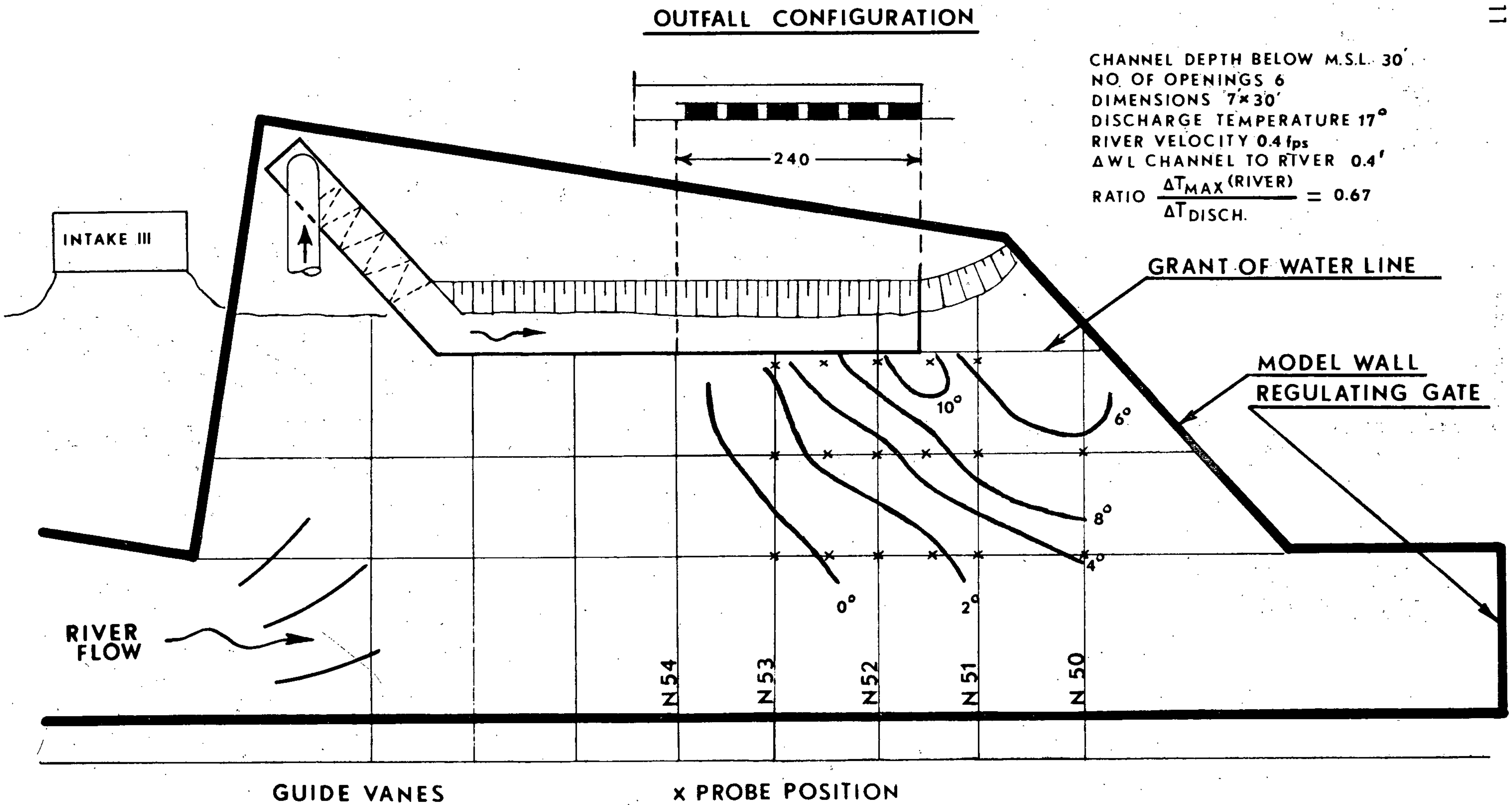

OUTFALL CONFIGURATION
CHANNEL DEPTH BELOW M.S.L. 20'
NO. OF OPENINGS 12
DIMENSIONS 6.5'x15'
DISCHARGE TEMPERATURE 14°
RIVER VELOCITY 0.4 fps
ΔWL CHANNEL TO RIVER 0.5'
RATIO ΔT MAX (RIVER) / ΔT DISCH. = 0.61
240
INTAKE III
GRANT OF WATER LINE
MODEL WALL
REGULATING GATE
8°
1°
4°
6°
RIVER FLOW
N 54
N 53
N 52
N 51
N 50
GUIDE VANES
x PROBE POSITION
ALDEN RESEARCH LABORATORIES
WORCESTER POLYTECHNIC INSTITUTE
INDIAN POINT II SUB-MODEL
MODEL SCALE 1:50 (UNDISTORTED)
SURFACE ISOTHERMS
TEST DATE MAR '69

FIG. 10

FIG. 11



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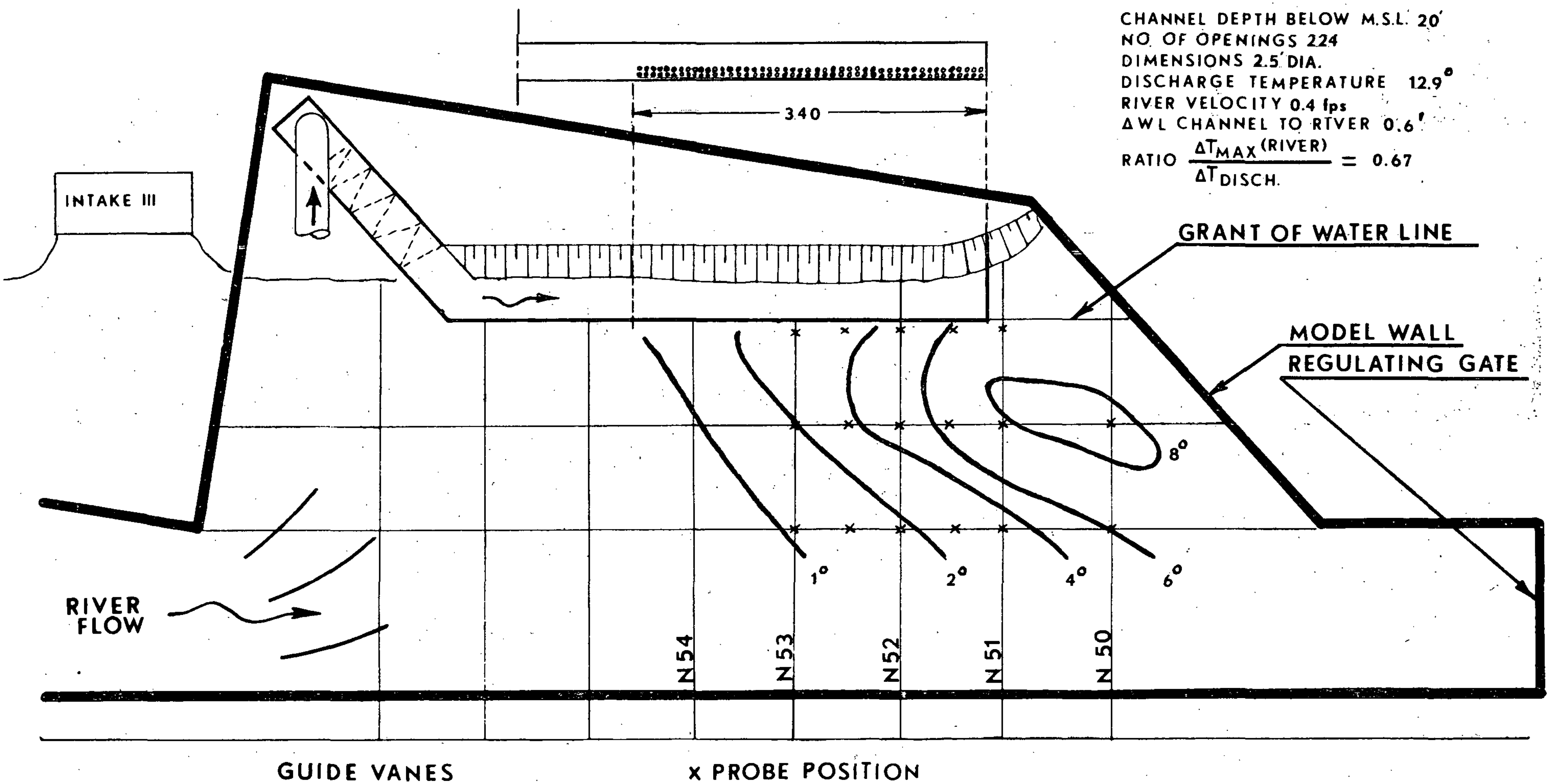
INDIAN POINT II SUB-MODEL

MODEL SCALE 1:50 (UNDISTORTED)

SURFACE ISOTHERMS

TEST DATE OCT. '68

OUTFALL CONFIGURATION



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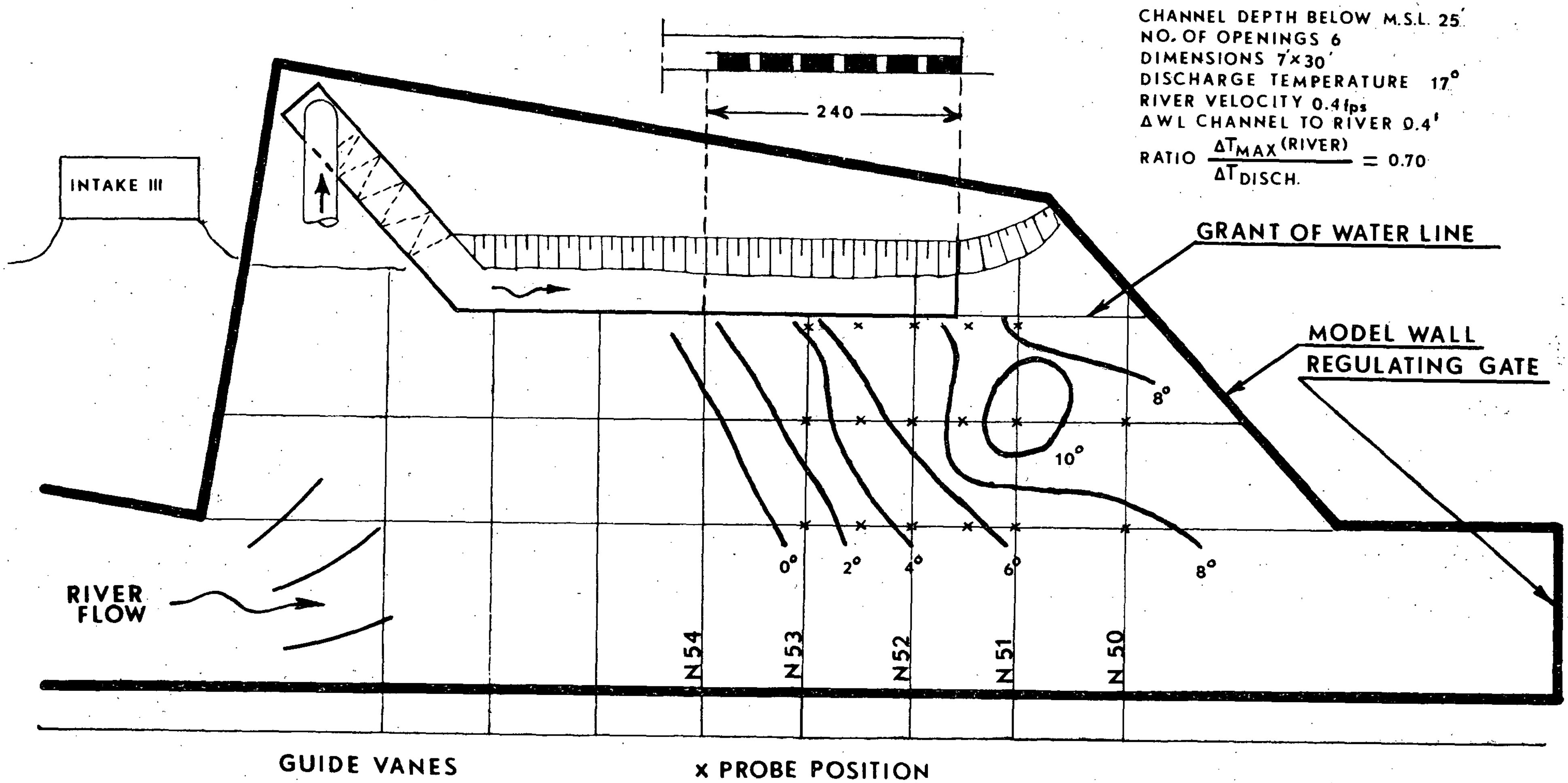
WORCESTER POLYTECHNIC INSTITUTE
INDIAN POINT II SUB-MODEL
MODEL SCALE 1:50 (UNDISTORTED)
SURFACE ISOTHERMS
TEST DATE MAR '69

FIG. 12

FIG. 13

OUTFALL CONFIGURATION



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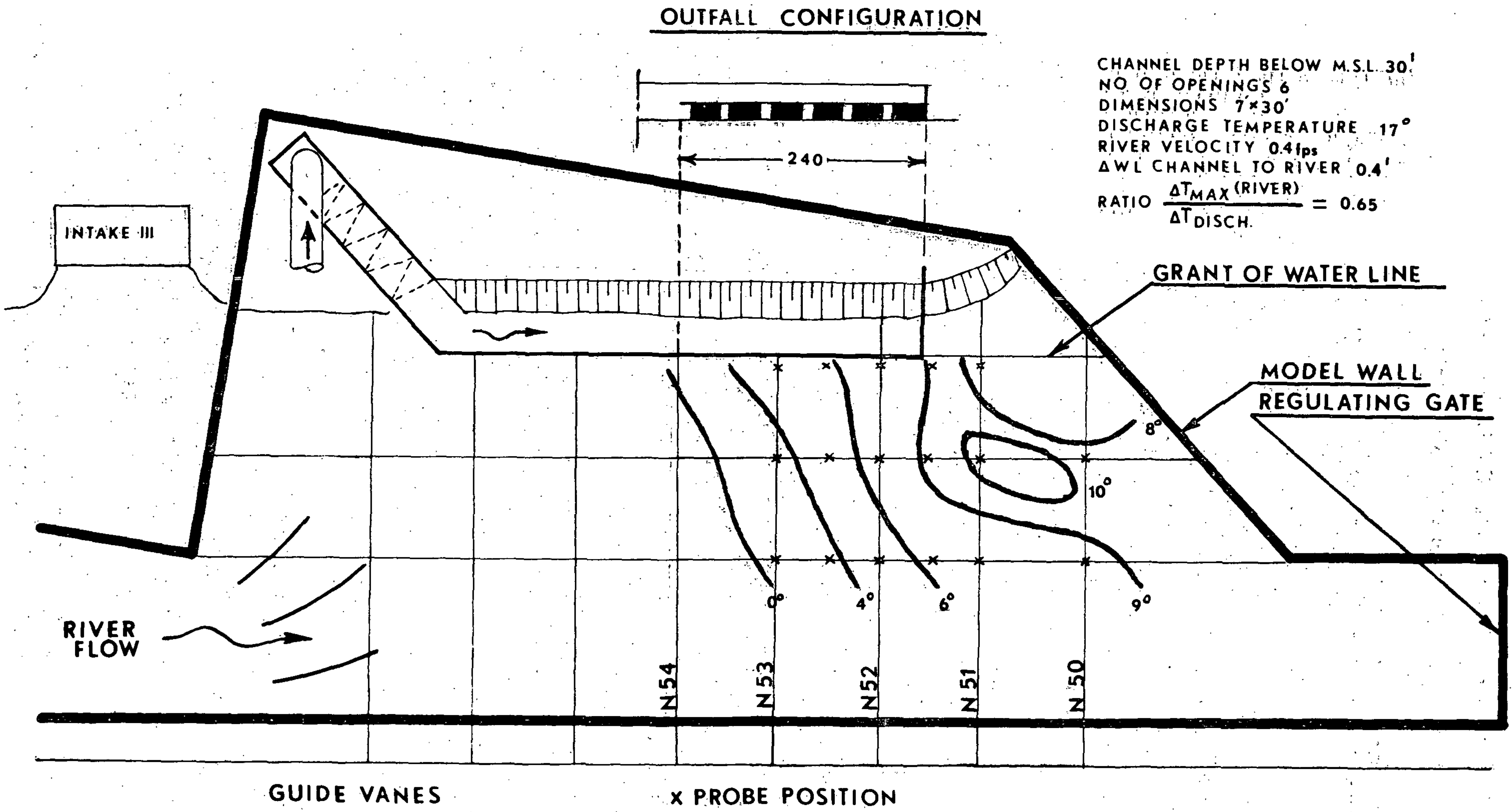
INDIAN POINT II SUB-MODEL
MODEL SCALE 1:50 (UNDISTORTED)
SURFACE ISOTHERMS
TEST DATE OCT. '68



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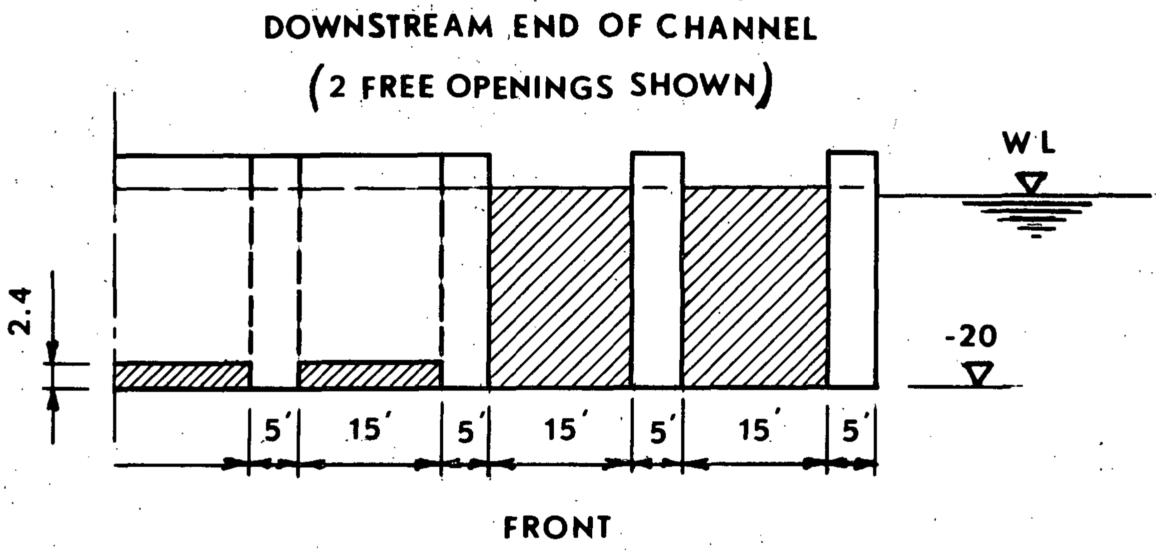
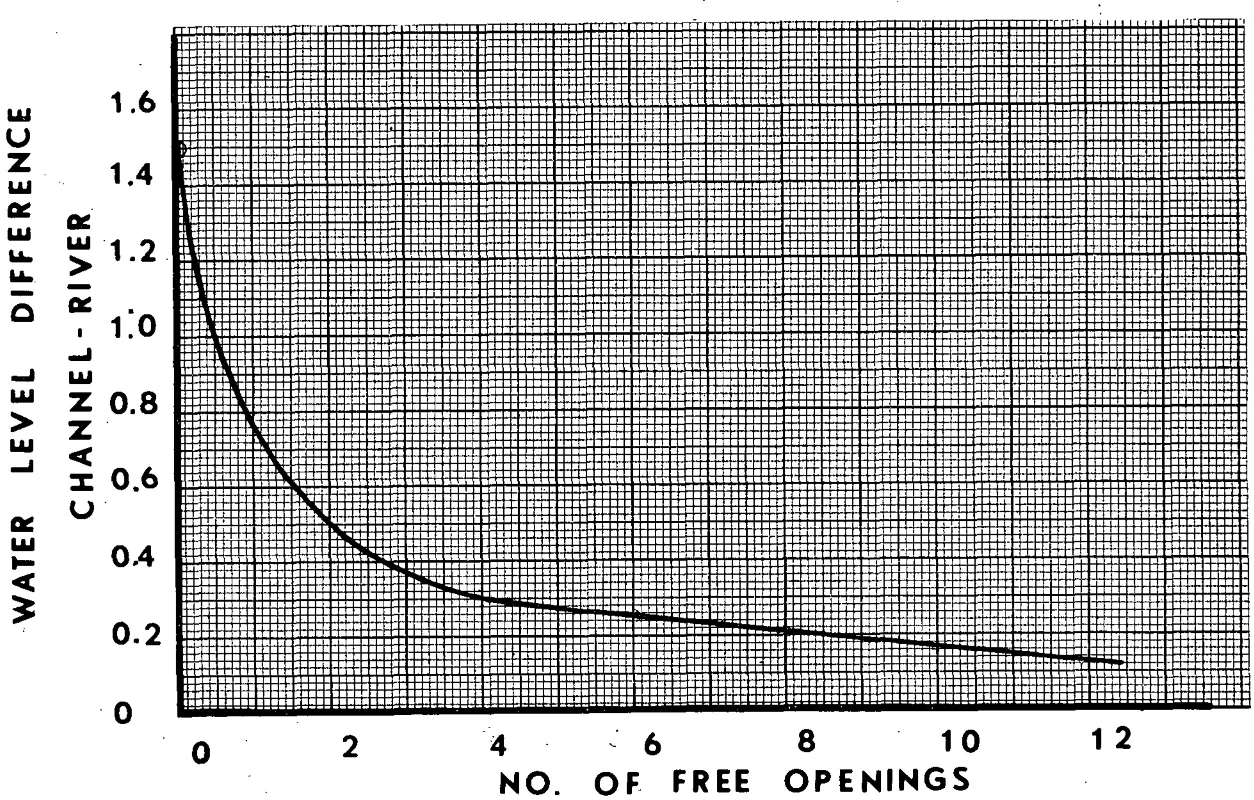
INDIAN POINT II SUB-MODEL
MODEL SCALE 1:50 (UNDISTORTED)
SURFACE ISOTHERMS
TEST DATE OCT. '68

FIG. 14

FIG. 15





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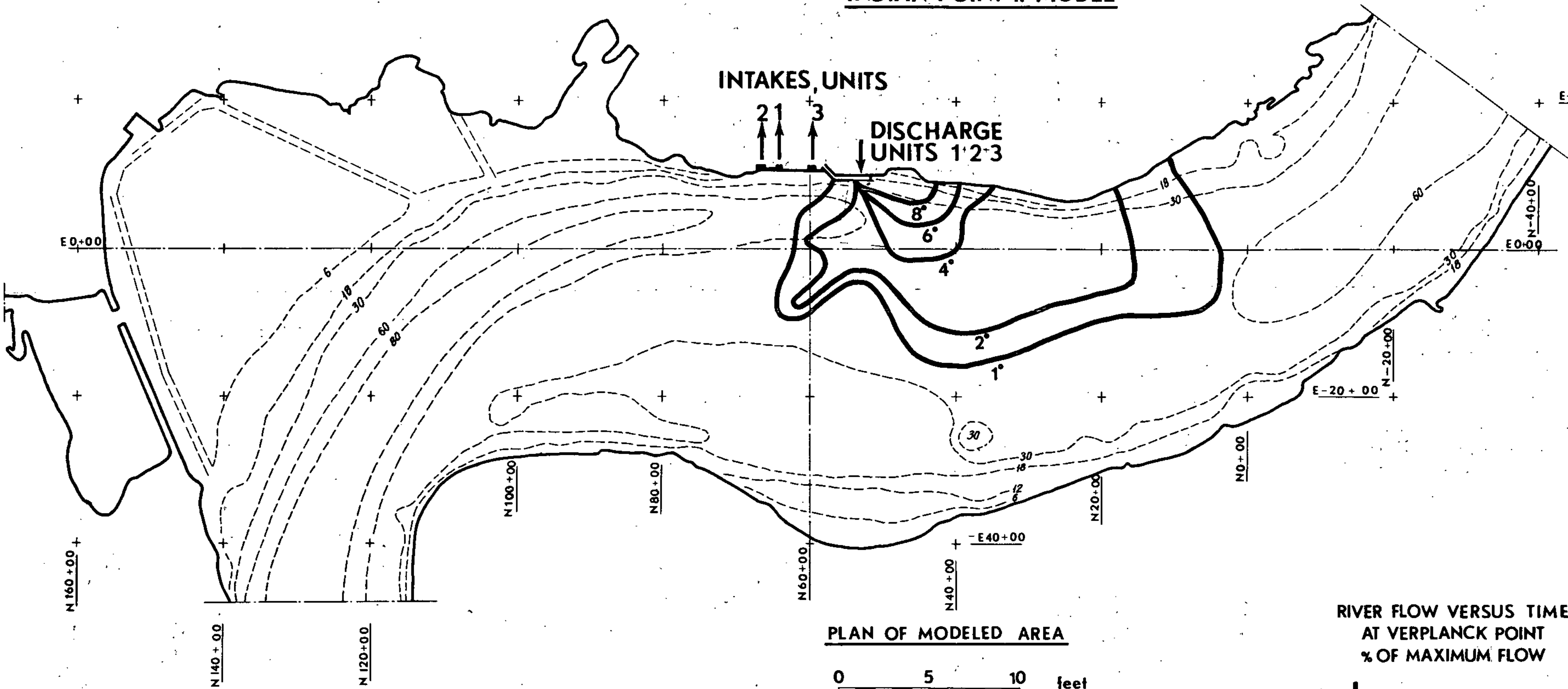
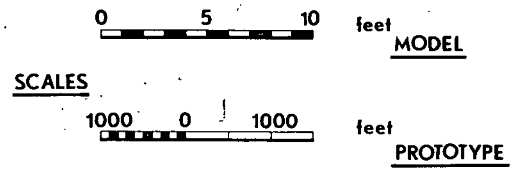
INDIAN POINT II SUB-MODEL

MODEL SCALE 1:50 (UNDISTORED)
WATER LEVEL DIFFERENCE CHANNEL - RIVER

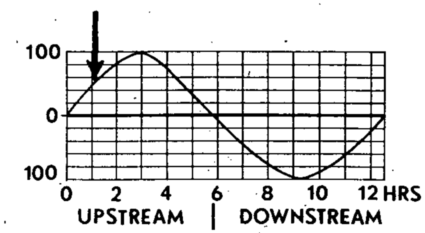
INDIAN POINT II MODEL



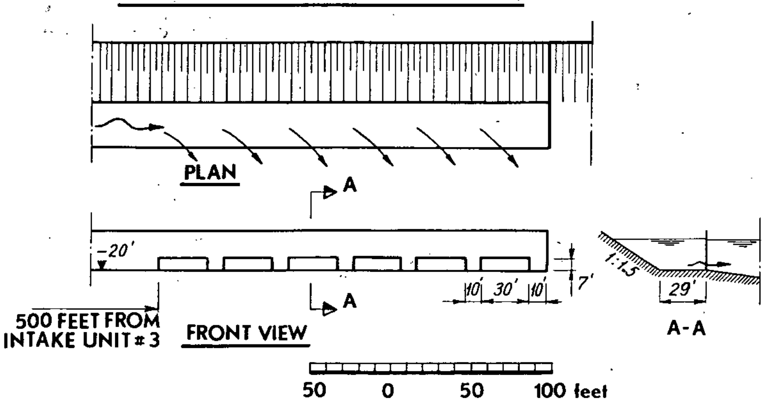
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 522 ; 26 NOV , 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 44 °F
AIR TEMPERATURE DRY BULB 46.4 °F
AIR TEMPERATURE WET BULB 39.5 °F
RELATIVE HUMIDITY 53 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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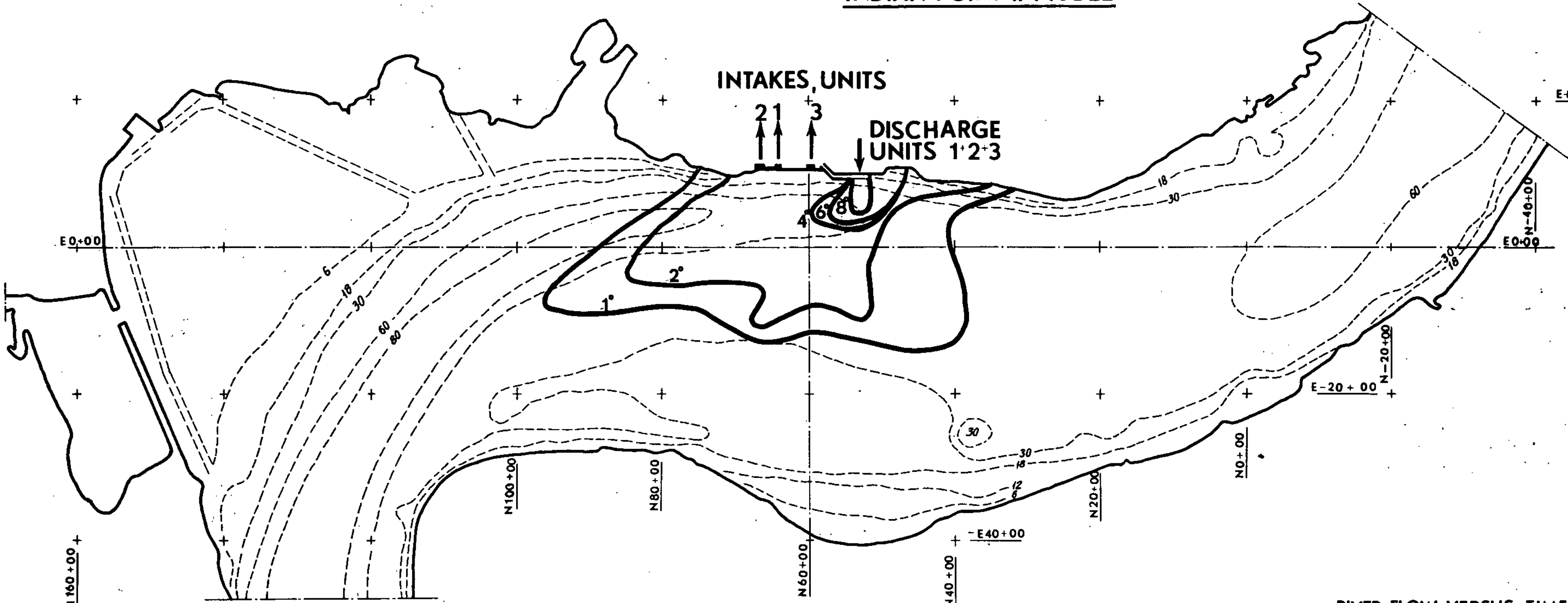
FIG. 16

FIG. 17

INDIAN POINT II MODEL



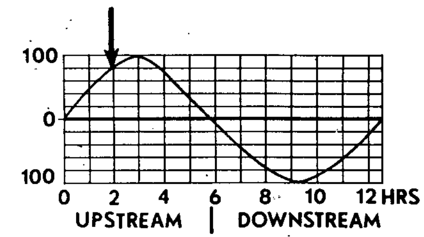
PLAN OF MODELED AREA

SCALES

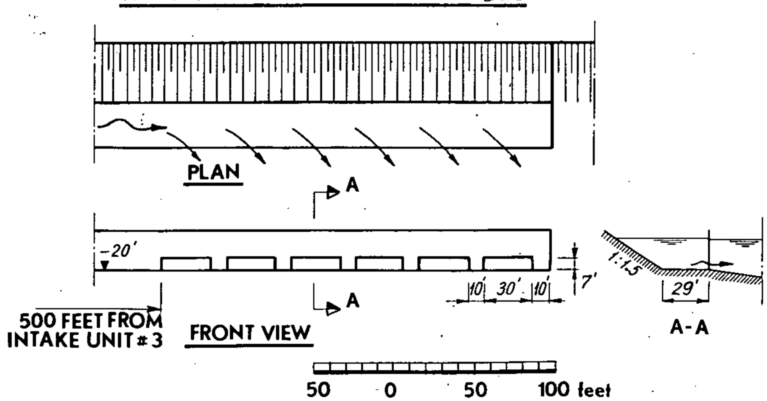
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 522 ; 26, NOV ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 44 °F
AIR TEMPERATURE DRY BULB 46.4 °F
AIR TEMPERATURE WET BULB 39.5 °F
RELATIVE HUMIDITY 53 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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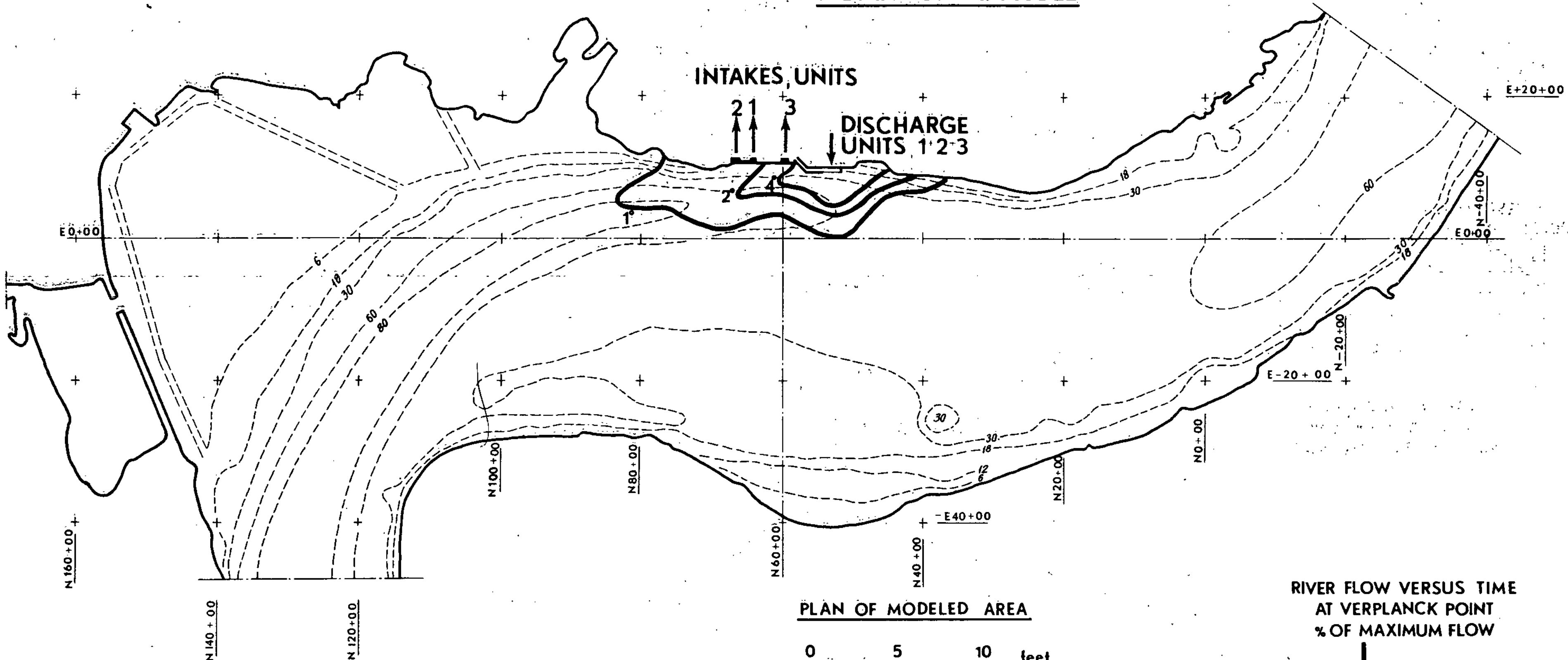
INDIAN POINT II MODEL



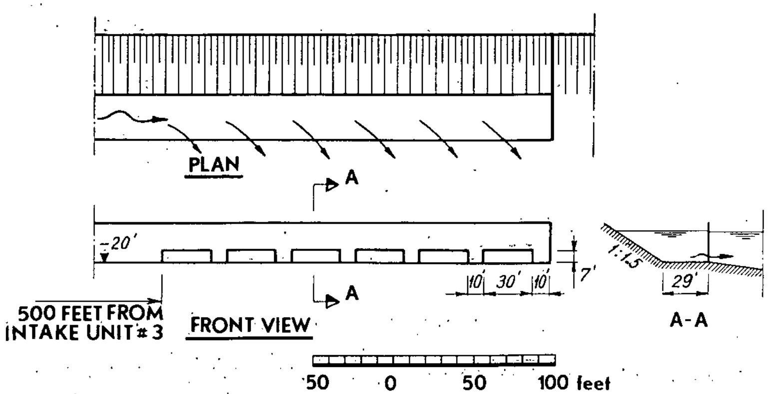
PLAN OF MODELED AREA

SCALES

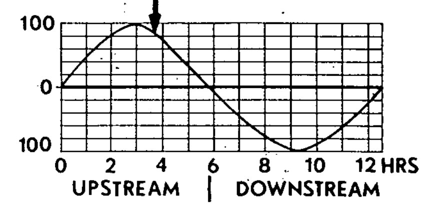
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 522 ; 26, NOV , 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 44 °F
AIR TEMPERATURE DRY BULB 46.4 °F
AIR TEMPERATURE WET BULB 39.5 °F
RELATIVE HUMIDITY 53 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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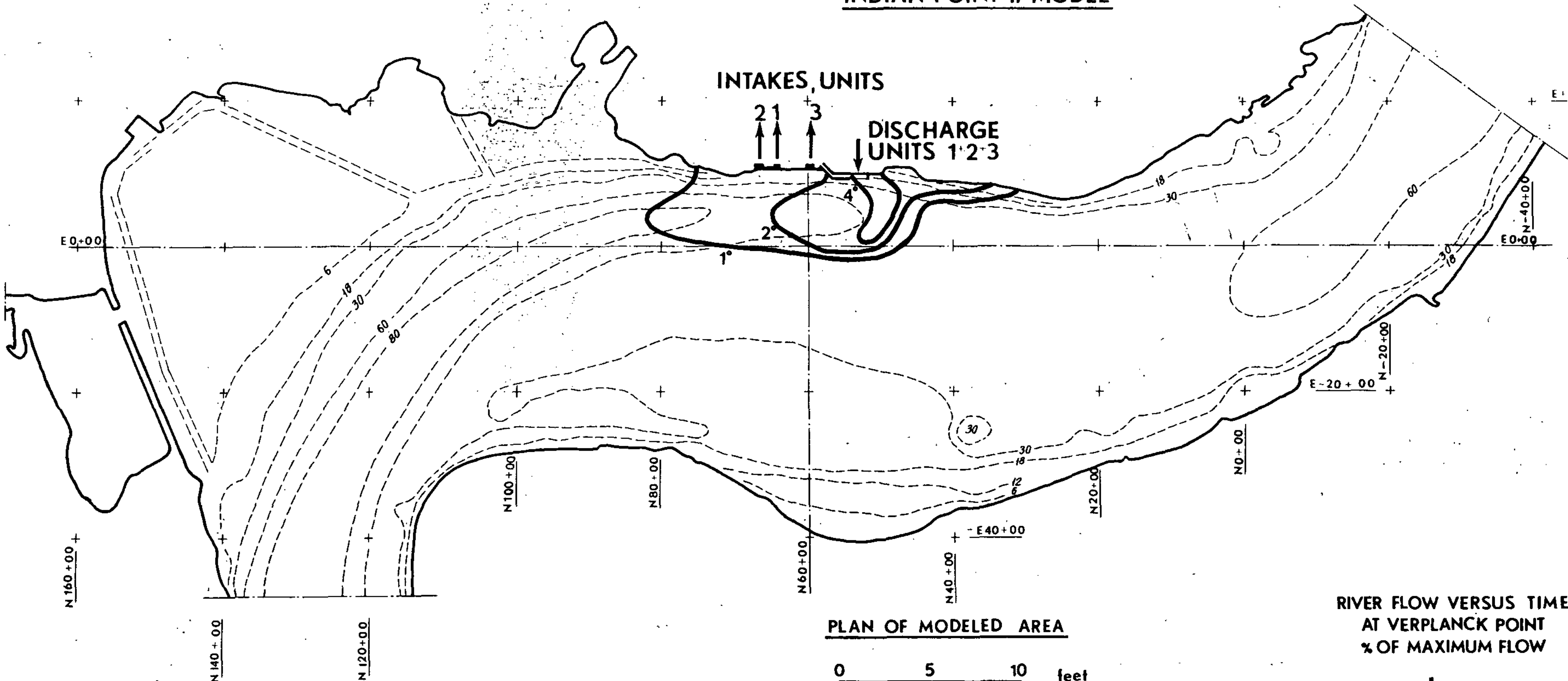
FIG. 18

FIG. 19

INDIAN POINT II MODEL



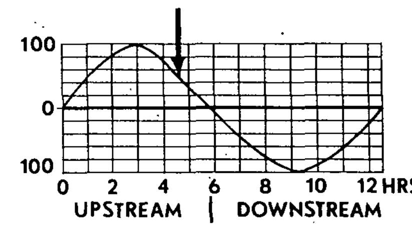
PLAN OF MODELED AREA

SCALES

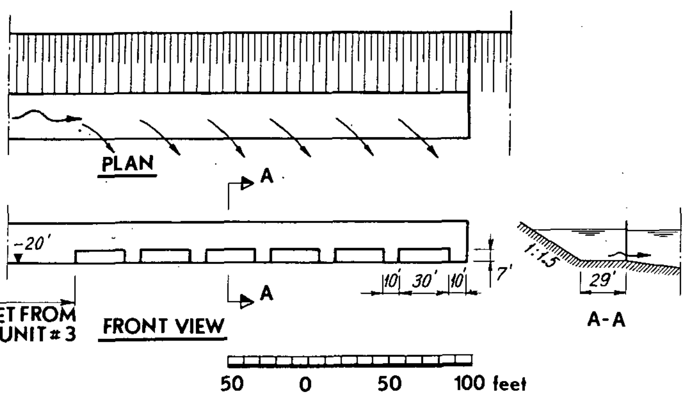
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 522 ; 26 NOV, 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 44 °F
AIR TEMPERATURE DRY BULB 46.4°F
AIR TEMPERATURE WET BULB 35.9°F
RELATIVE HUMIDITY 53 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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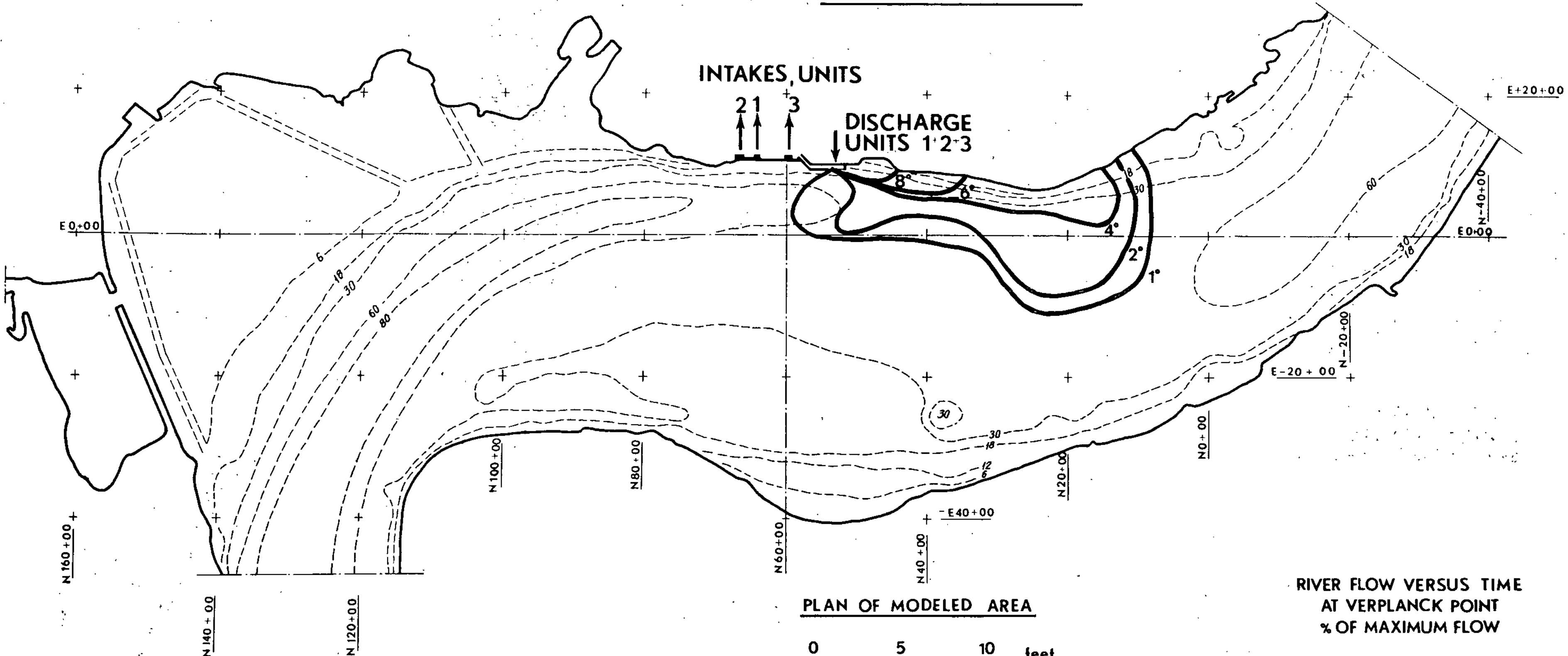
INDIAN POINT II MODEL



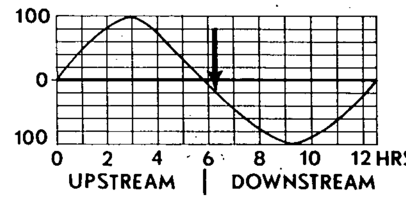
PLAN OF MODELED AREA

SCALES

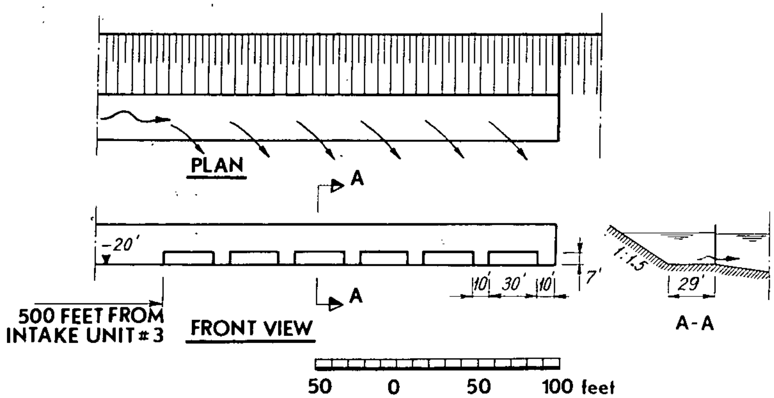
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 522 ; 26 NOV ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 44 °F
AIR TEMPERATURE DRY BULB 46.4 °F
AIR TEMPERATURE WET BULB 39.5 °F
RELATIVE HUMIDITY 53 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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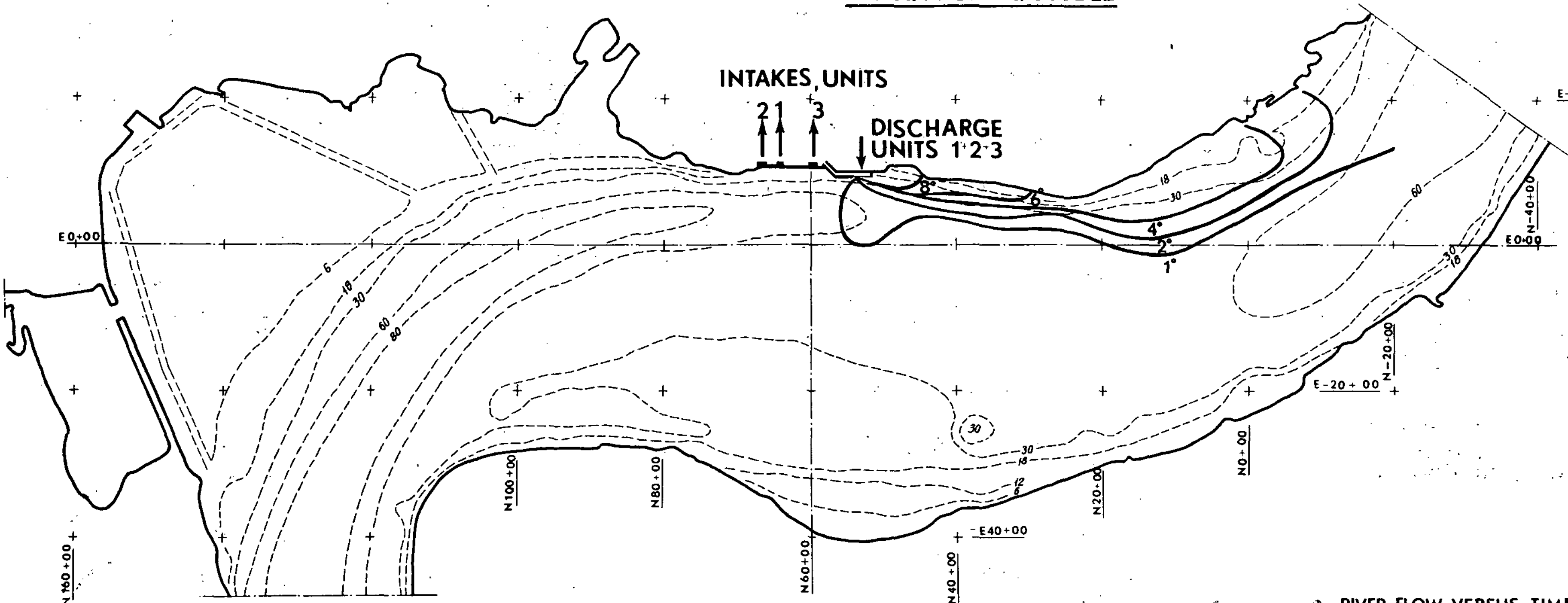
FIG. 20

INDIAN POINT II MODEL



N 140+00 N 120+00

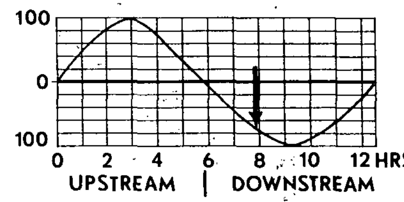
PLAN OF MODELED AREA

SCALES

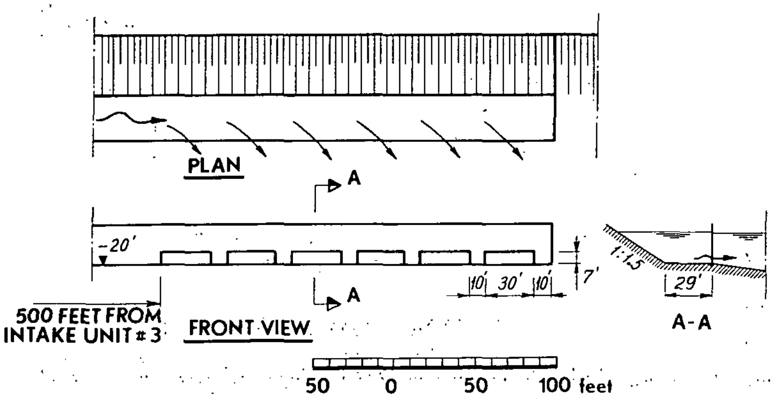
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 522 ; 26 NOV ,1968
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DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 44 °F
AIR TEMPERATURE DRY BULB 46.4°F
AIR TEMPERATURE WET BULB 39.5°F
RELATIVE HUMIDITY 53 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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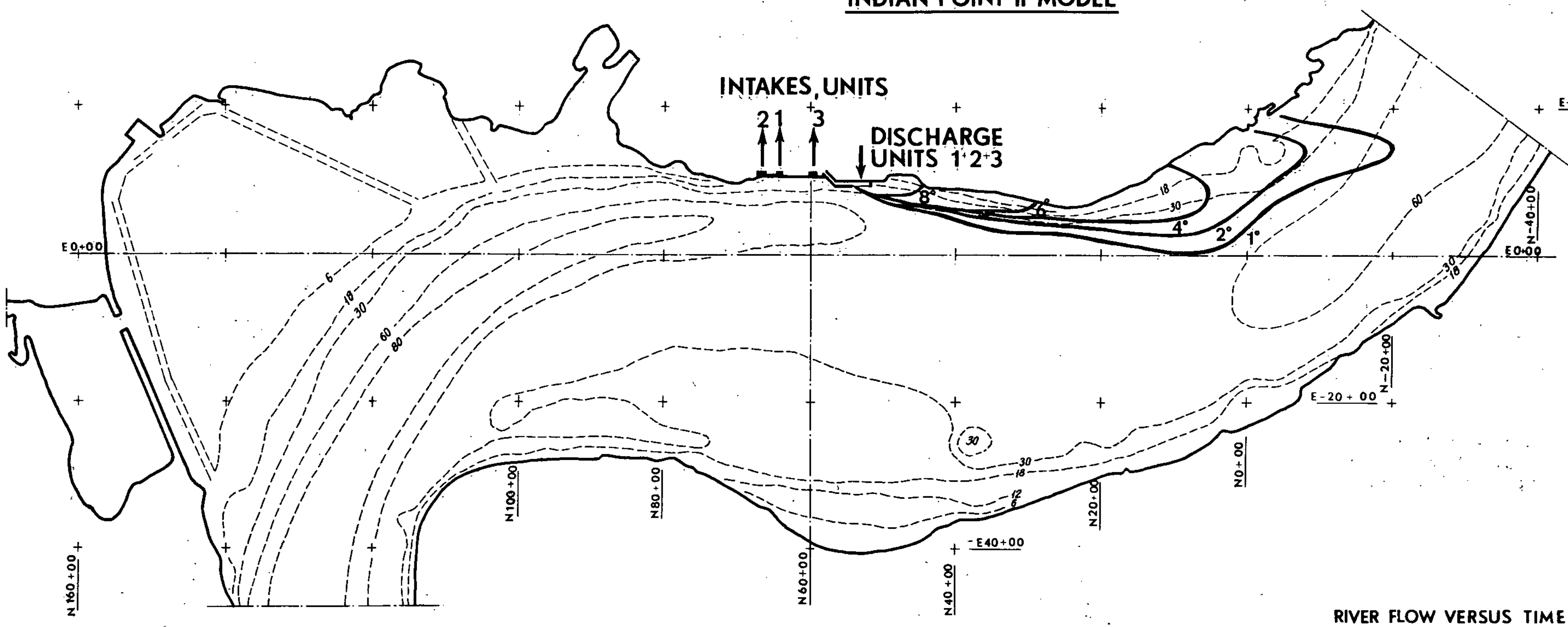
INDIAN POINT II MODEL



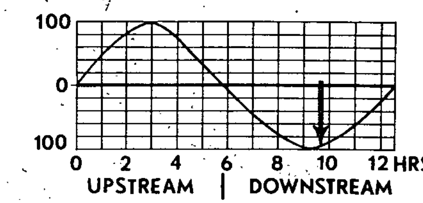
PLAN OF MODELED AREA

SCALES

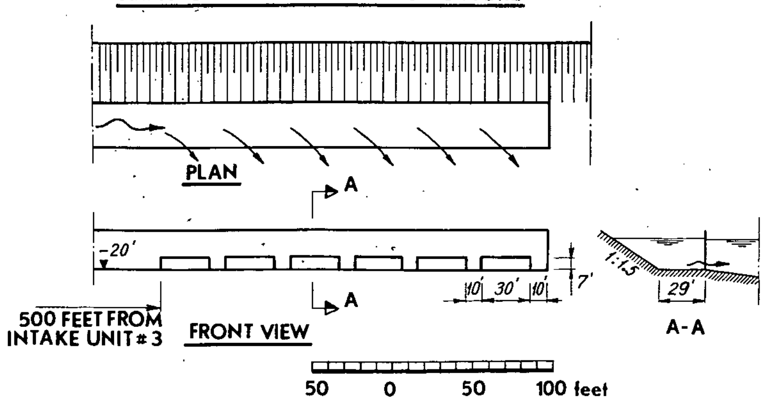
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 522 ; 26 NOV ,1968
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AIR TEMPERATURE DRY BULB 46.4 °F
AIR TEMPERATURE WET BULB 39.5 °F
RELATIVE HUMIDITY 53%
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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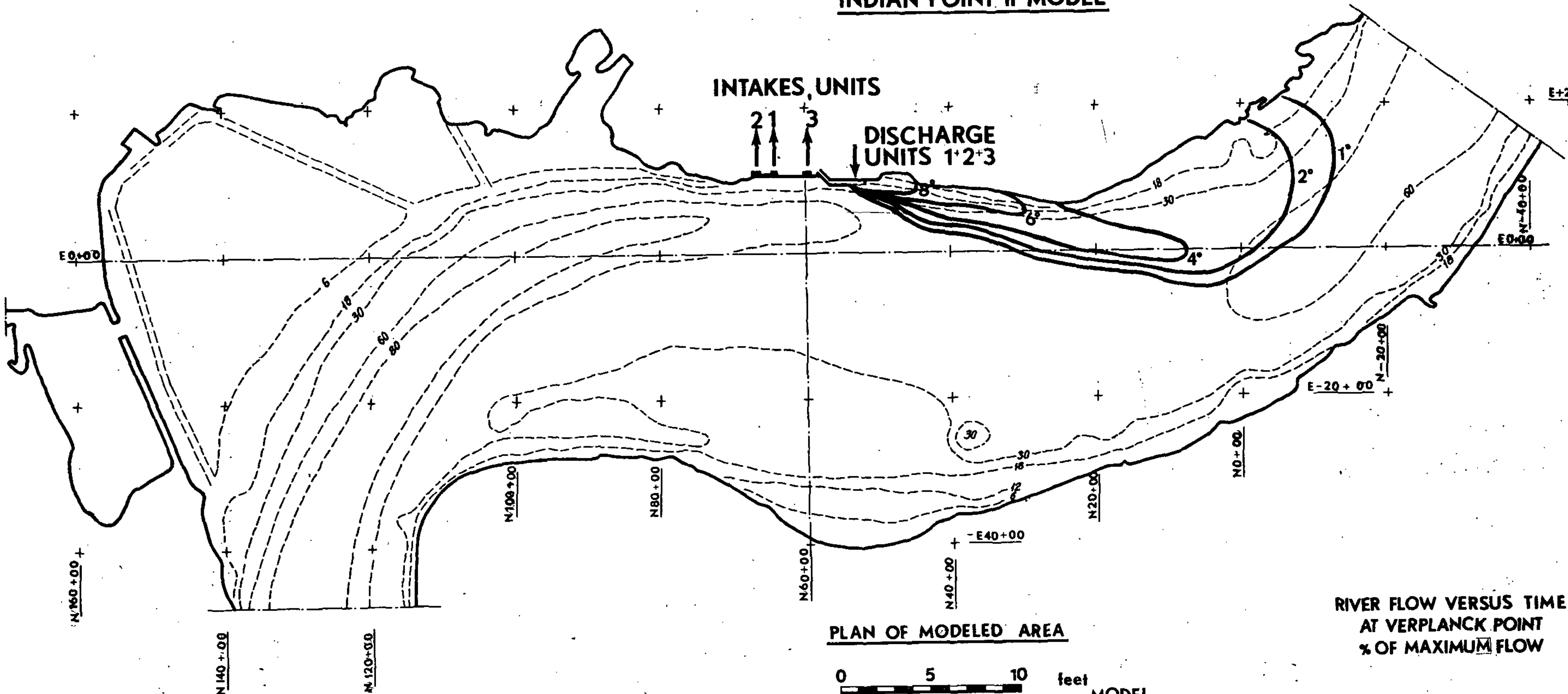
FIG. 22

FIG. 23

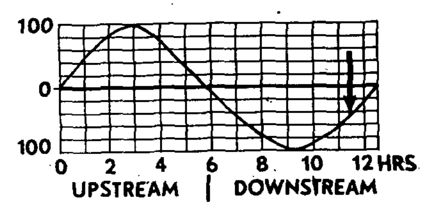
INDIAN POINT II MODEL

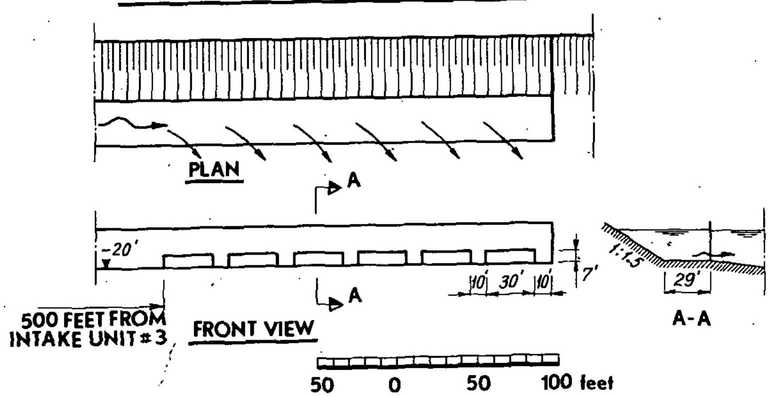


SCALES

0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE





TEST CONDITIONS

TEST NUMBER AND DATE 522 ; 26 NOV , 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 44°F
AIR TEMPERATURE DRY BULB 46.4°F
AIR TEMPERATURE WET BULB 39.5°F
RELATIVE HUMIDITY 53%
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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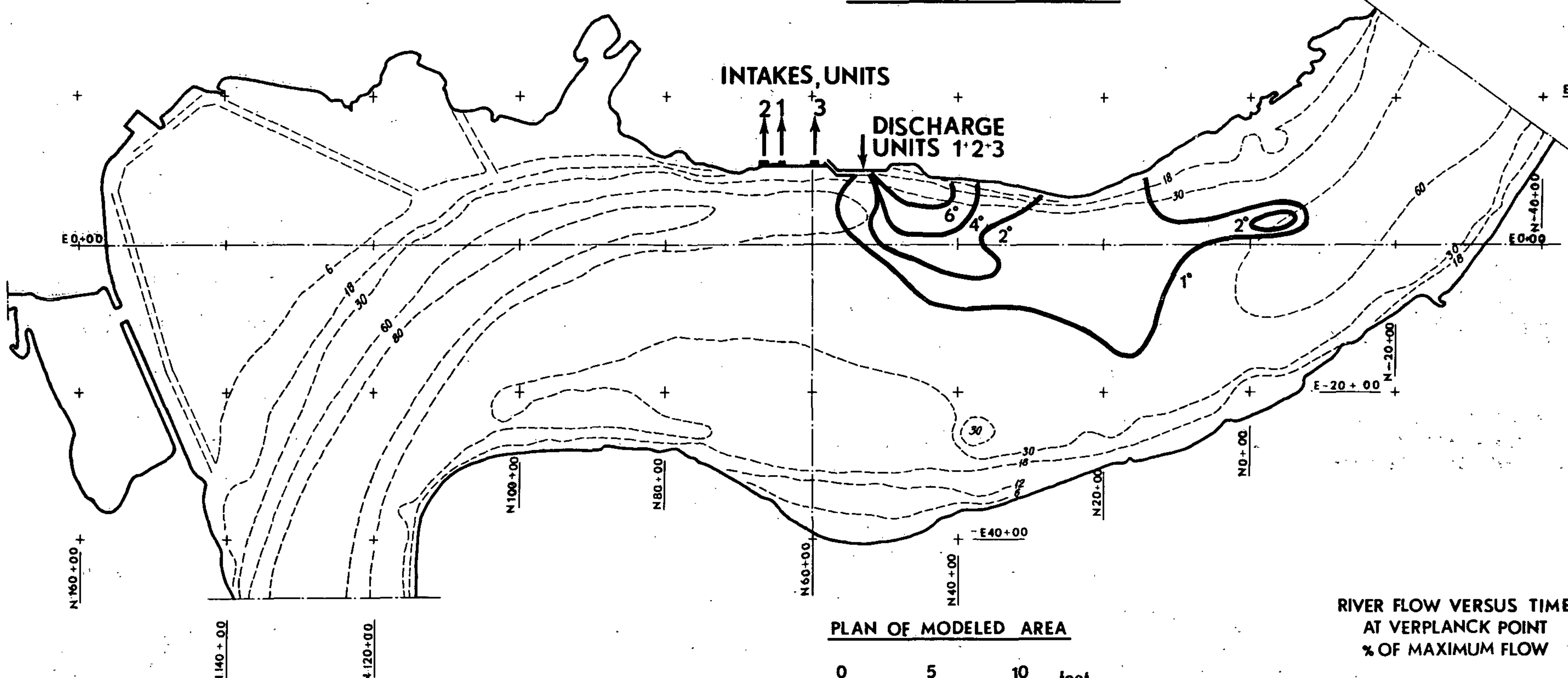
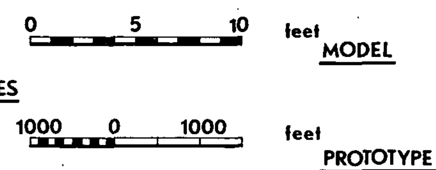
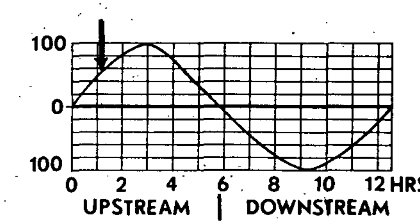
INDIAN POINT II MODEL



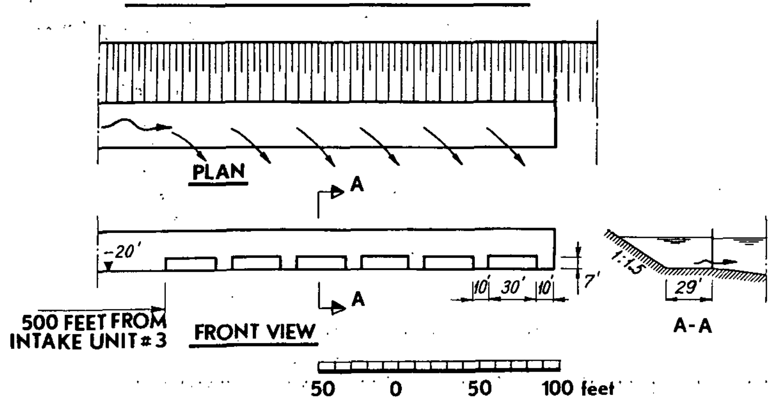
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 525 ; NOV 27 , 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 50 °F
AIR TEMPERATURE DRY BULB 55 °F
AIR TEMPERATURE WET BULB 49 °F
RELATIVE HUMIDITY 62%
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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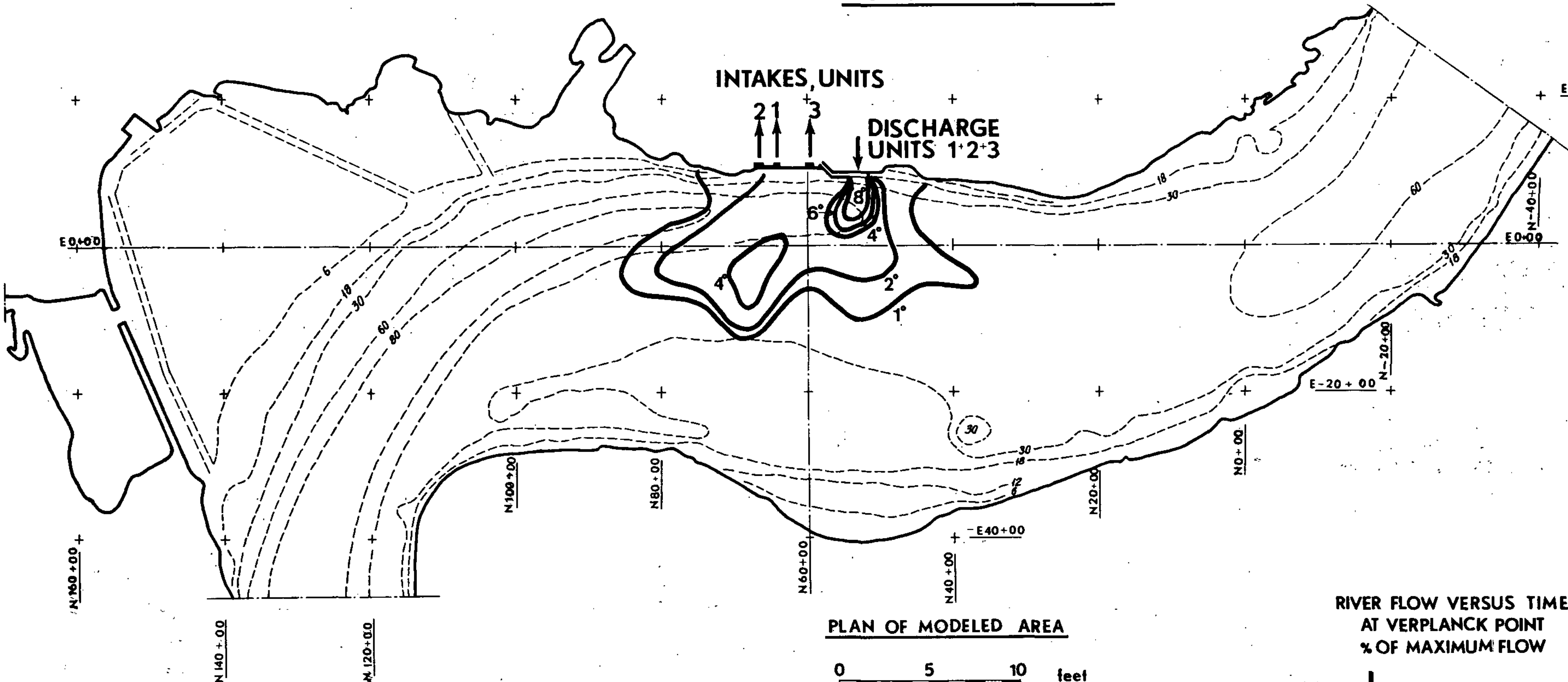
FIG. 24

INDIAN POINT II MODEL



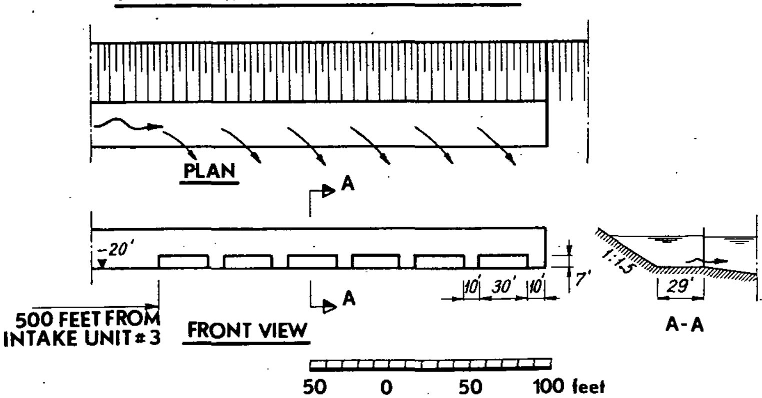
PLAN OF MODELED AREA

SCALES

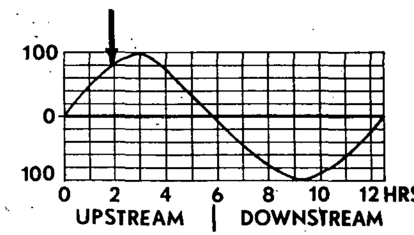
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 525 ; NOV 27 ,1968
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TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE DRY BULB 55 °F
AIR TEMPERATURE WET BULB 49 °F
RELATIVE HUMIDITY 62 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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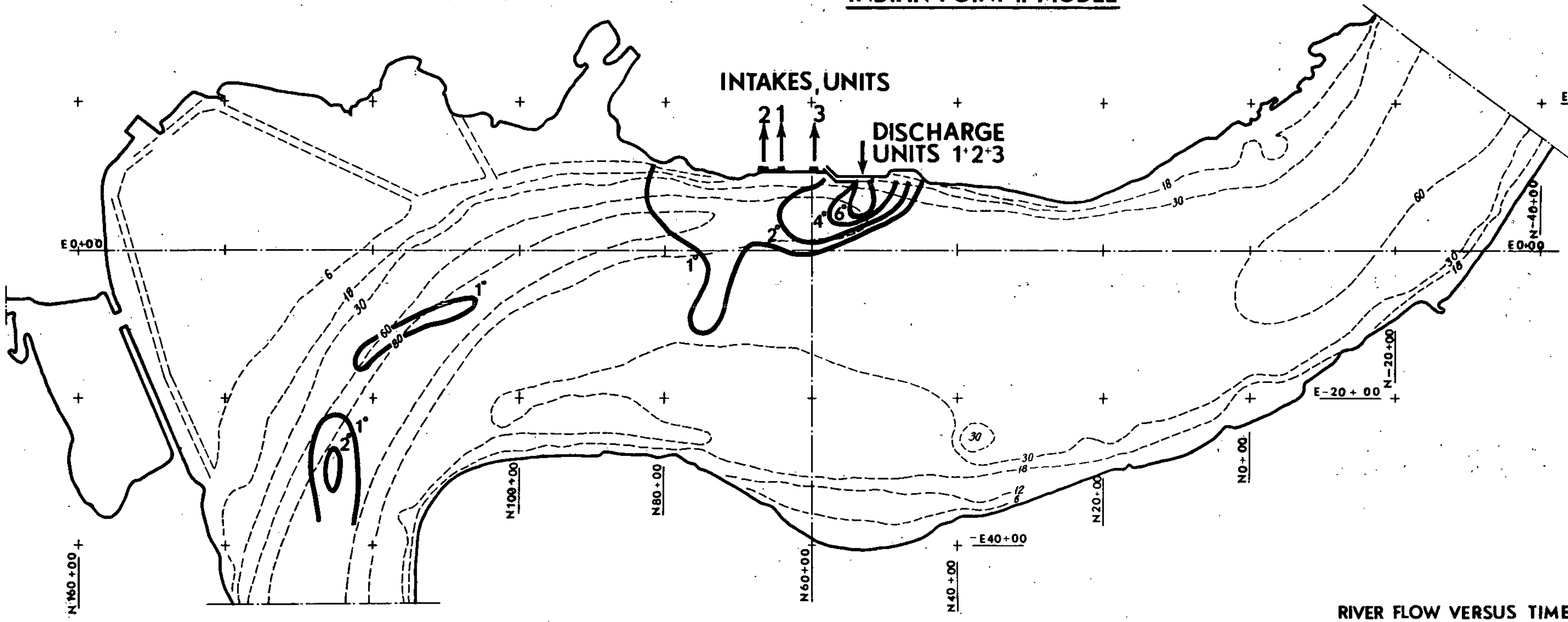
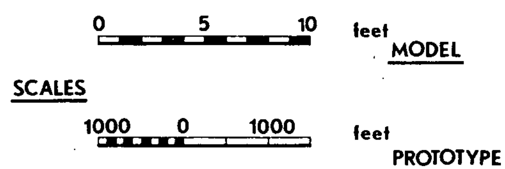
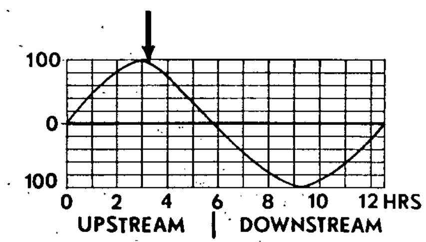
INDIAN POINT II MODEL



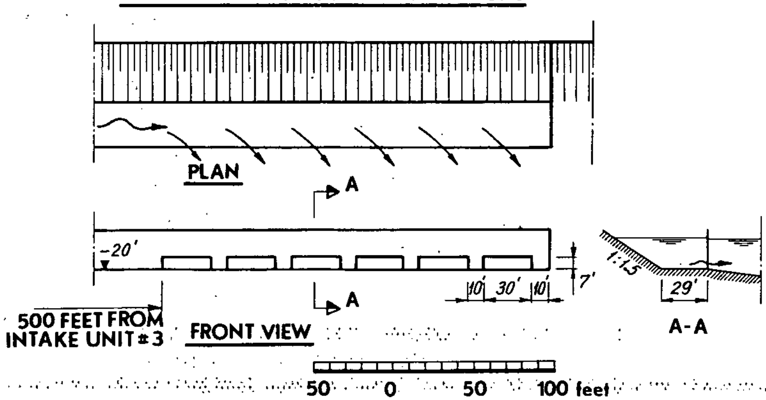
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 525 ; NOV 27, 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 50 °F
AIR TEMPERATURE DRY BULB 55 °F
AIR TEMPERATURE WET BULB 49 °F
RELATIVE HUMIDITY 62 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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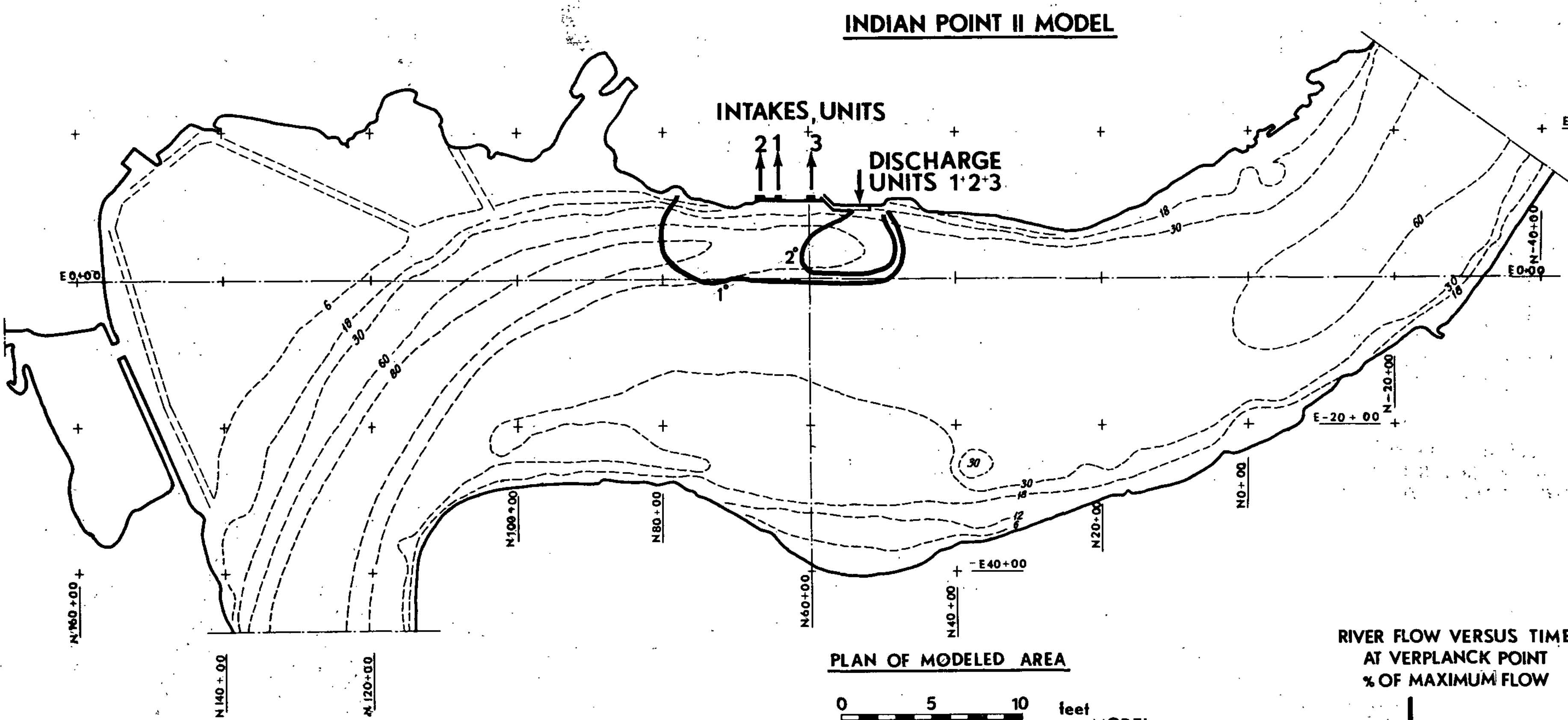
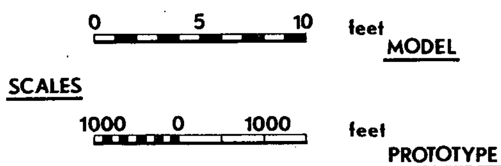
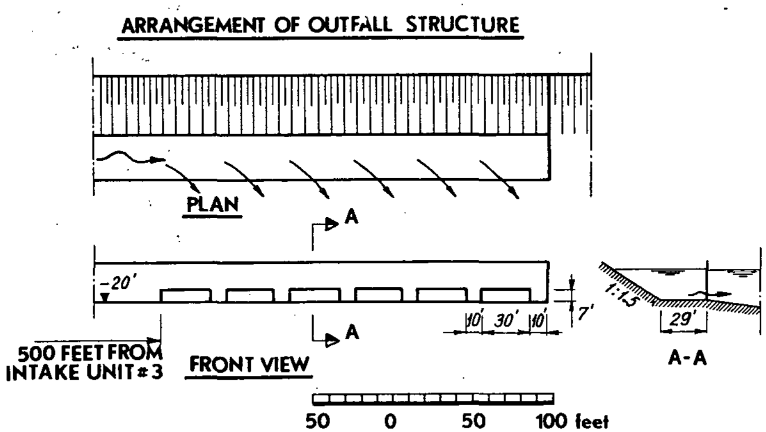
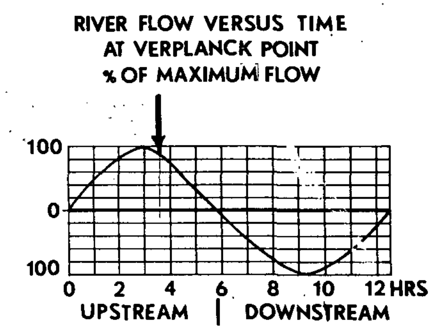
FIG. 26

FIG. 27









TEST CONDITIONS

TEST NUMBER AND DATE 525, NOV 27, 1968
UNITS OPERATING AND DISCHARGE 1,2,3; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 50°F
AIR TEMPERATURE DRY BULB 55°F
AIR TEMPERATURE WET BULB 49°F
RELATIVE HUMIDITY 62 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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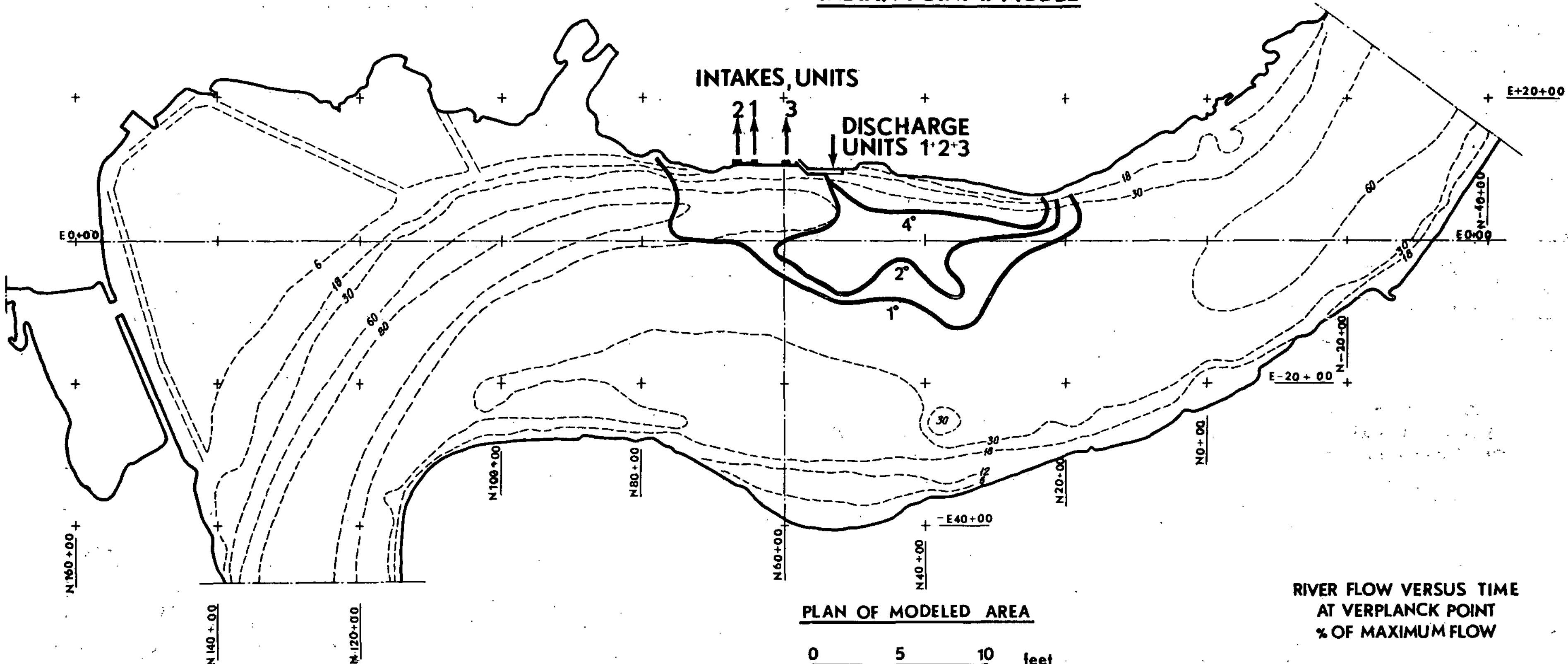
INDIAN POINT II MODEL



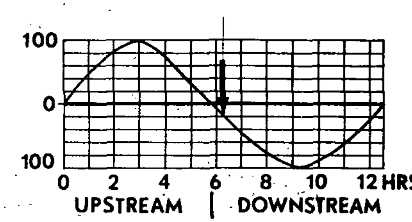
PLAN OF MODELED AREA

SCALES

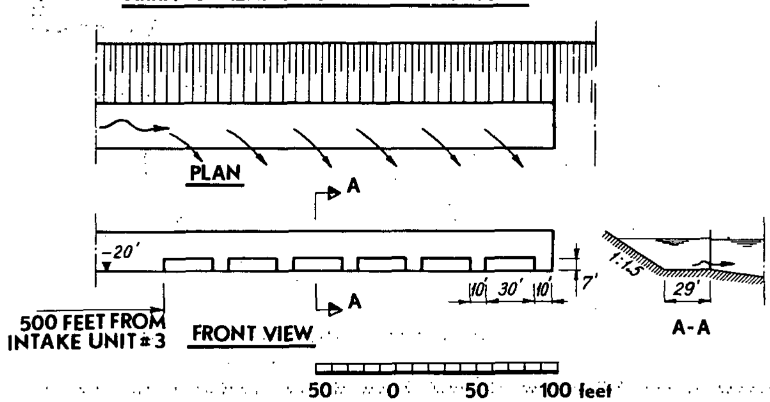
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 525 ; NOV 27 ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 50 °F
AIR TEMPERATURE DRY BULB 55 °F
AIR TEMPERATURE WET BULB 49 °F
RELATIVE HUMIDITY 62 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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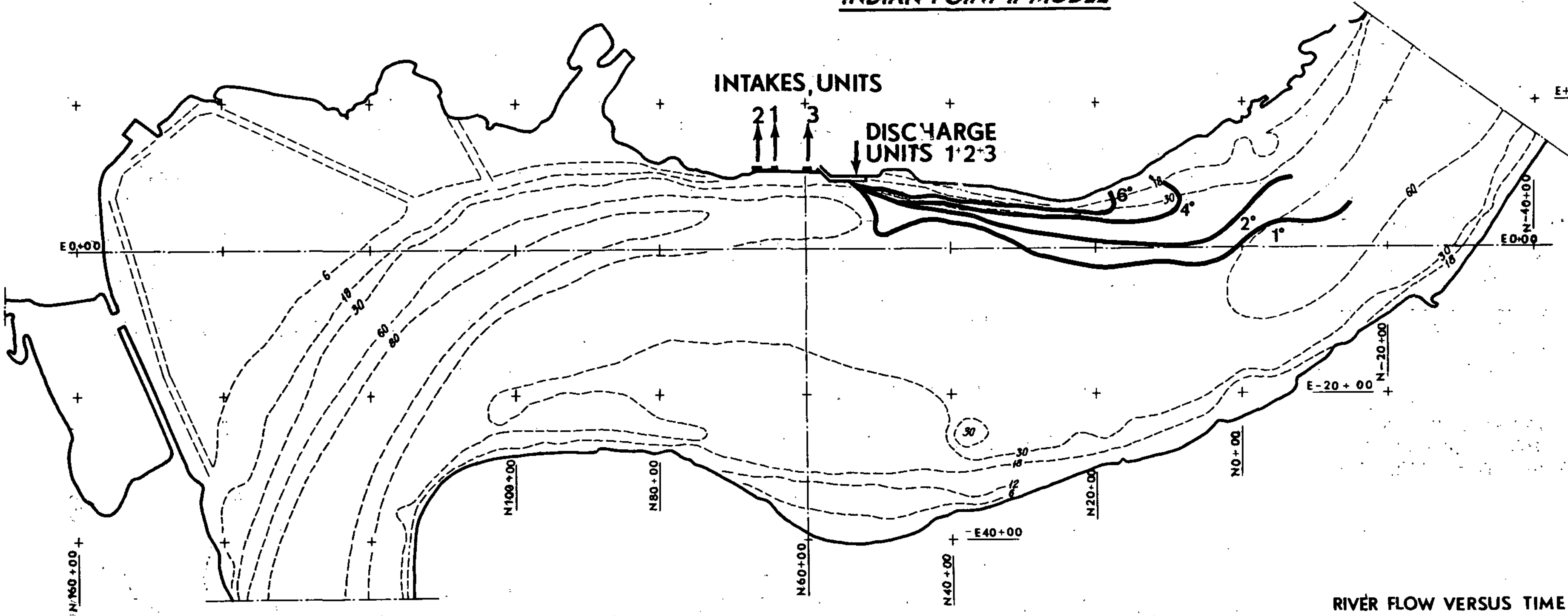
FIG. 28

FIG. 29

INDIAN POINT II MODEL



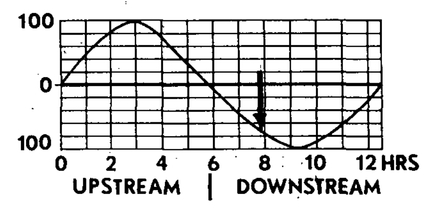
PLAN OF MODELED AREA

SCALES

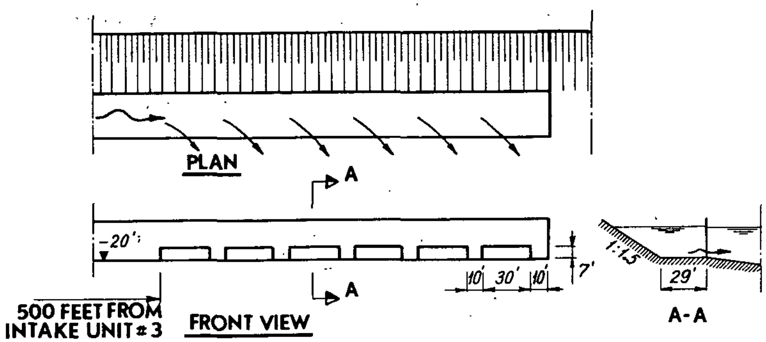
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 525 ; NOV 27 ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 50 °F
AIR TEMPERATURE DRY BULB 55 °F
AIR TEMPERATURE WET BULB 49 °F
RELATIVE HUMIDITY 62 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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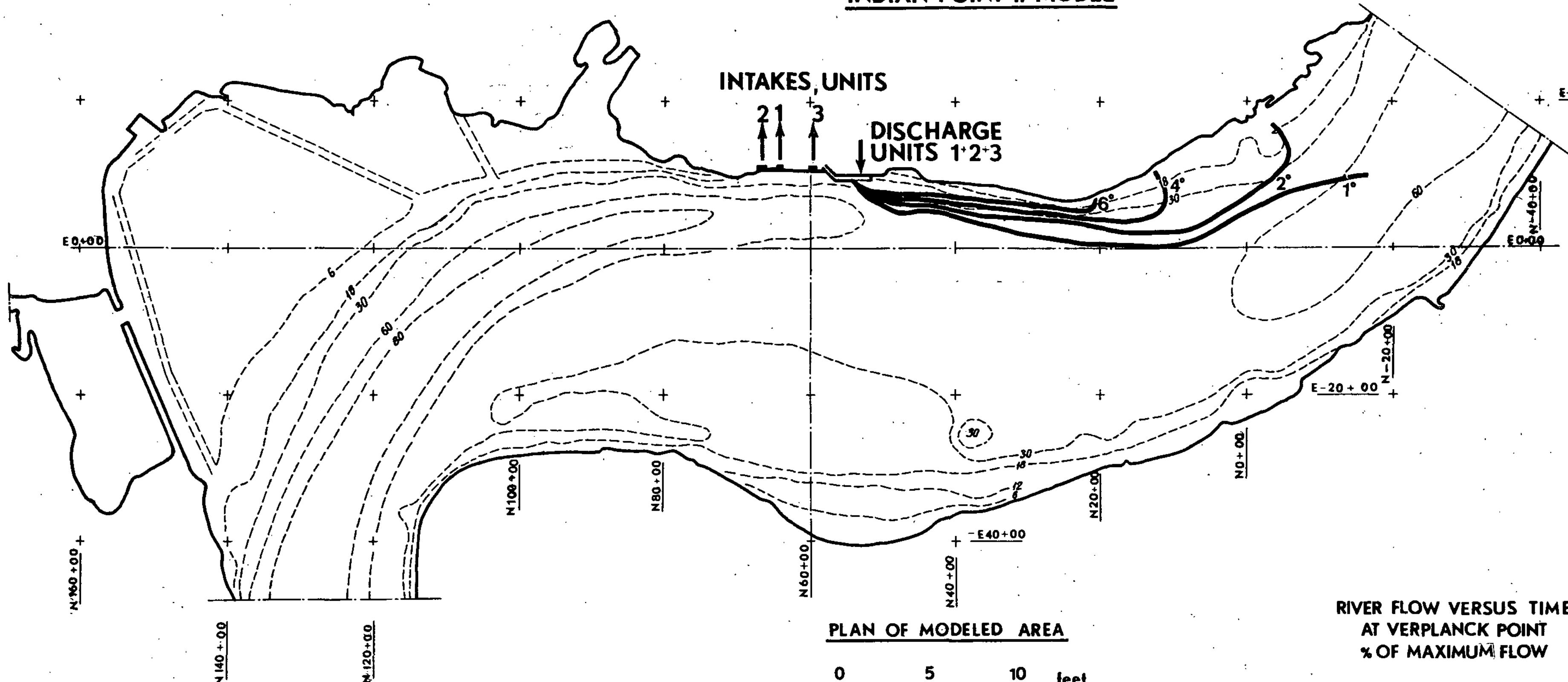
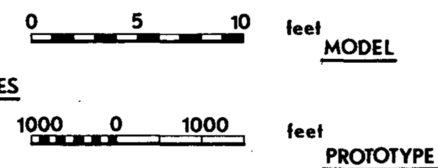
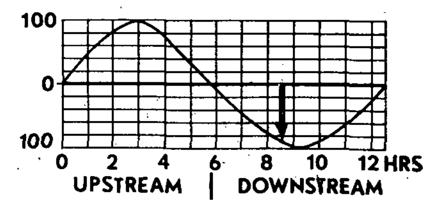
INDIAN POINT II MODEL



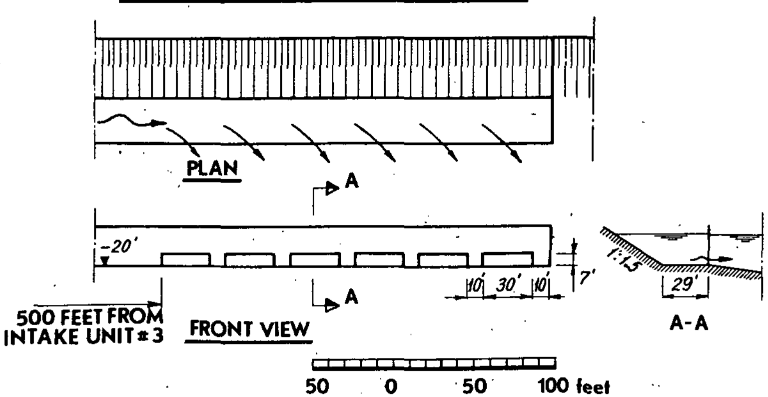
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 525 ; NOV 27 ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 50 °F
AIR TEMPERATURE DRY BULB 55 °F
AIR TEMPERATURE WET BULB 49 °F
RELATIVE HUMIDITY 62 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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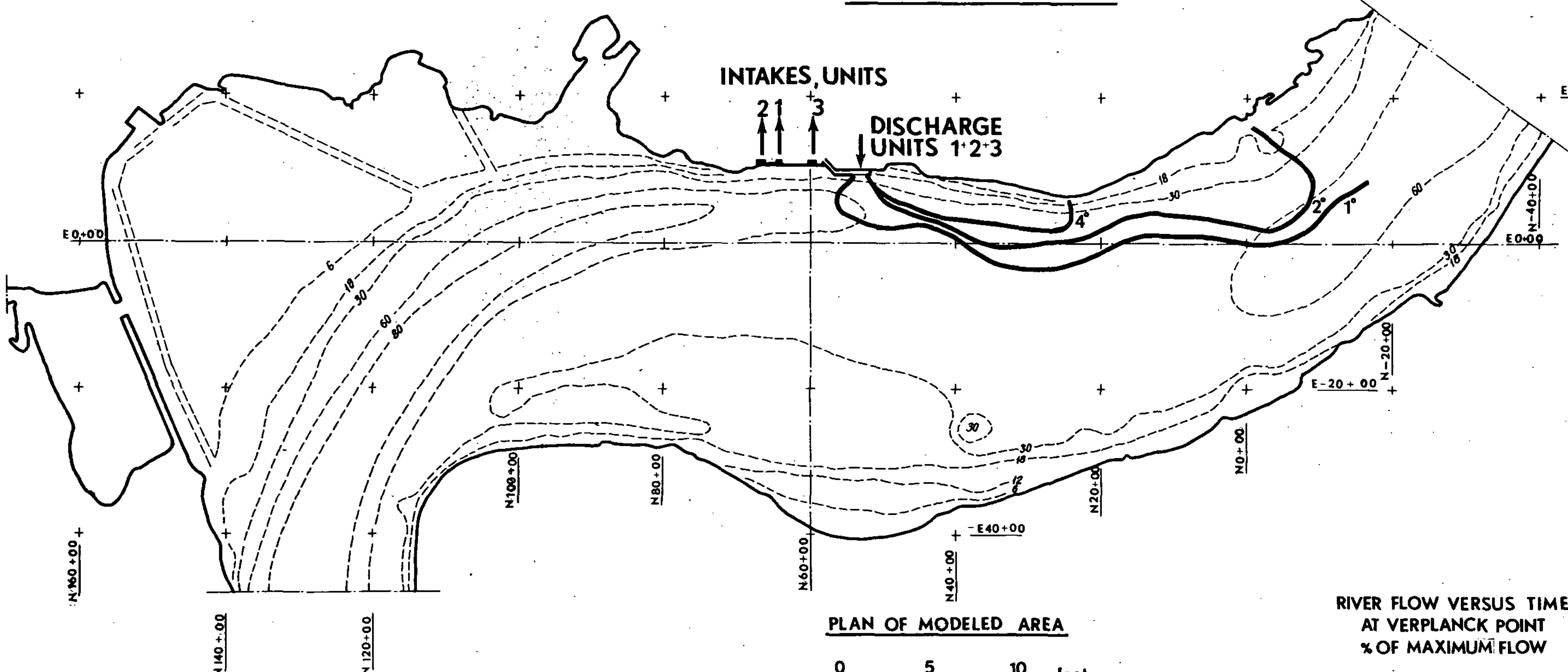
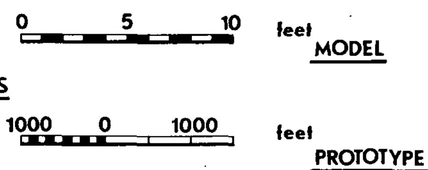
FIG. 30

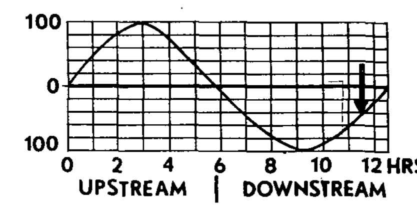
INDIAN POINT II MODEL



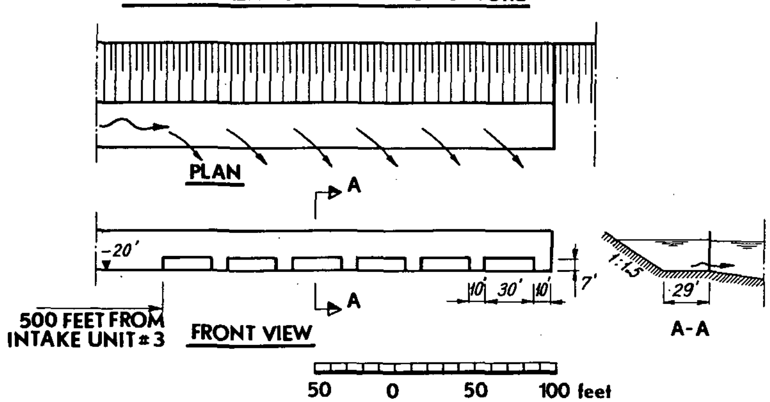
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 525 ; NOV 27 ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 50 °F
AIR TEMPERATURE DRY BULB 55 °F
AIR TEMPERATURE WET BULB 49 °F
RELATIVE HUMIDITY 62 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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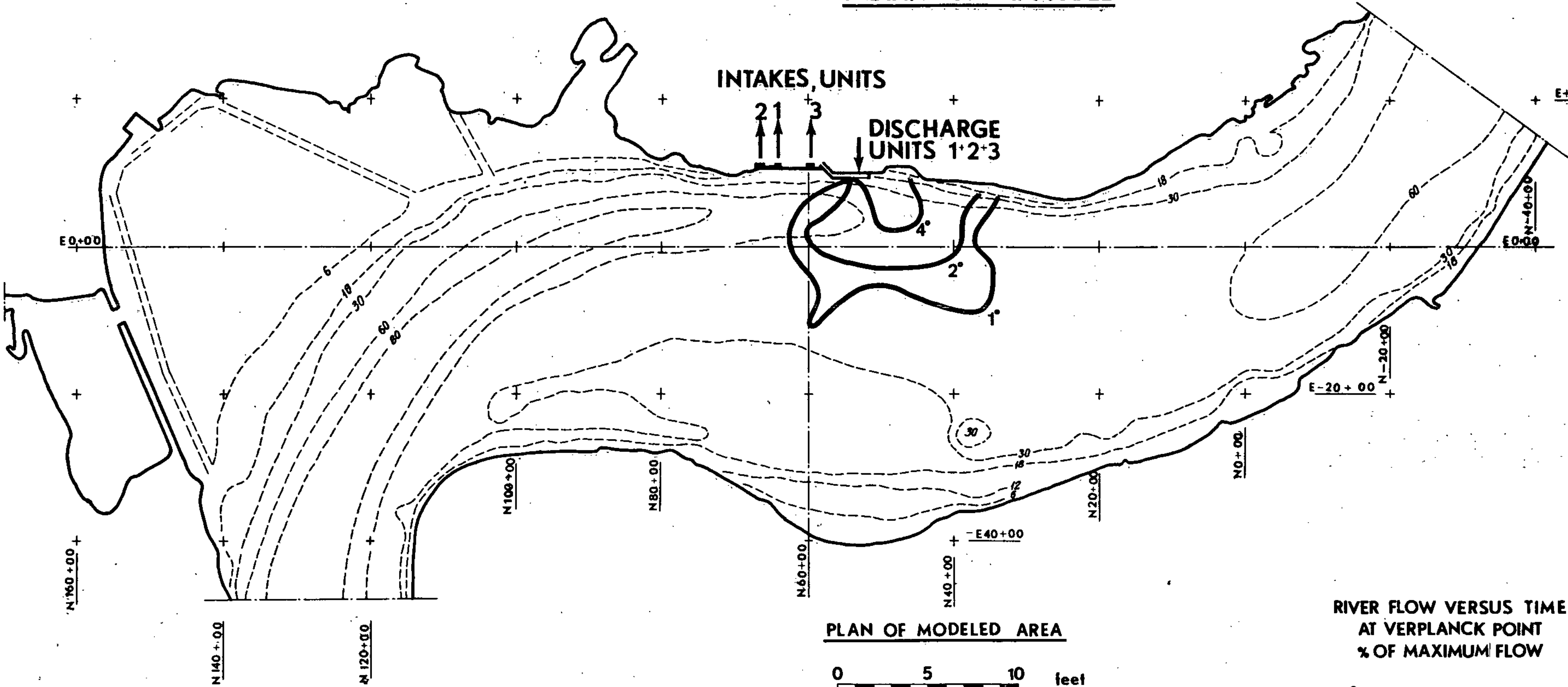
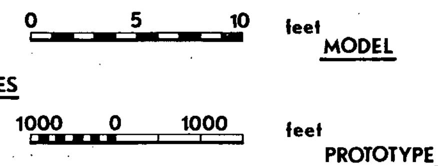
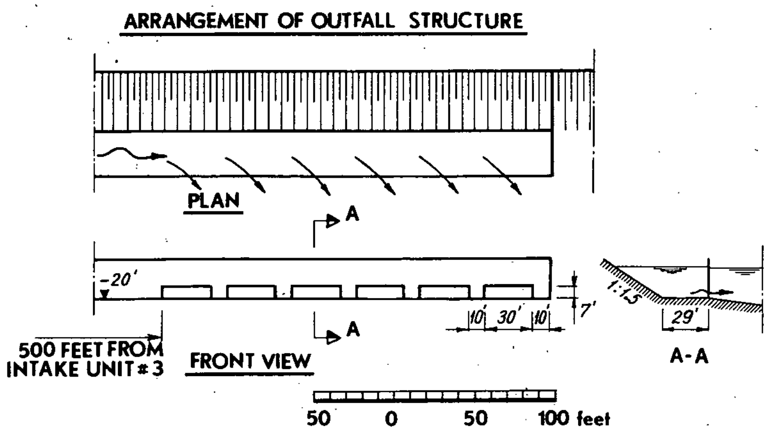
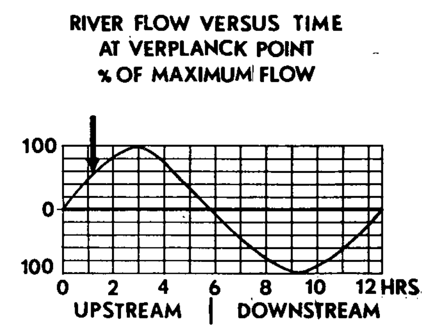
INDIAN POINT II MODEL



PLAN OF MODELED AREA







TEST CONDITIONS

TEST NUMBER AND DATE 527 ; NOV 27 ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 51 °F
AIR TEMPERATURE DRY BULB 52.9 °F
AIR TEMPERATURE WET BULB 48.0 °F
RELATIVE HUMIDITY 70 %
DEPTH OF ISOTHERMS 12 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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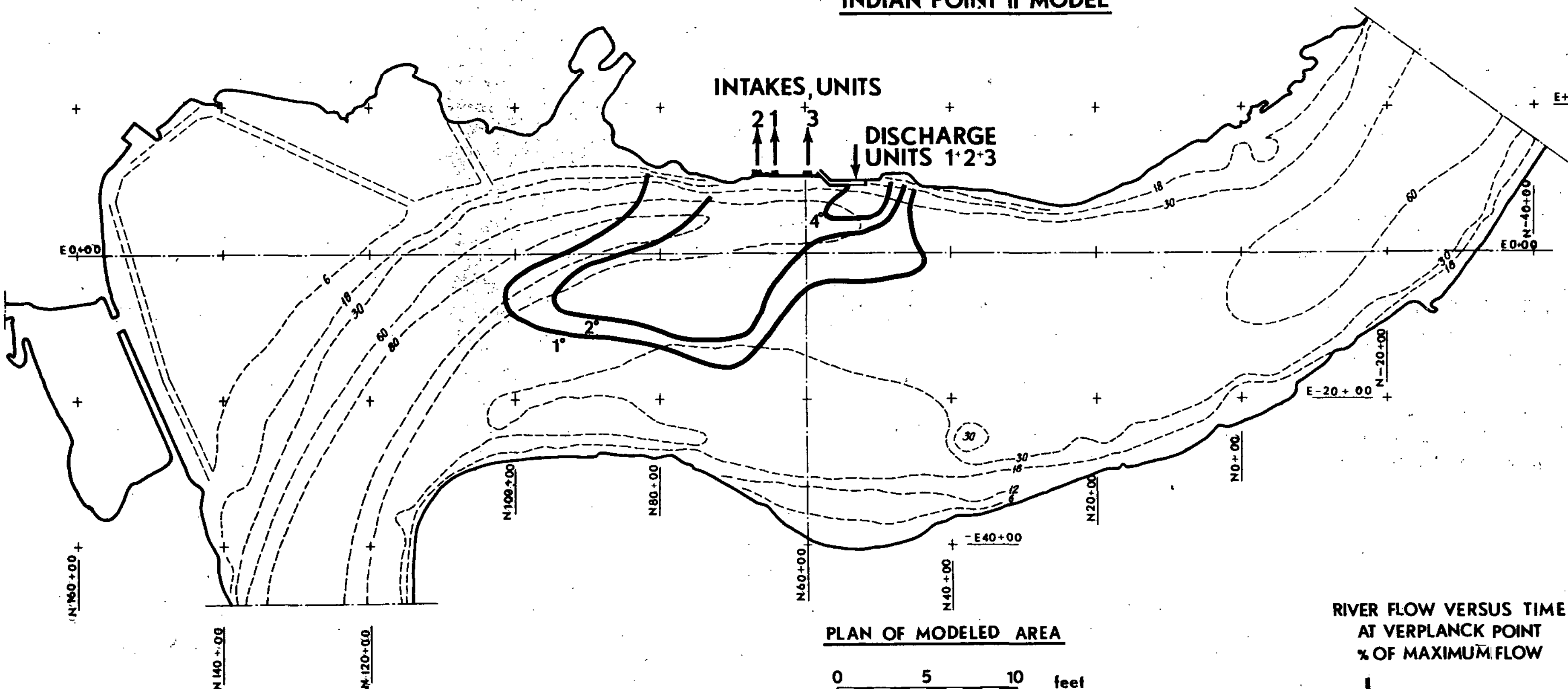
FIG. 32

FIG. 33

INDIAN POINT II MODEL



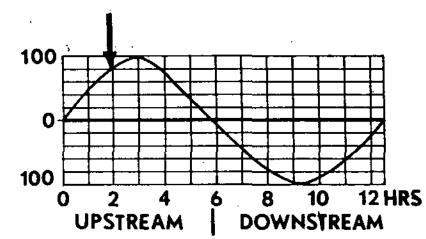
PLAN OF MODELED AREA

SCALES

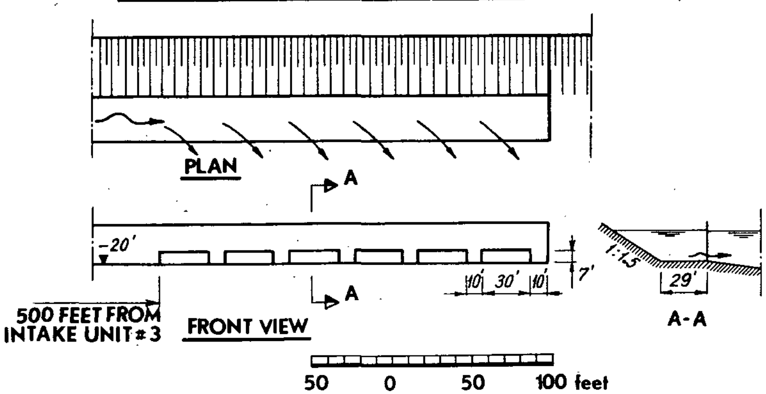
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 527 ; NOV 27 , 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 51 °F
AIR TEMPERATURE DRY BULB 52.9 °F
AIR TEMPERATURE WET BULB 48.0 °F
RELATIVE HUMIDITY 70%
DEPTH OF ISOTHERMS 12 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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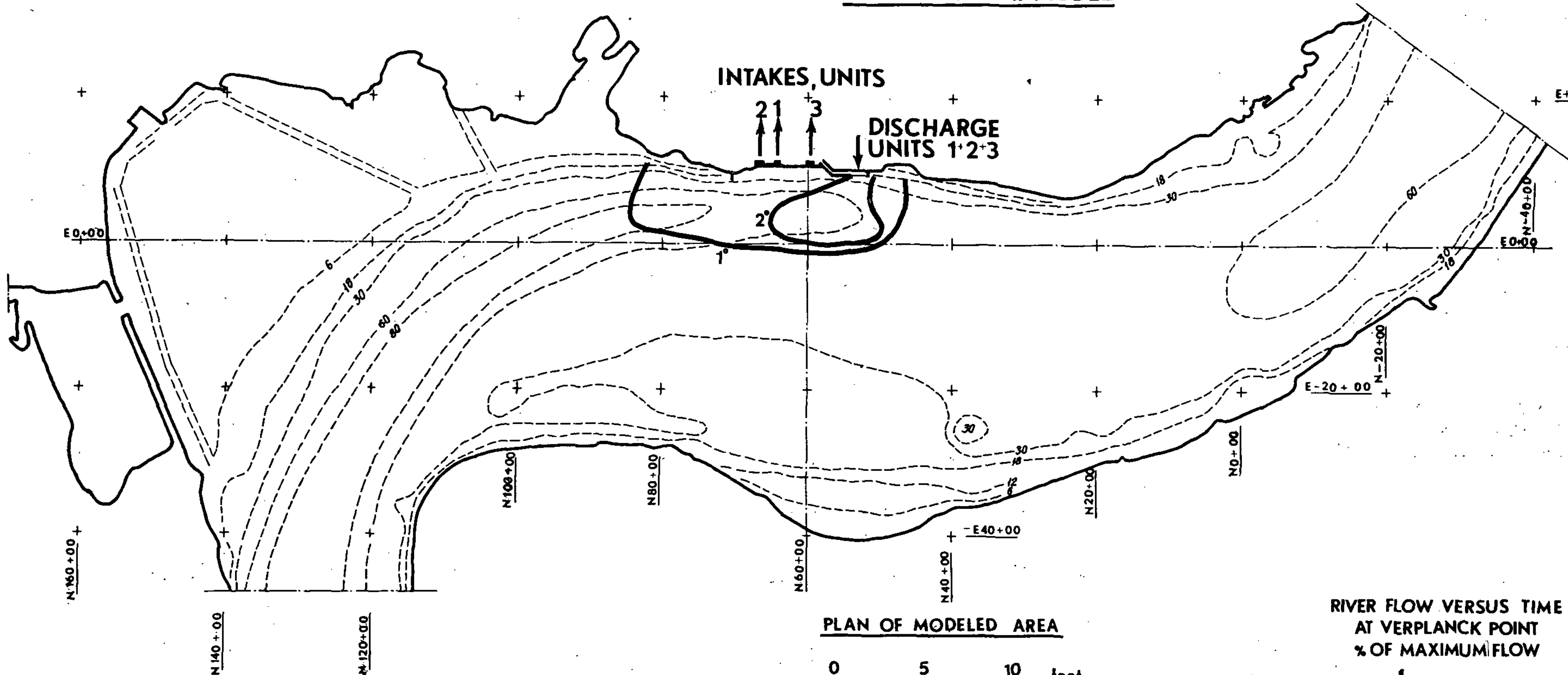
INDIAN POINT II MODEL



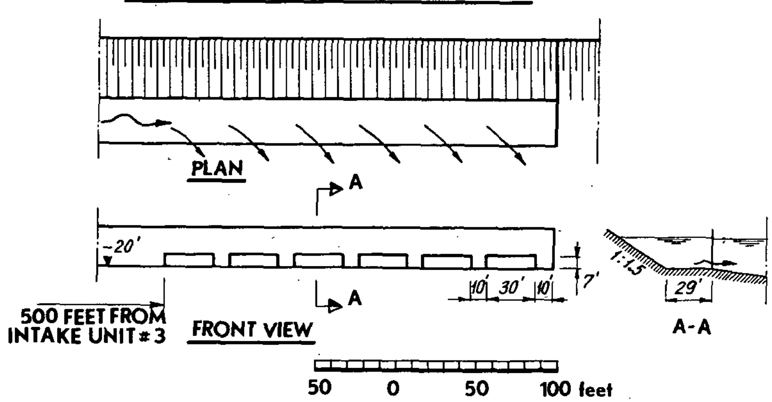
PLAN OF MODELED AREA

SCALES

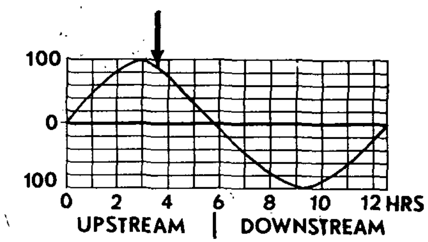
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 527 ; NOV 27 , 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 51 °F
AIR TEMPERATURE DRY BULB 52.9 °F
AIR TEMPERATURE WET BULB 48.0 °F
RELATIVE HUMIDITY 70 %
DEPTH OF ISOTHERMS 12 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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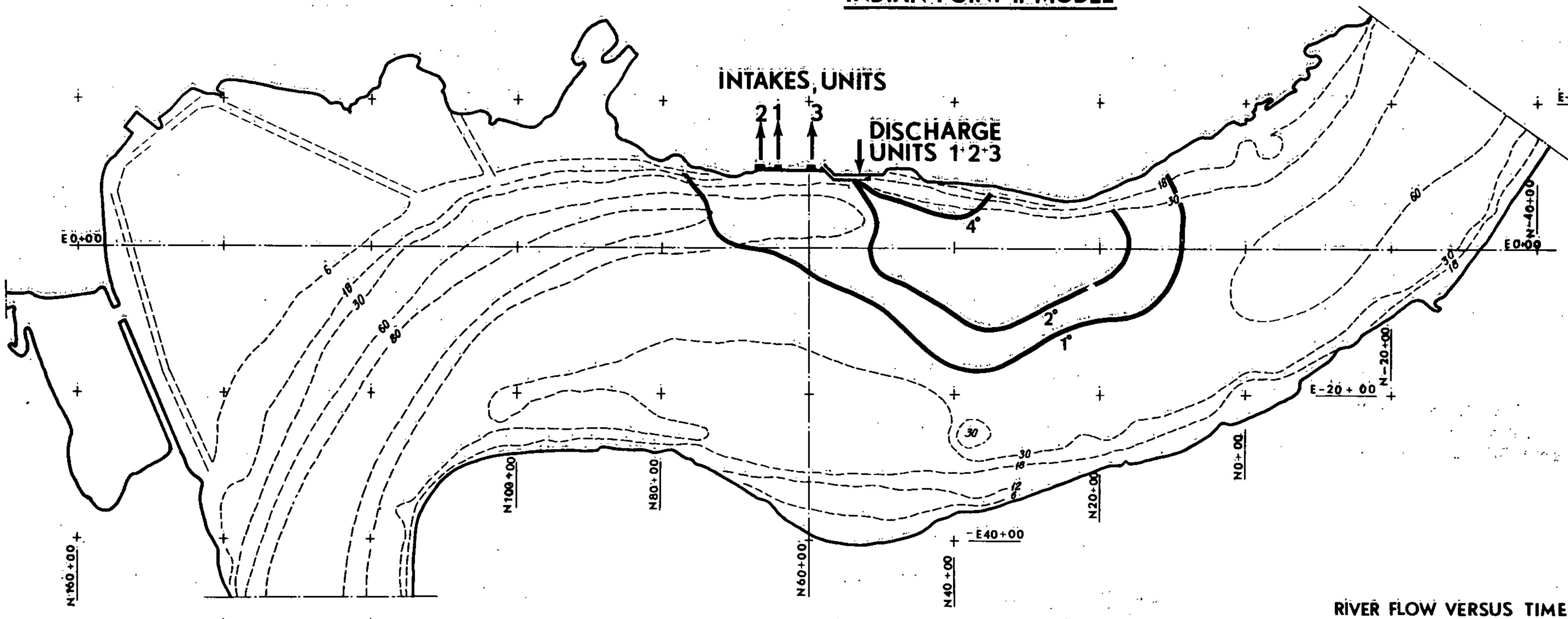
FIG. 34

FIG. 35

INDIAN POINT II MODEL



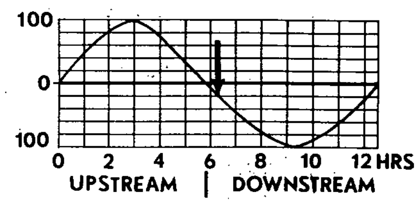
PLAN OF MODELED AREA

SCALES

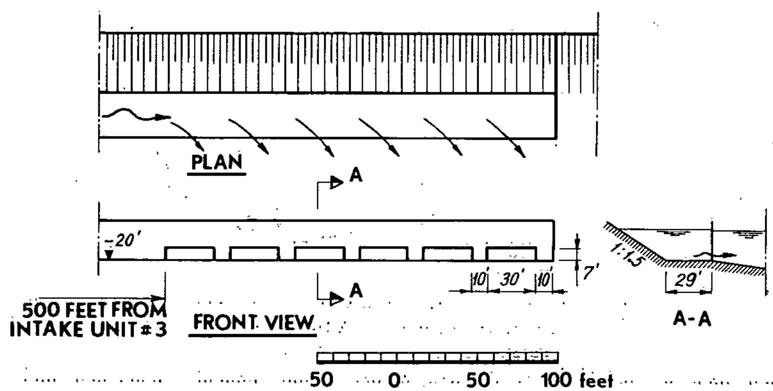
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 527 ; NOV 27 ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 51 °F
AIR TEMPERATURE DRY BULB 52.9°F
AIR TEMPERATURE WET BULB 48.0°F
RELATIVE HUMIDITY 70 %
DEPTH OF ISOTHERMS 12 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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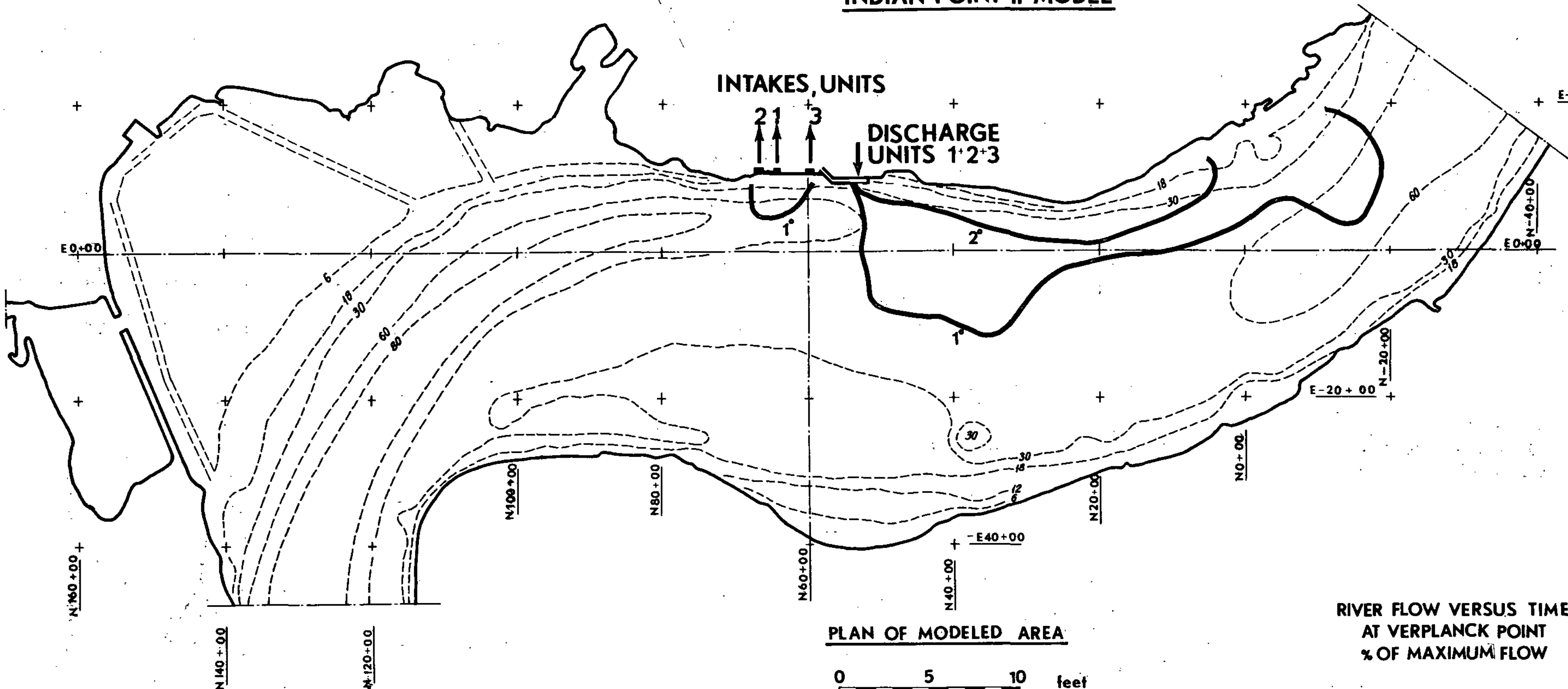
INDIAN POINT II MODEL



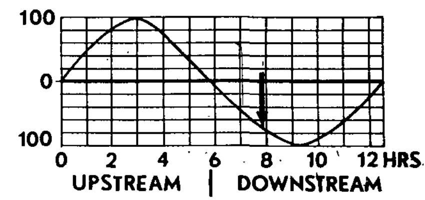
PLAN OF MODELED AREA

SCALES

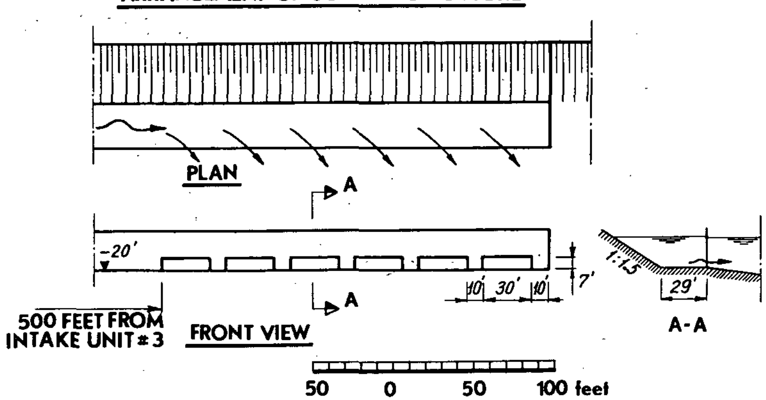
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 527 ; NOV 27, 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 51 °F
AIR TEMPERATURE DRY BULB 52.9°F
AIR TEMPERATURE WET BULB 48.0°F
RELATIVE HUMIDITY 70 %
DEPTH OF ISOTHERMS 12 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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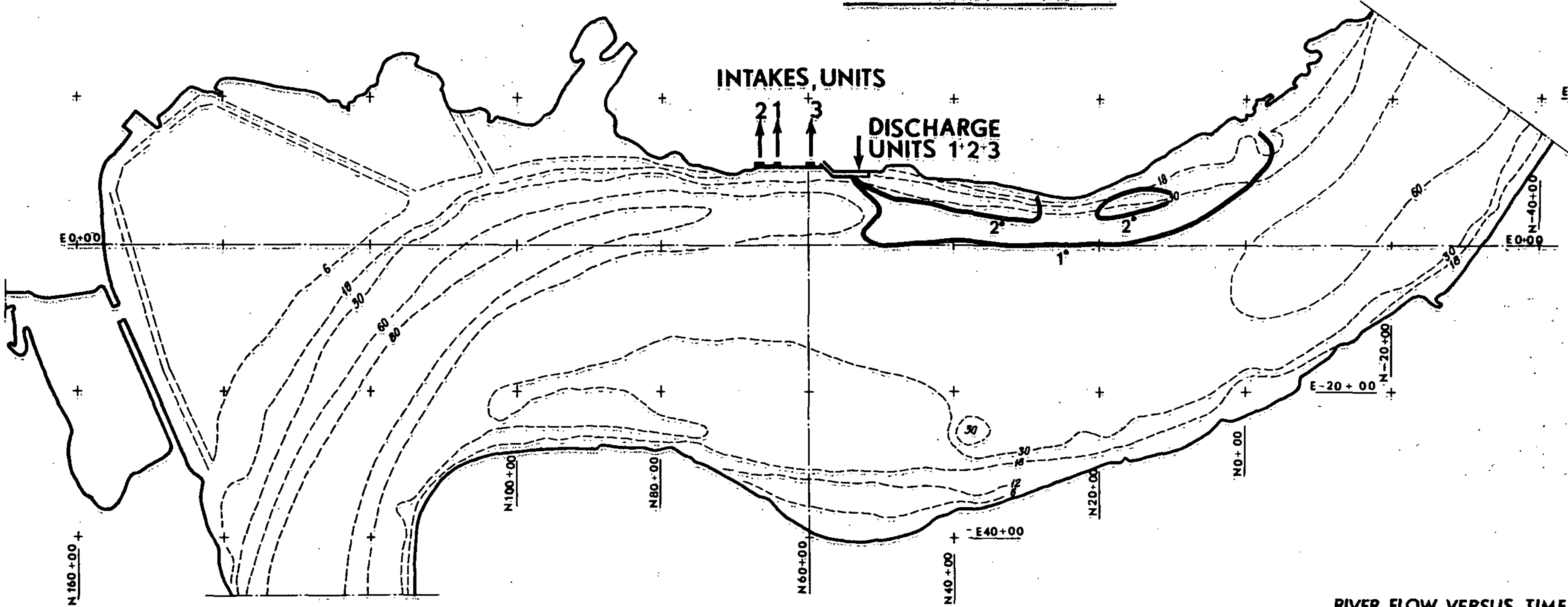
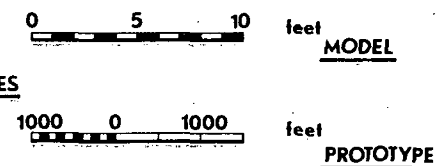
FIG. 36

FIG. 37

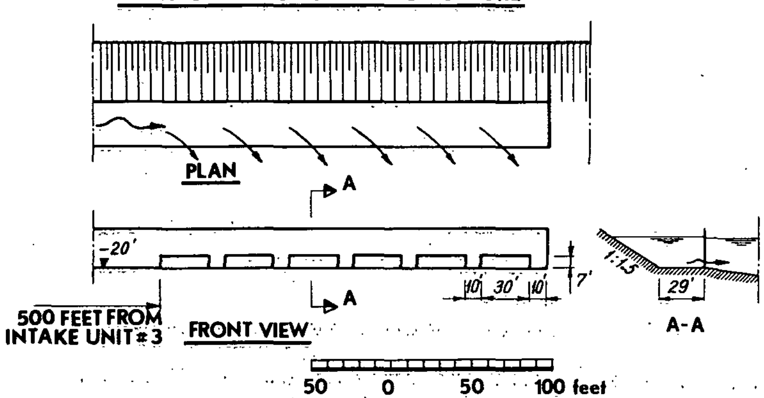
INDIAN POINT II MODEL



PLAN OF MODELED AREA



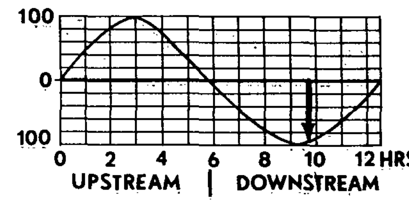
ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 527 ; NOV 27 , 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 51 °F
AIR TEMPERATURE DRY BULB 52.9 °F
AIR TEMPERATURE WET BULB 48.0 °F
RELATIVE HUMIDITY 70 %
DEPTH OF ISOTHERMS 12 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



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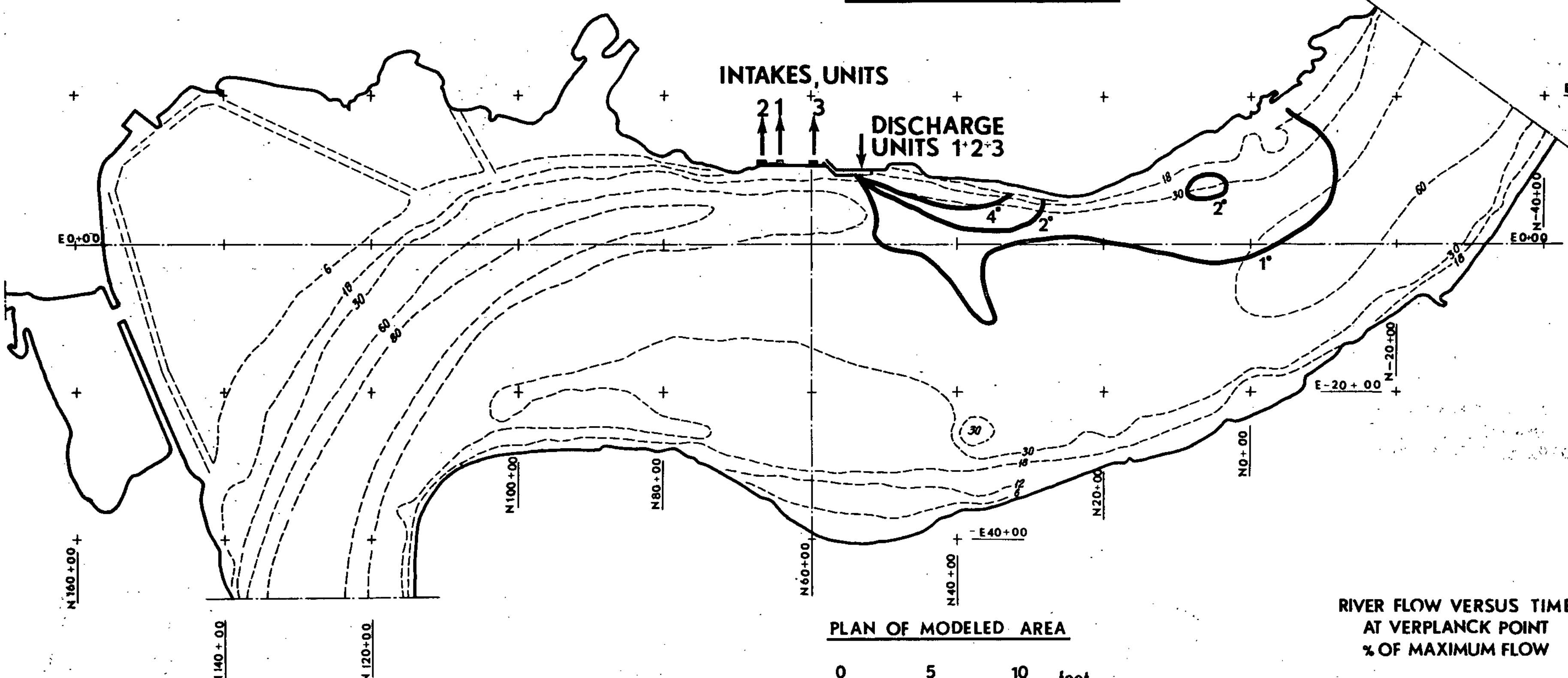
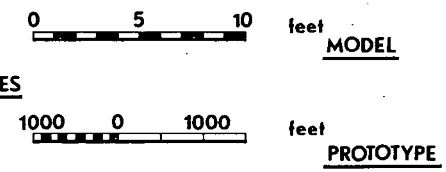
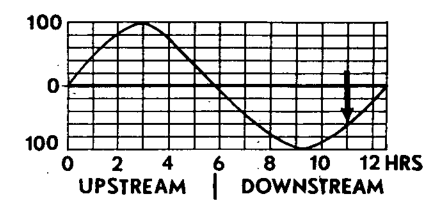
INDIAN POINT II MODEL



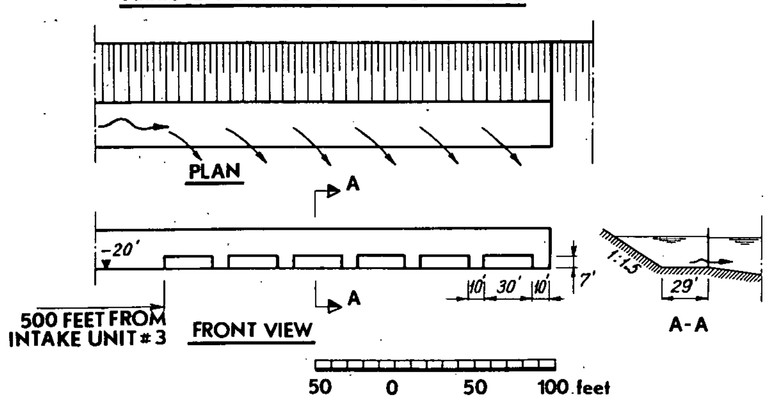
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 527 ; NOV 27 ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 51 °F
AIR TEMPERATURE DRY BULB 52.9 °F
AIR TEMPERATURE WET BULB 48.0 °F
RELATIVE HUMIDITY 70 %
DEPTH OF ISOTHERMS 12 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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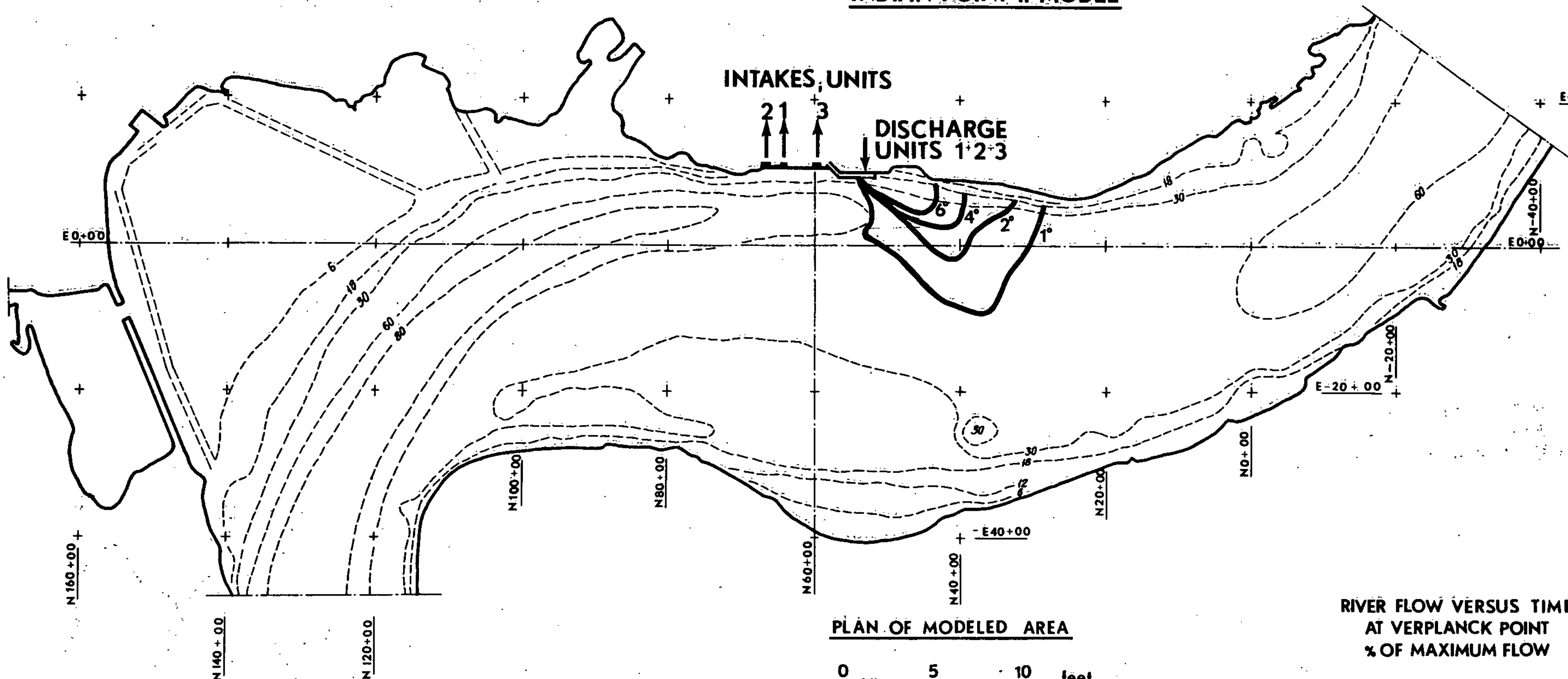
FIG. 38

FIG. 39

INDIAN POINT II MODEL



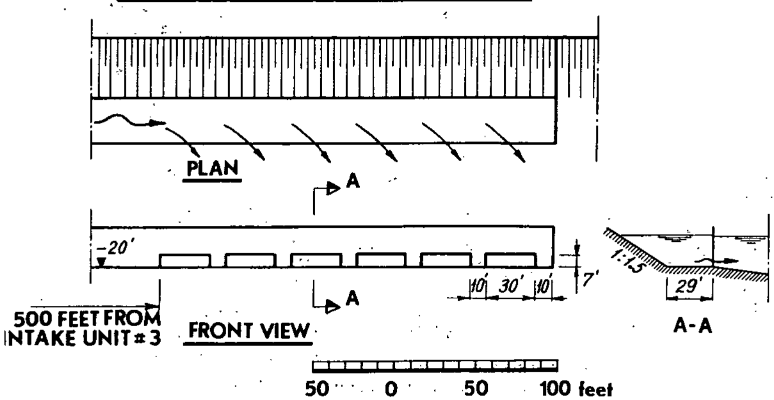
PLAN OF MODELED AREA

SCALES

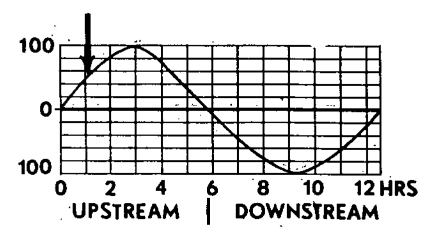
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 528A ; NOV 29 ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 46 °F
AIR TEMPERATURE DRY BULB 56.5°F
AIR TEMPERATURE WET BULB 51.3°F
RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 18 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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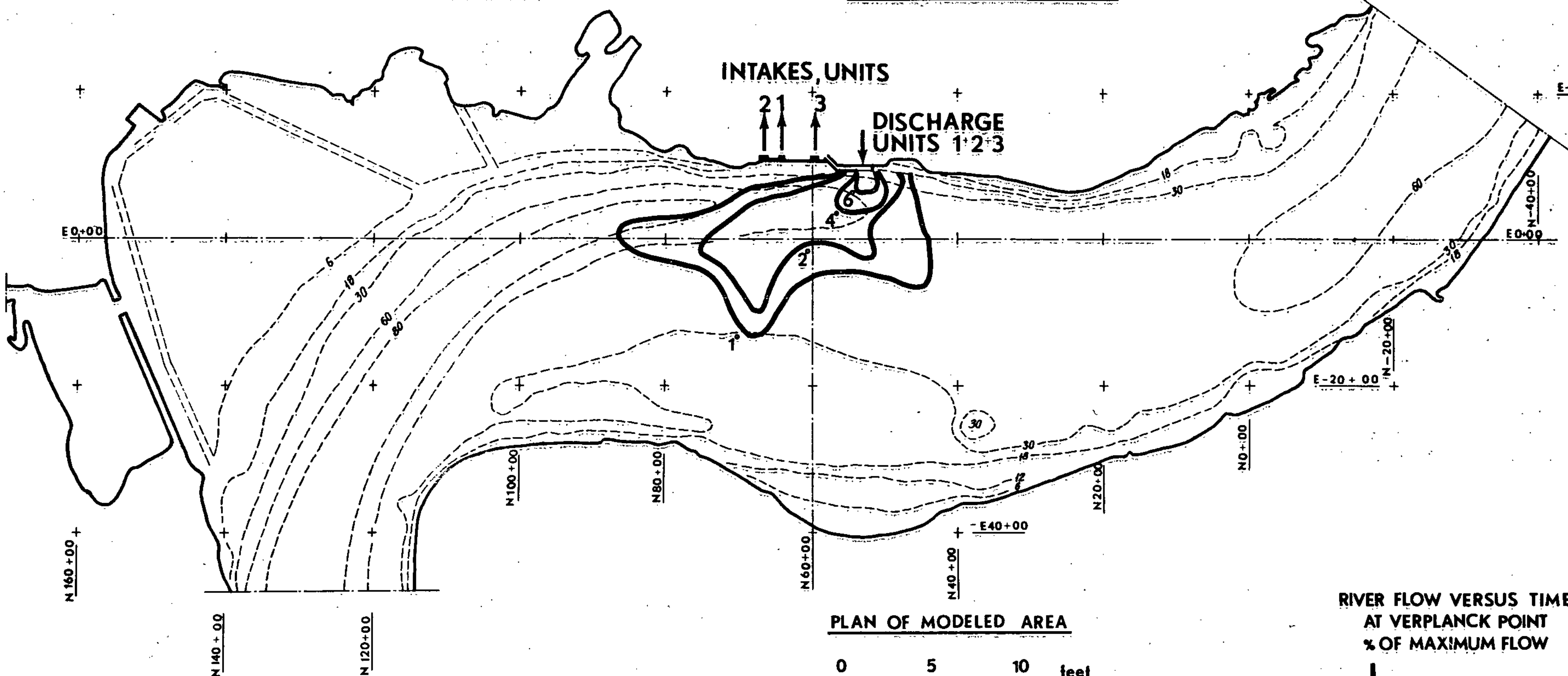
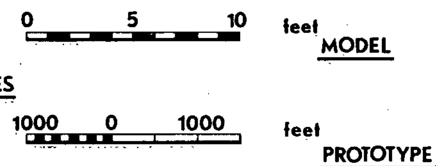
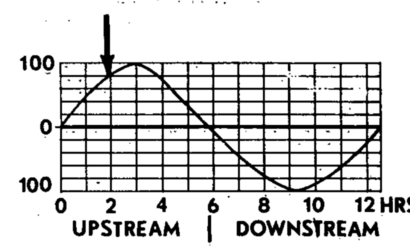
INDIAN POINT II MODEL

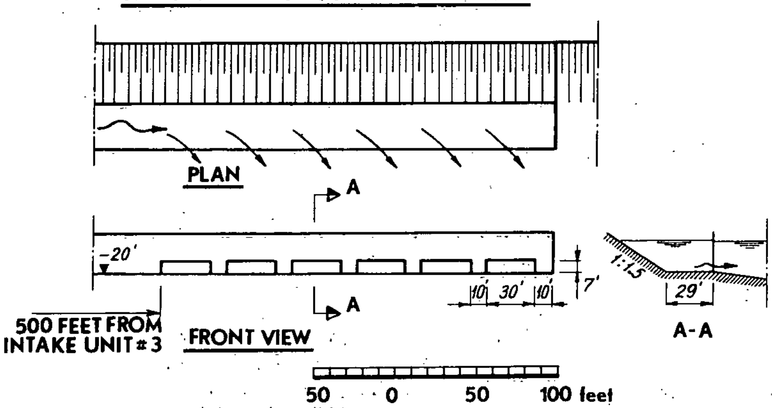


PLAN OF MODELED AREA





ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 528A ; NOV 29 , 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 6 °F
AIR TEMPERATURE DRY BULB 56.5°F
AIR TEMPERATURE WET BULB 51.3°F
RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 18 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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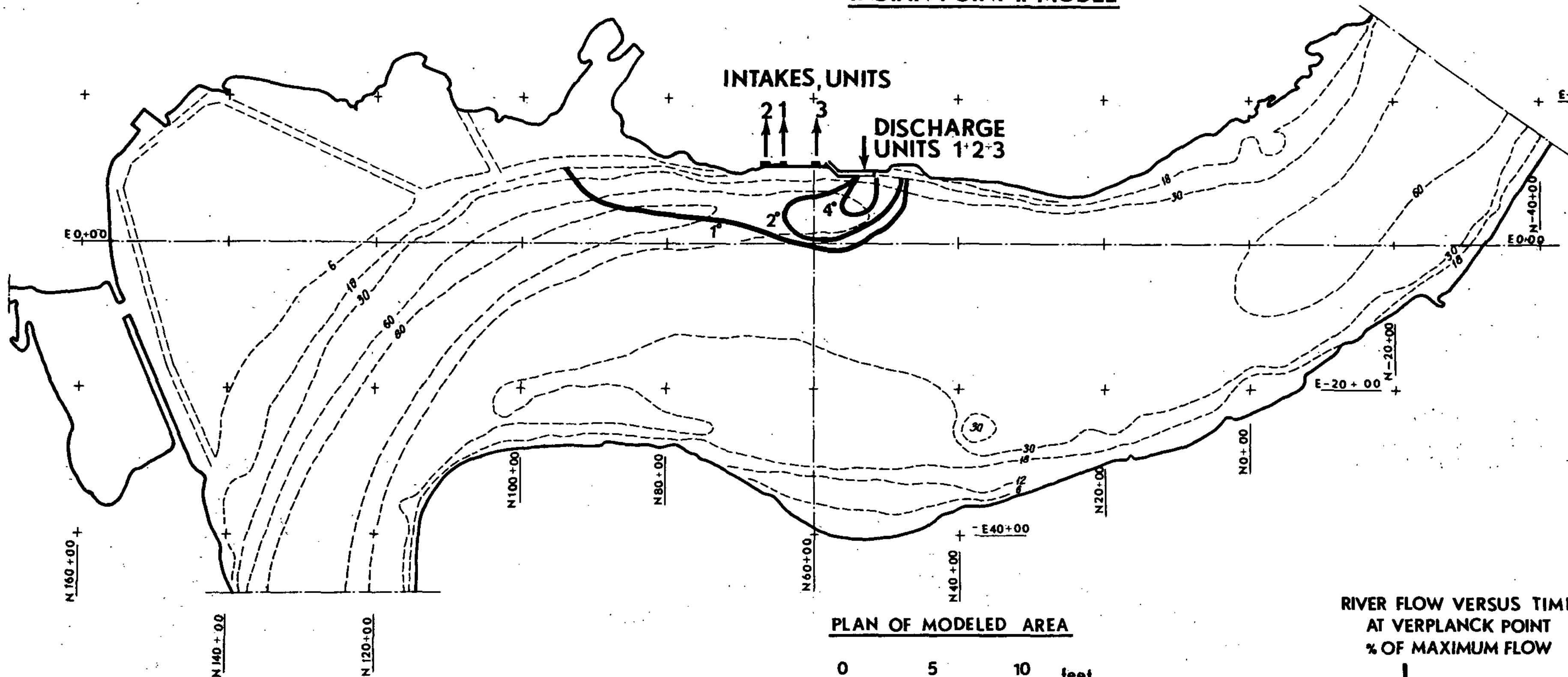
FIG. 40

INDIAN POINT II MODEL



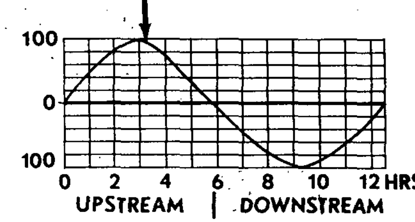
PLAN OF MODELED AREA

SCALES

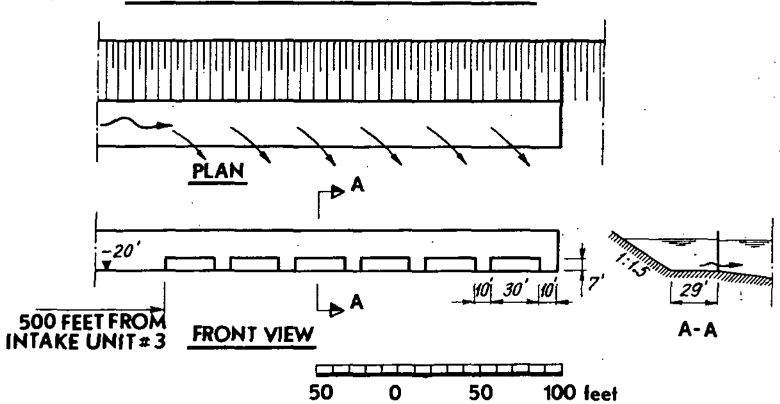
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 528A ; NOV 29 ,1968
UNITS OPERATING AND DISCHARGE 1, 2, 3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 46 °F
AIR TEMPERATURE DRY BULB 56.5°F
AIR TEMPERATURE WET BULB 51.3°F
RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 18 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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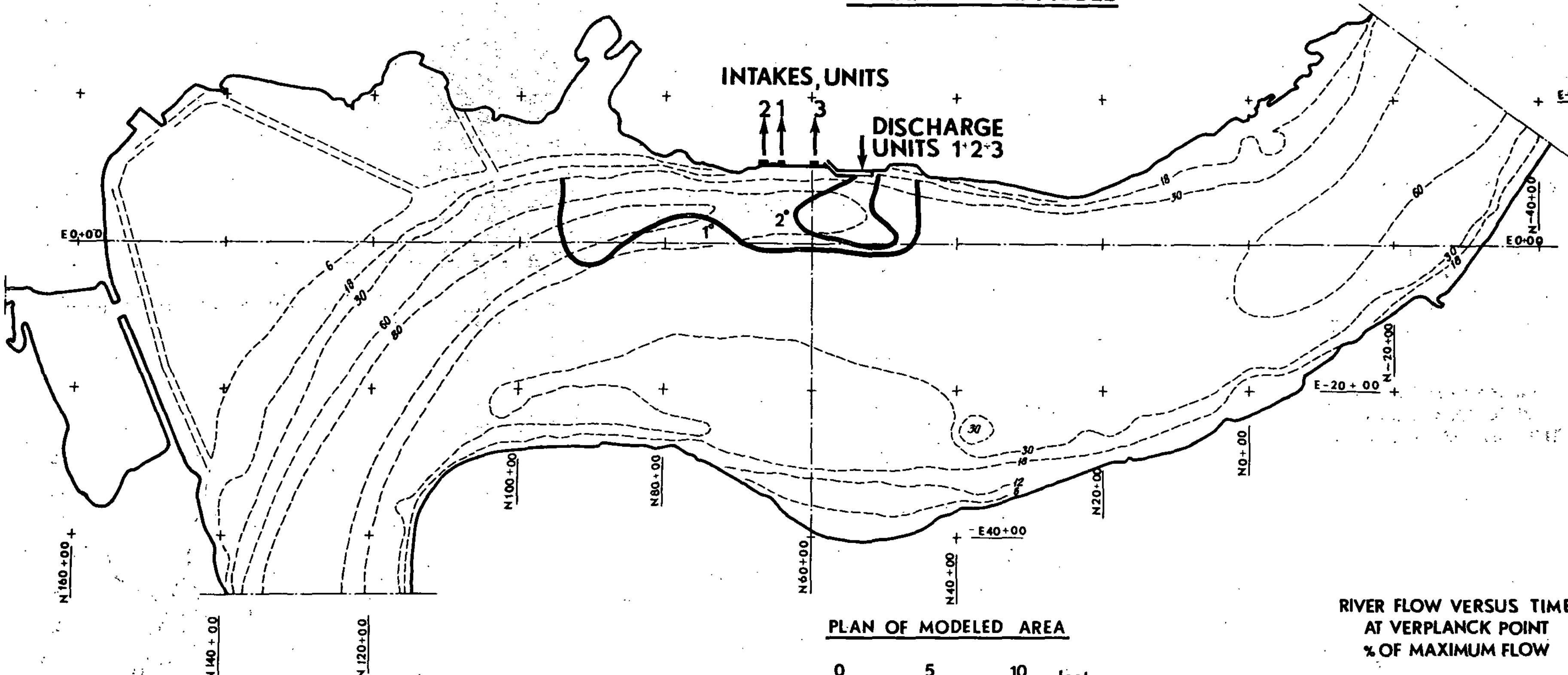
INDIAN POINT II MODEL



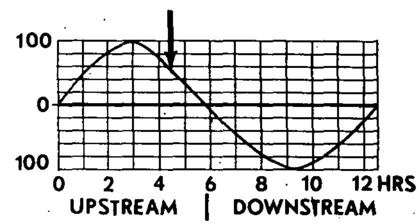
PLAN OF MODELED AREA

SCALES

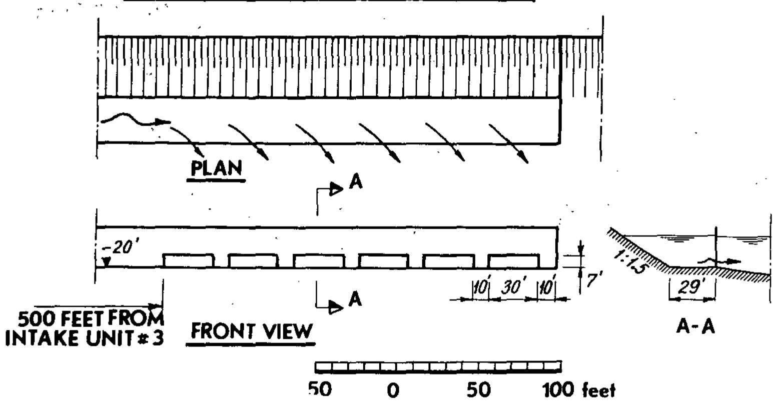
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



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RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 18 feet
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FOR
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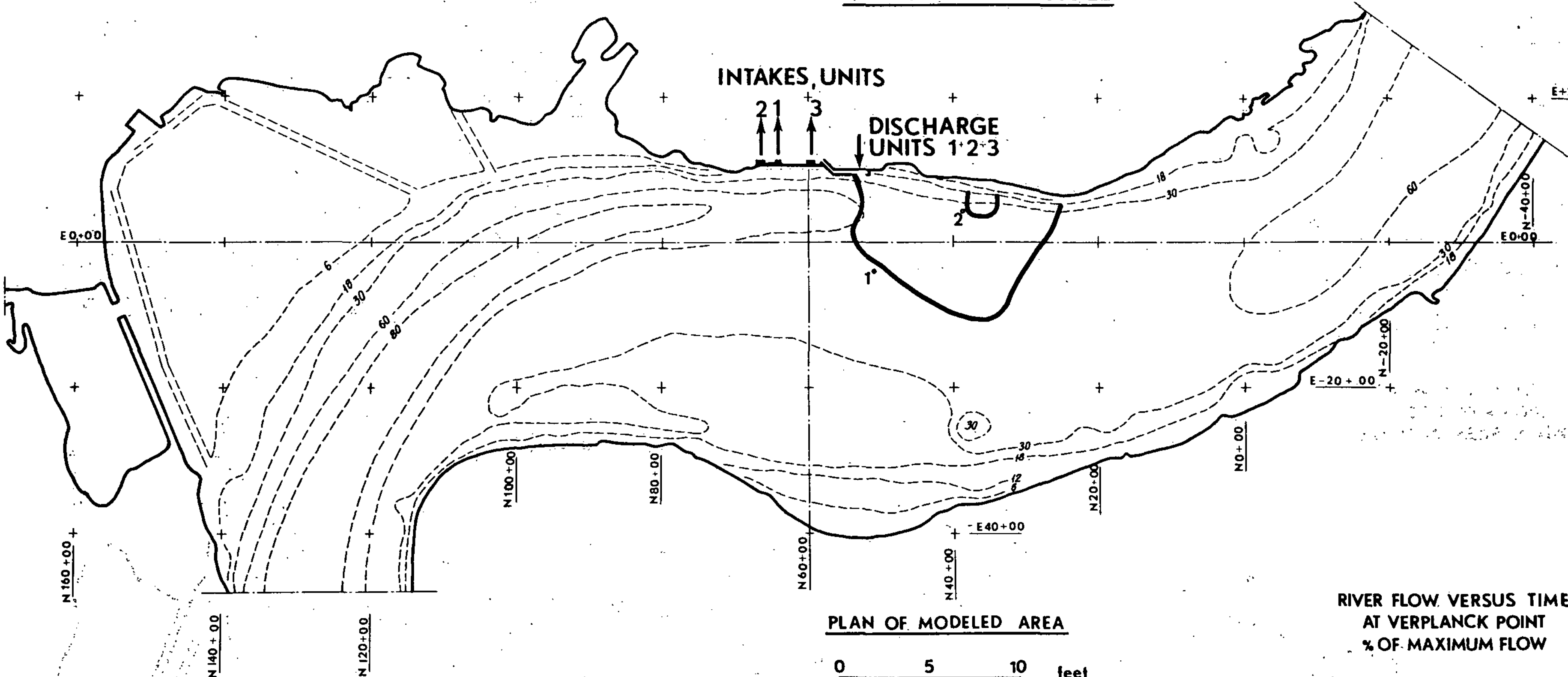
FIG. 42

FIG. 43

INDIAN POINT II MODEL



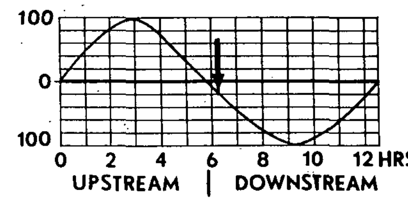
PLAN OF MODELED AREA

SCALES

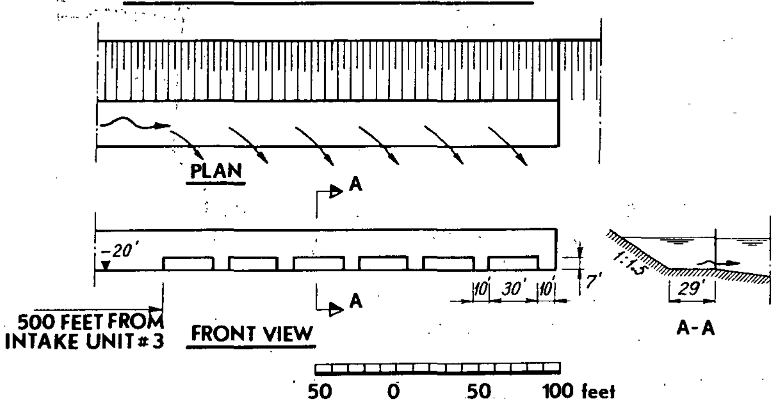
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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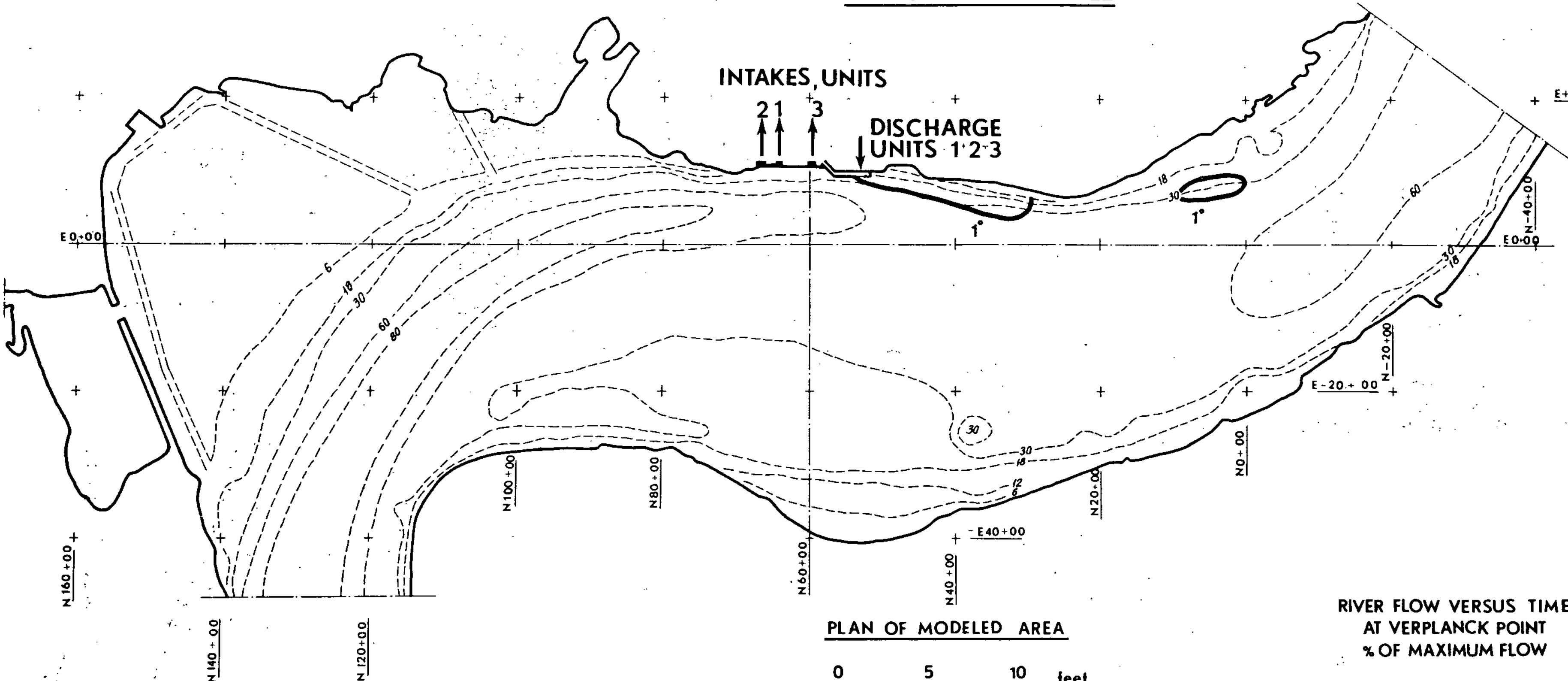
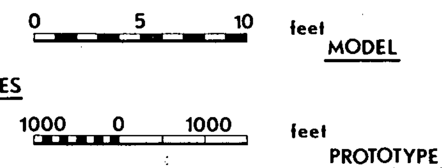
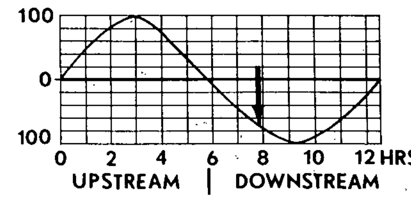
INDIAN POINT II MODEL



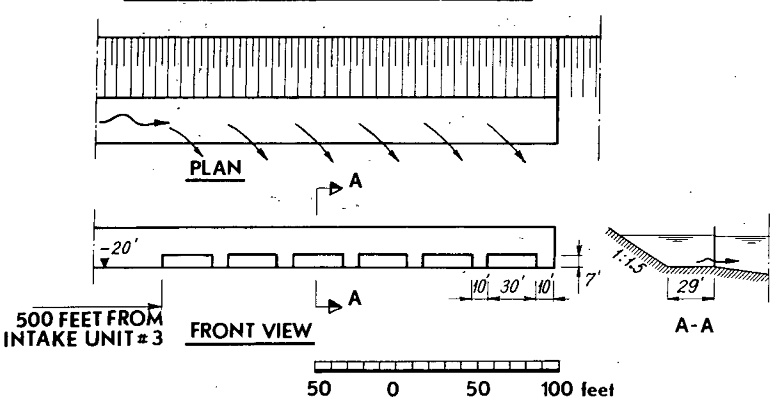
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 18 feet
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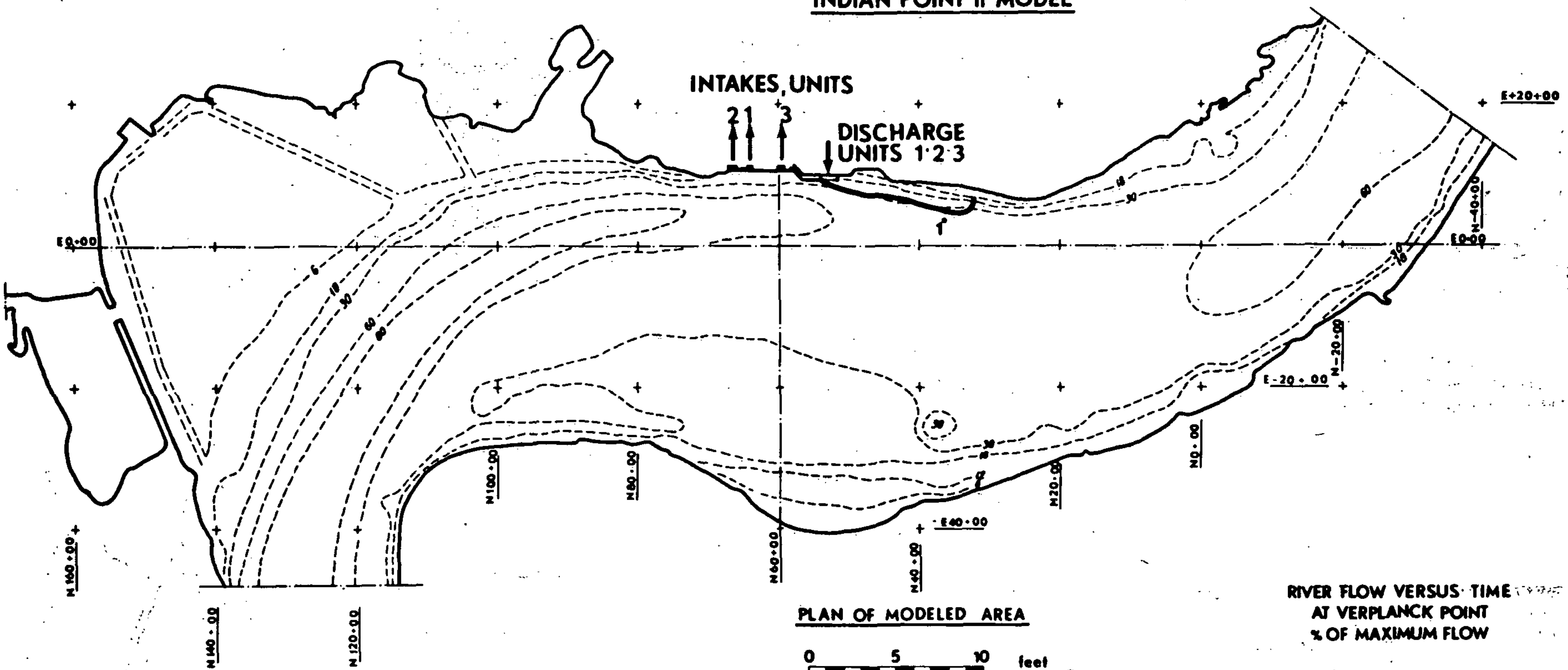
FIG. 44

FIG. 45

INDIAN POINT II MODEL



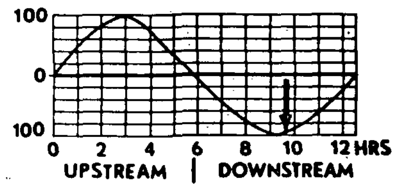
PLAN OF MODELED AREA

SCALES

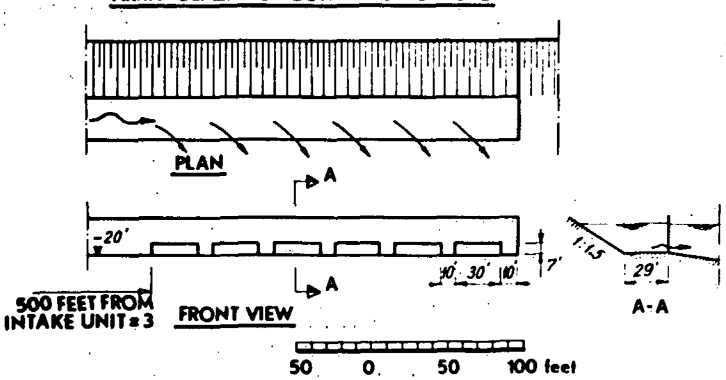
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 528A ; NOV 29 , 1968
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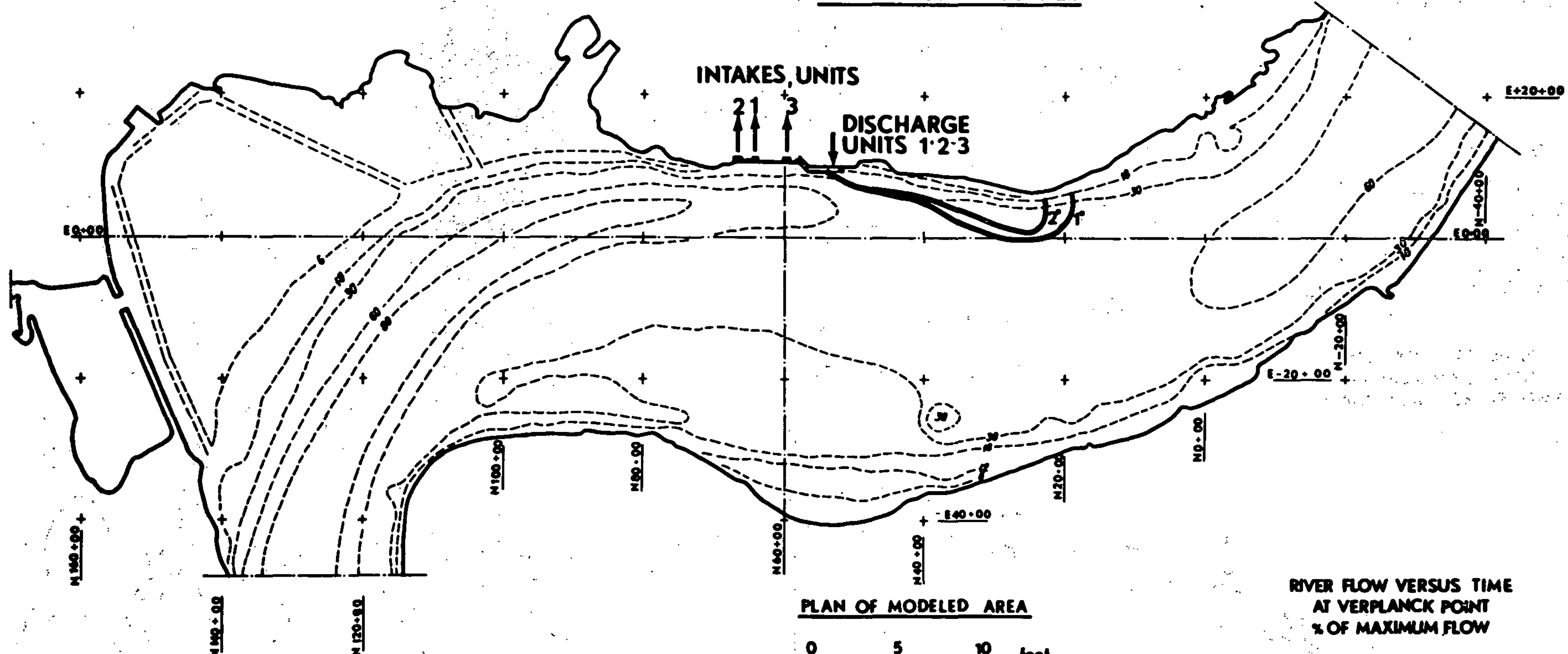
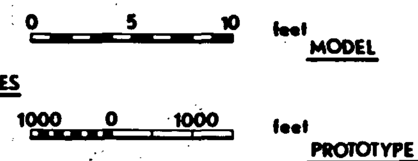
INDIAN POINT II MODEL

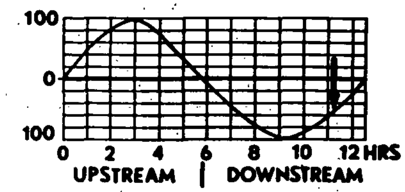


PLAN OF MODELED AREA

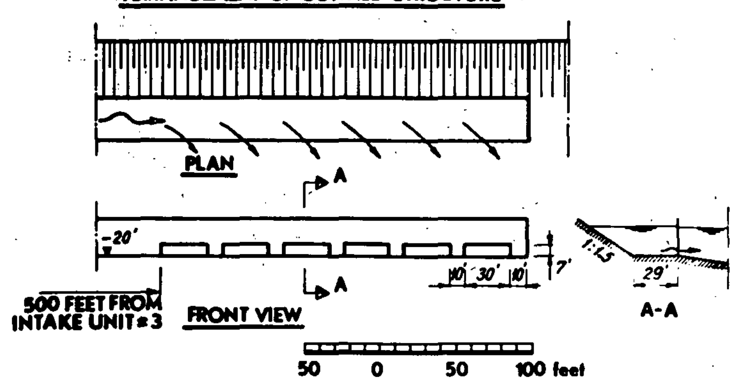
SCALES



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 528A ; NOV 29 , 1968
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RIVER AMBIENT TEMPERATURE 46 °F
AIR TEMPERATURE DRY BULB 56.5°F
AIR TEMPERATURE WET BULB 51.3°F
RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 18 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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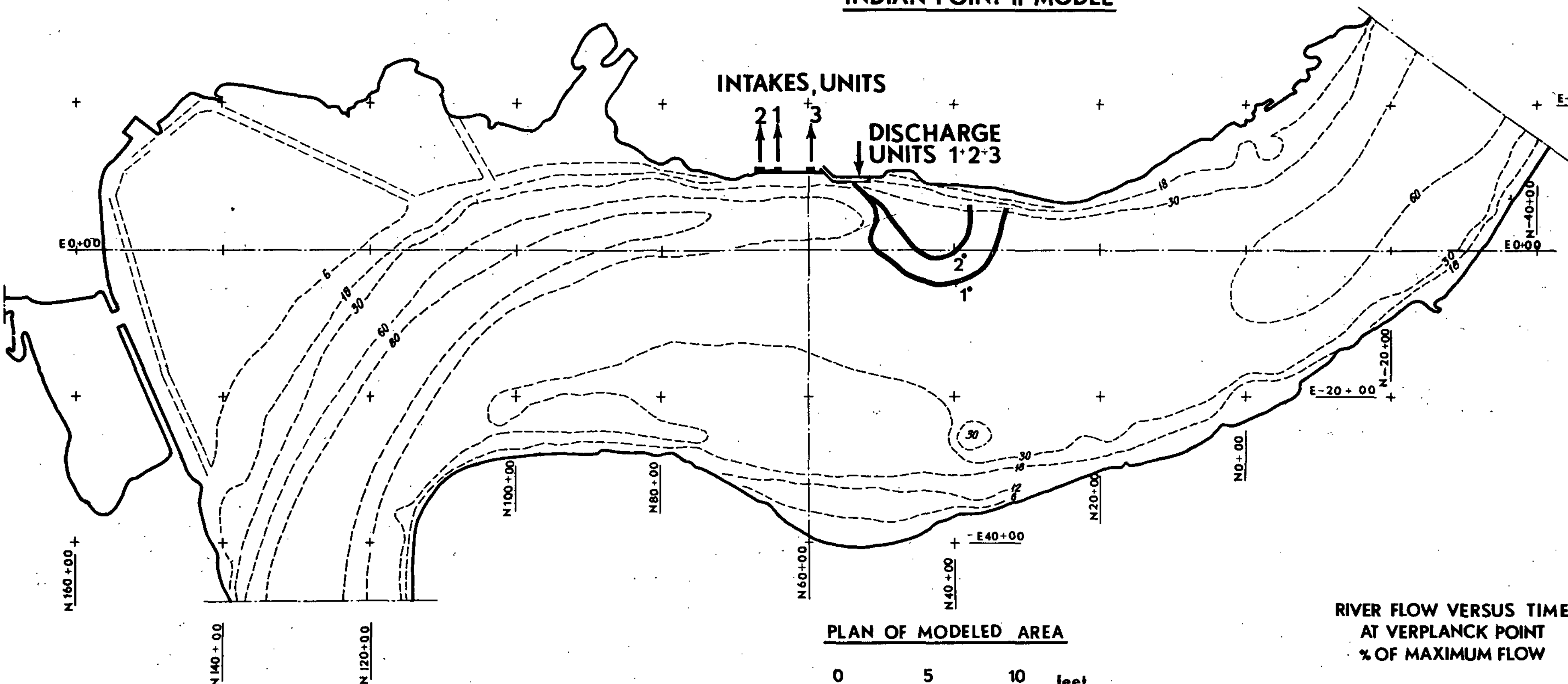
FIG. 46

INDIAN POINT II MODEL



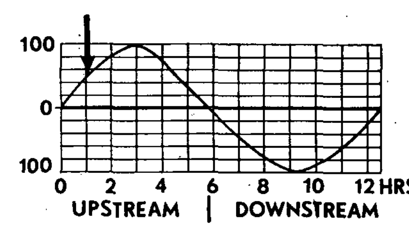
PLAN OF MODELED AREA

SCALES

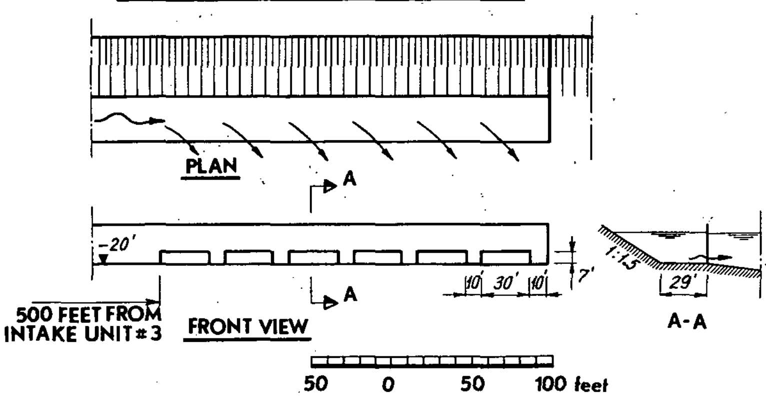
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 529A ; NOV 29 , 1968
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RIVER AMBIENT TEMPERATURE 51 °F
AIR TEMPERATURE DRY BULB 58.9°F
AIR TEMPERATURE WET BULB 53.5°F
RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 24 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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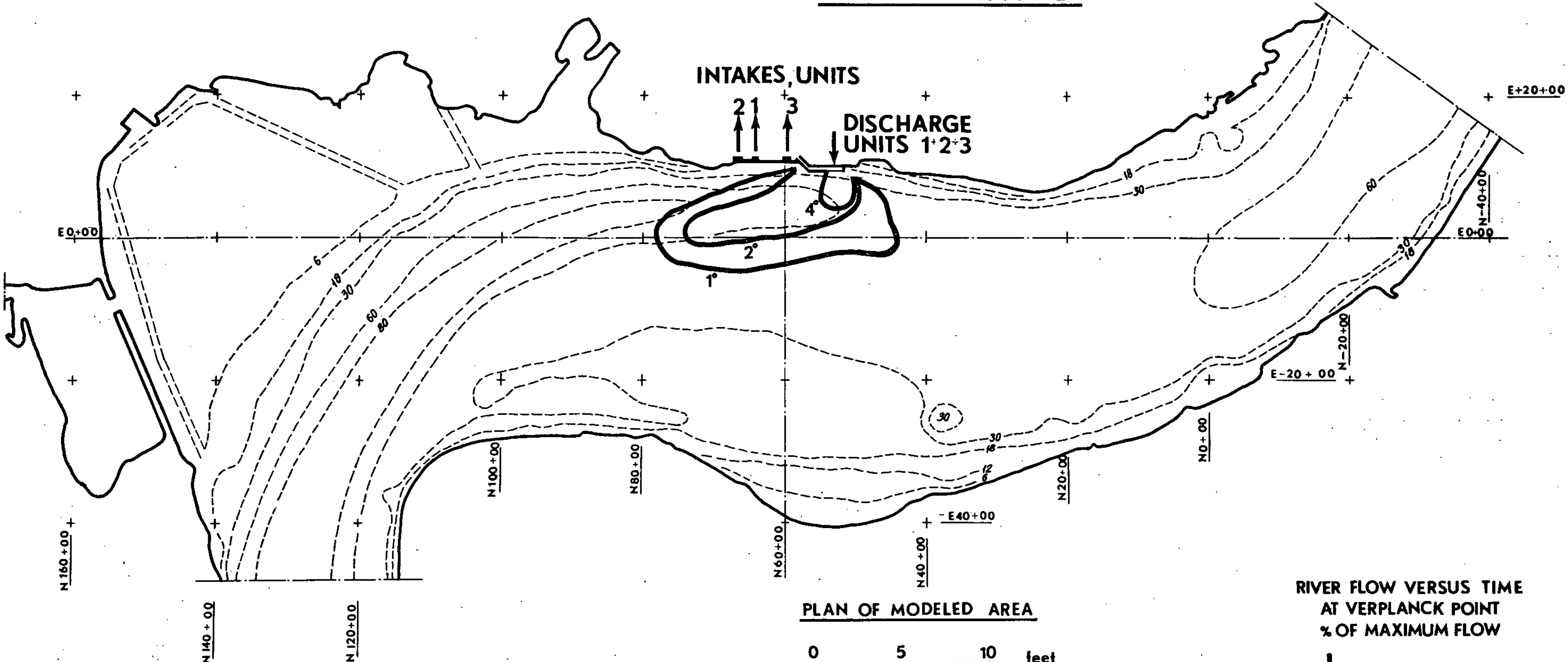
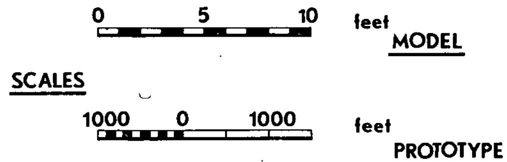
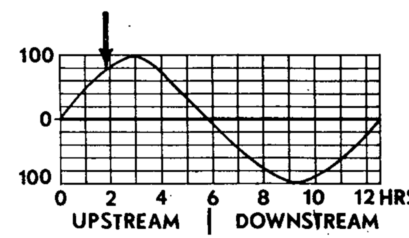
INDIAN POINT II MODEL



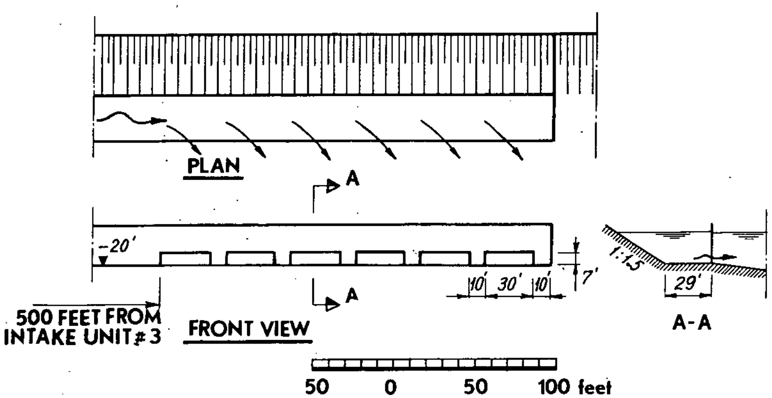
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 24 feet
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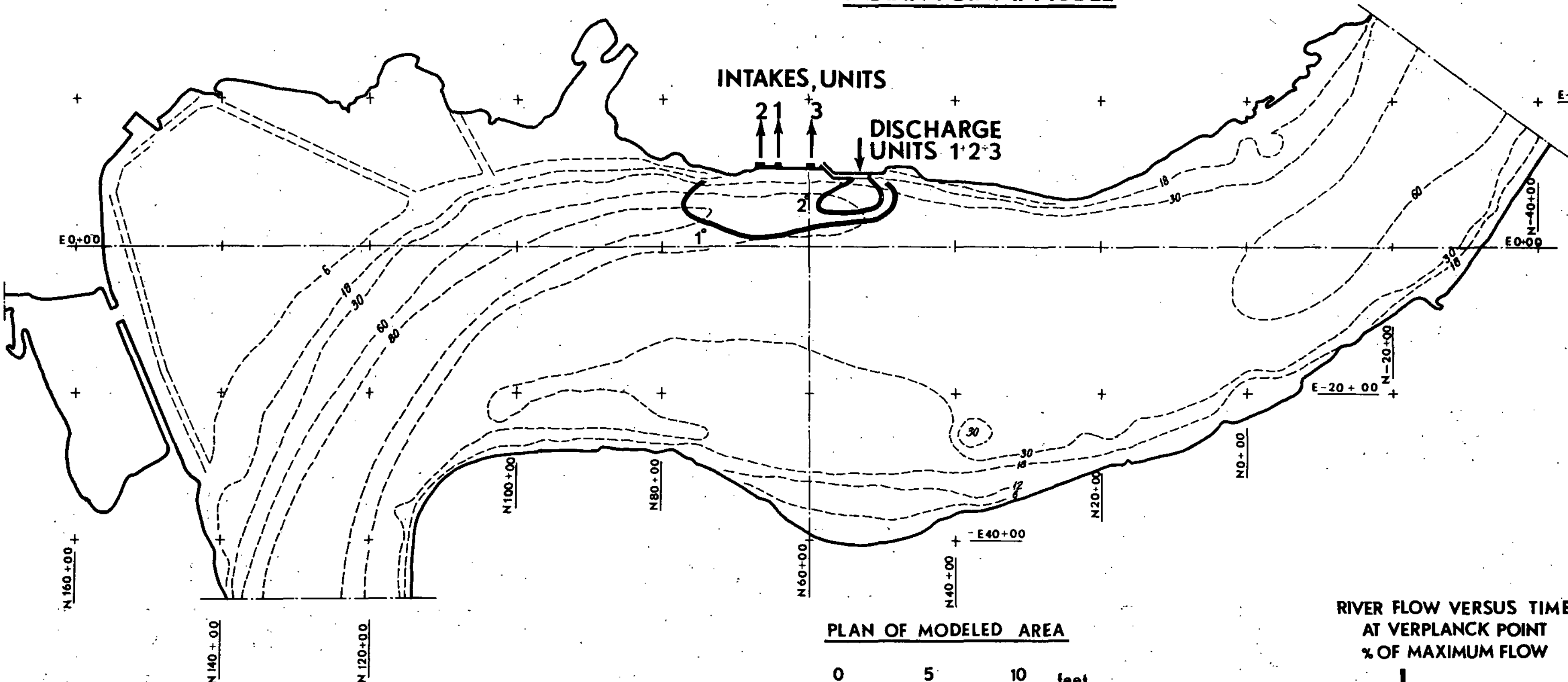
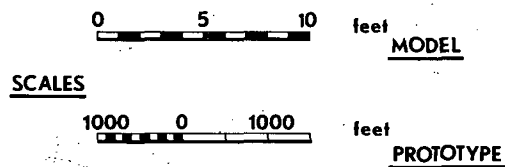
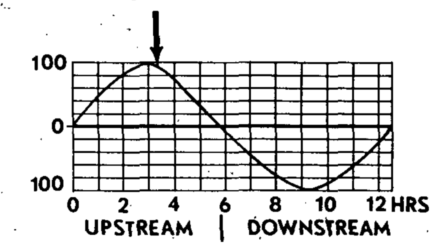
FIG. 48

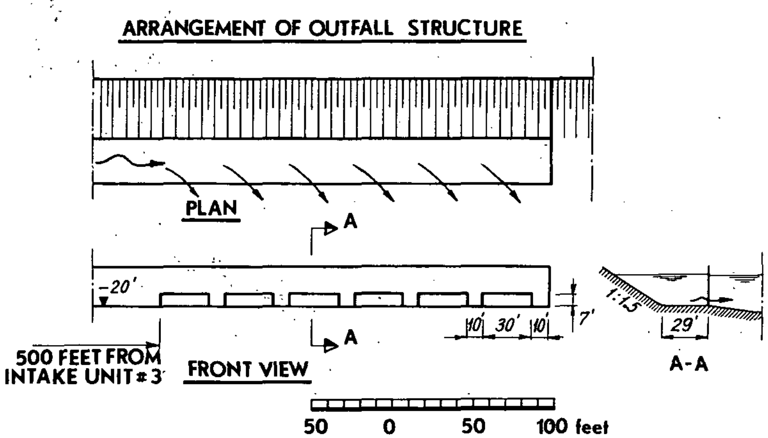
INDIAN POINT II MODEL



PLAN OF MODELED AREA







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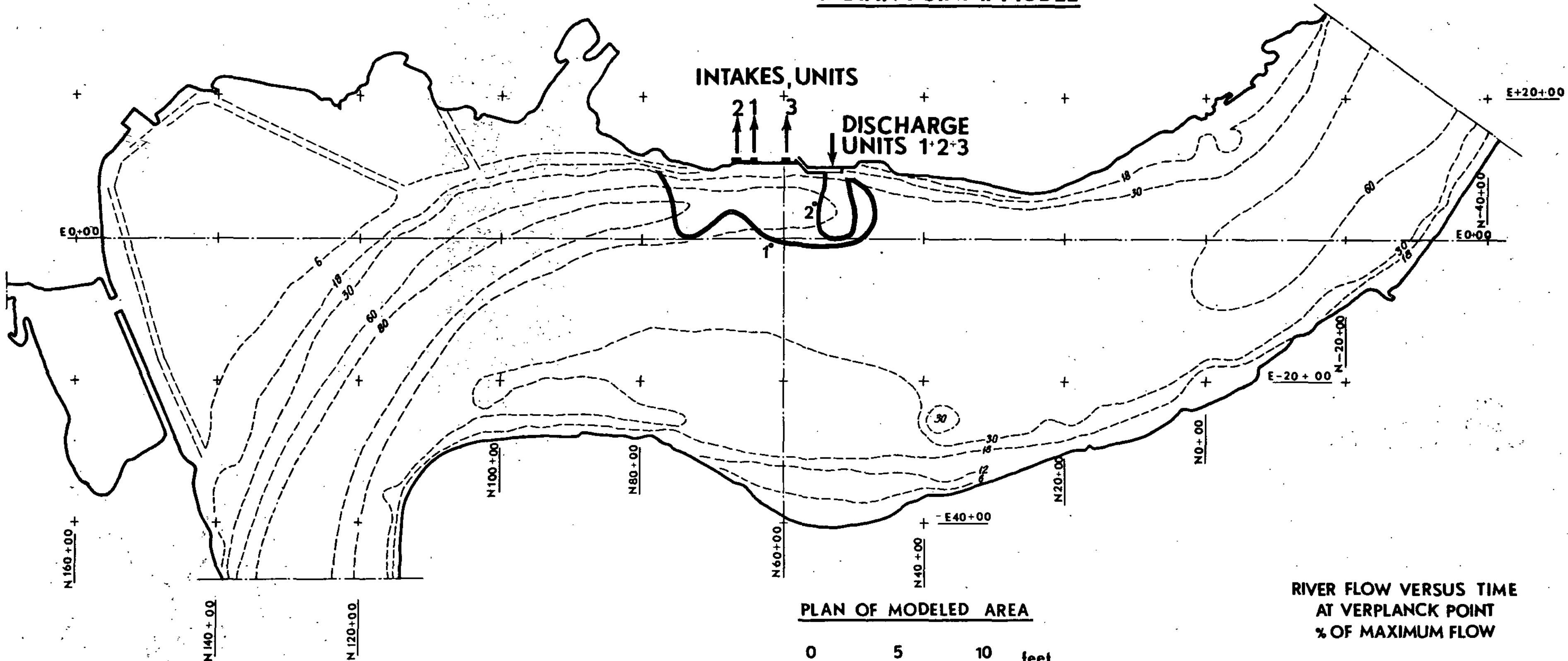
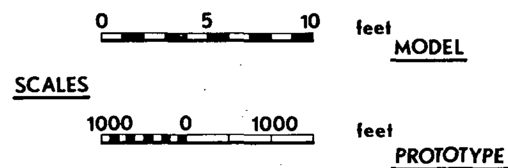
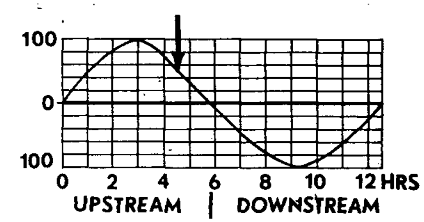
INDIAN POINT II MODEL



PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE

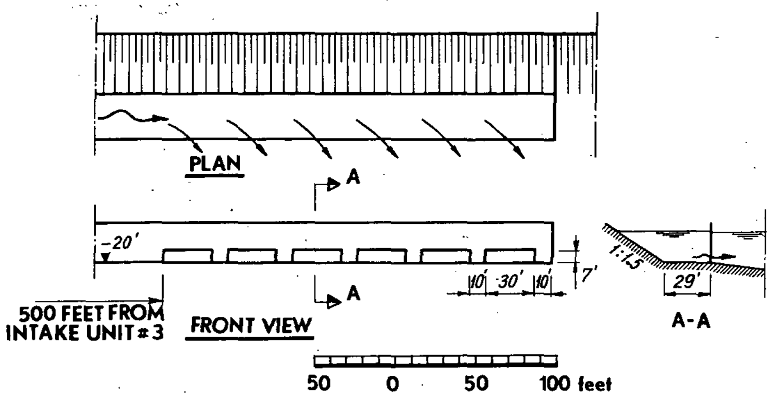


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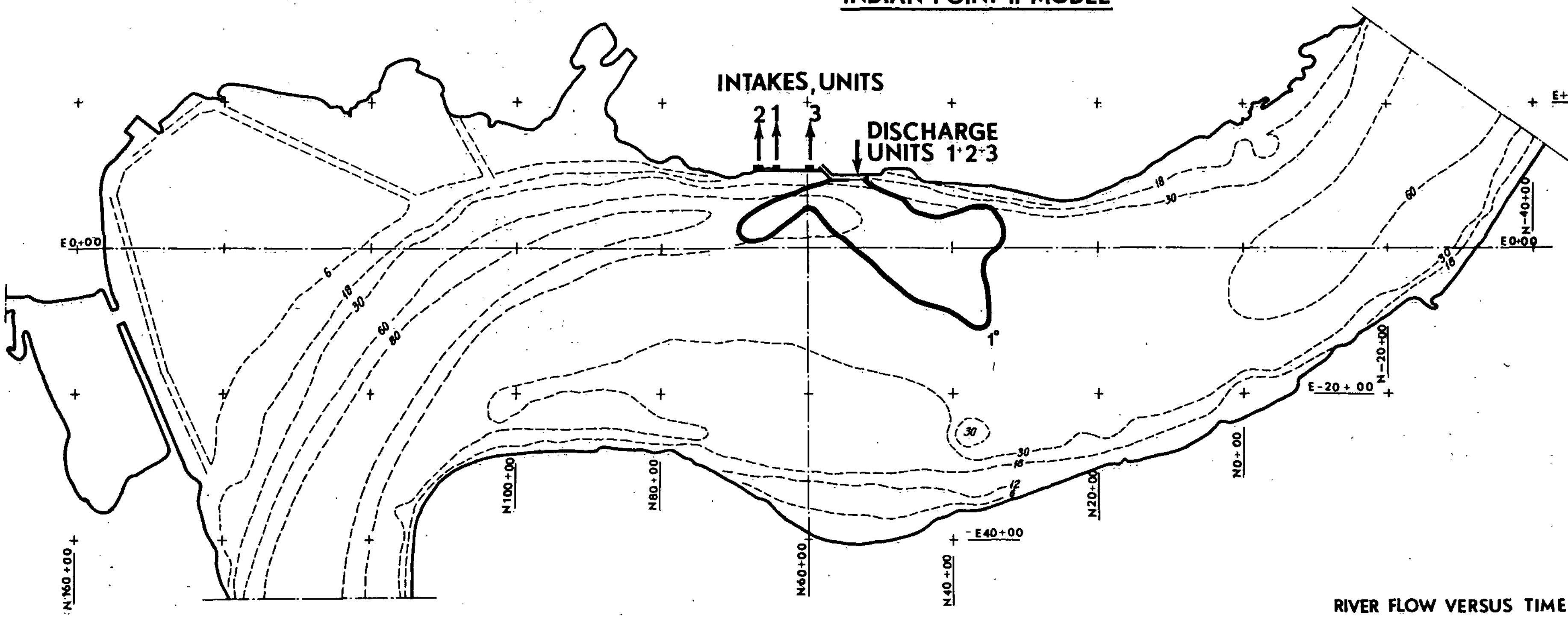
FIG. 50

INDIAN POINT II MODEL



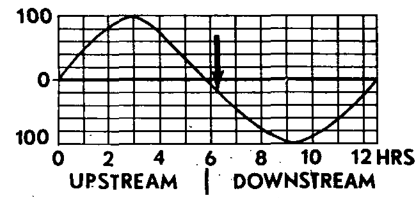
PLAN OF MODELED AREA

SCALES

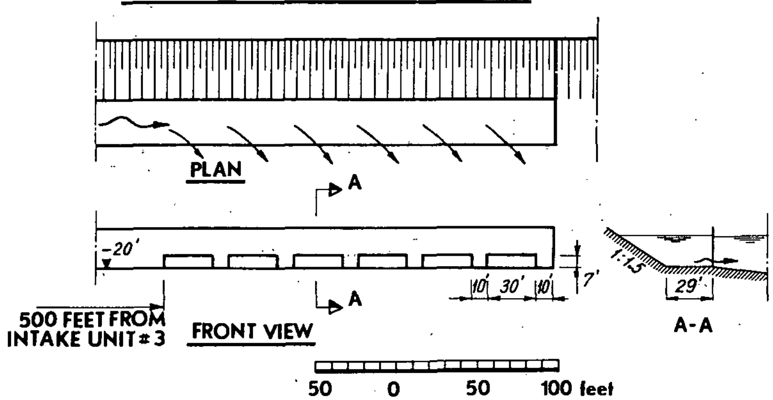
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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WORCESTER POLYTECHNIC INSTITUTE
HYDRAULIC MODEL STUDIES
FOR
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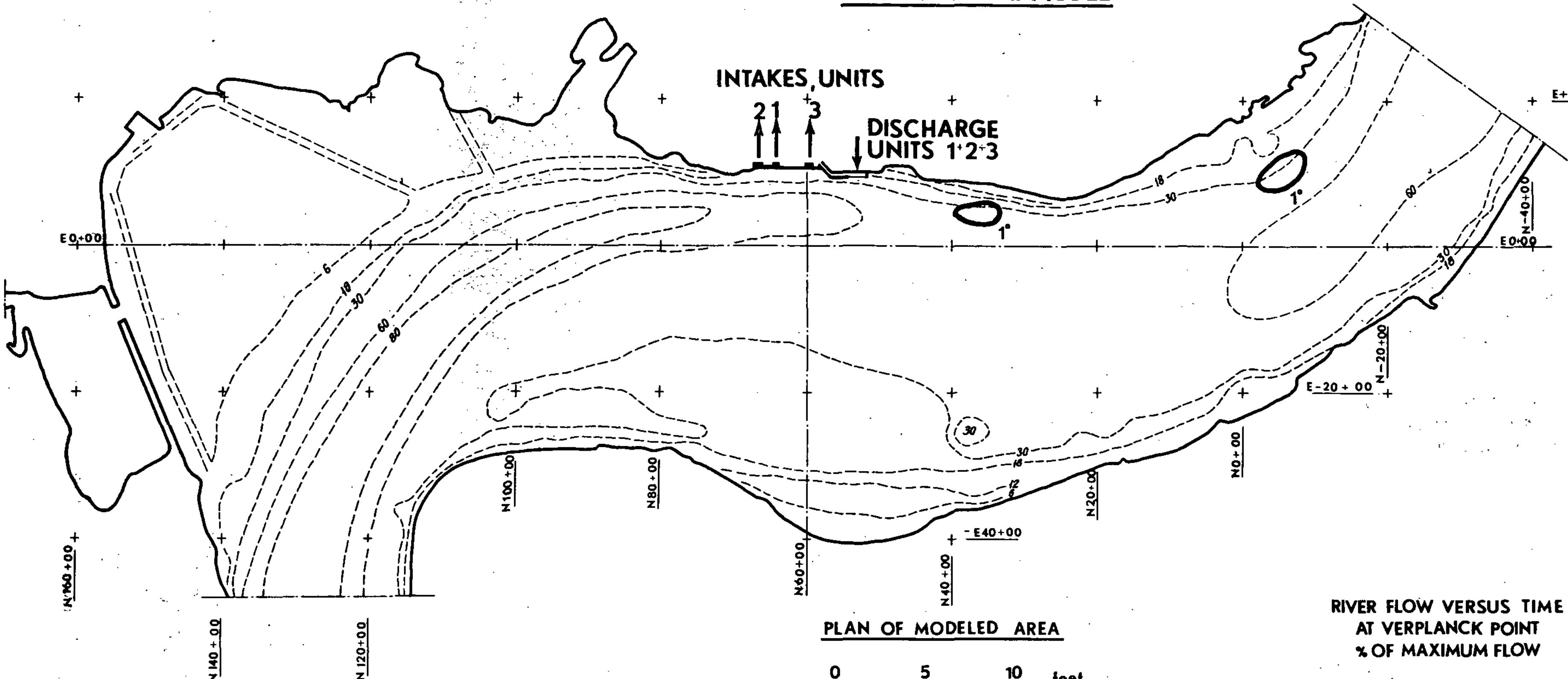
INDIAN POINT II MODEL



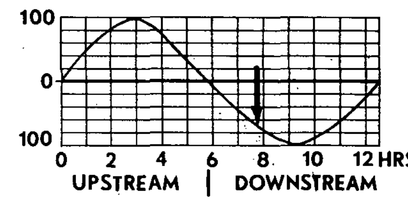
PLAN OF MODELED AREA

SCALES

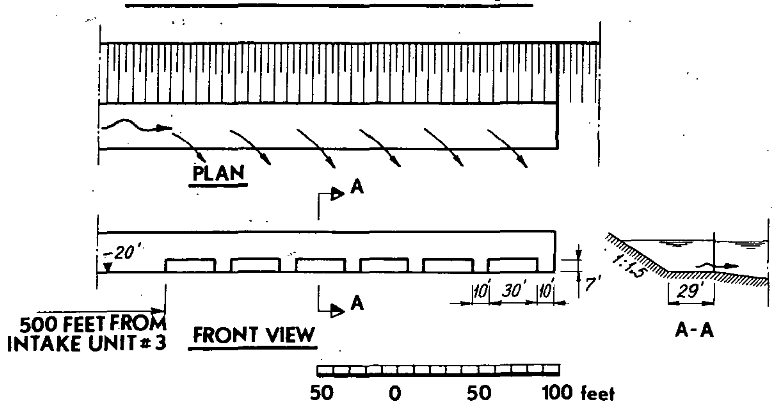
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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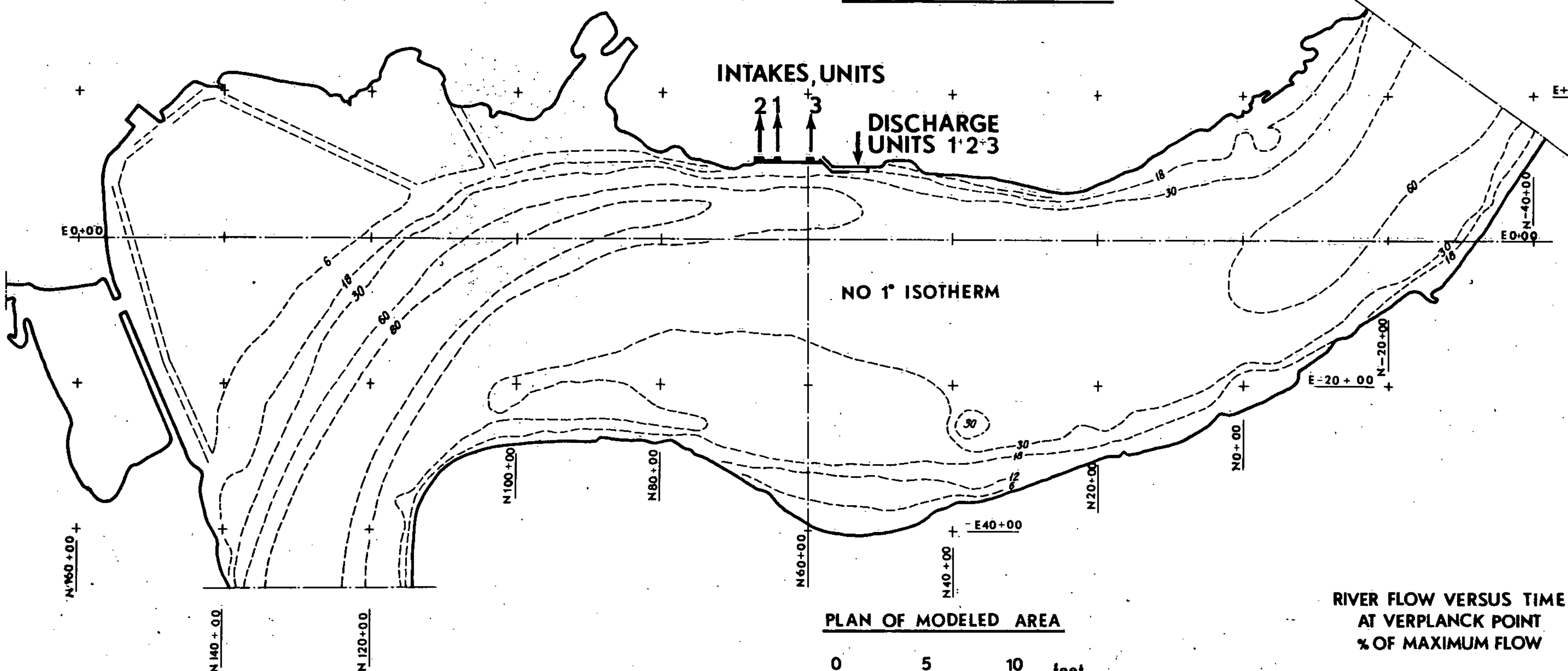
HYDRAULIC MODEL STUDIES
FOR
CONSOLIDATED EDISON COMPANY, N. Y.

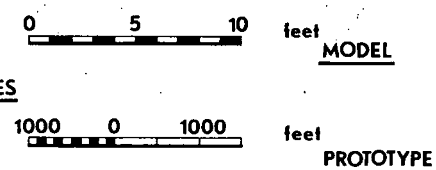
FIG. 52

FIG. 53

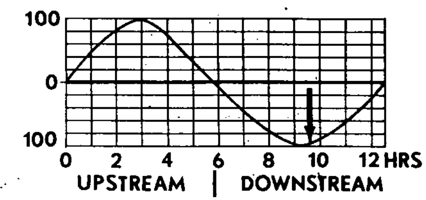
INDIAN POINT II MODEL



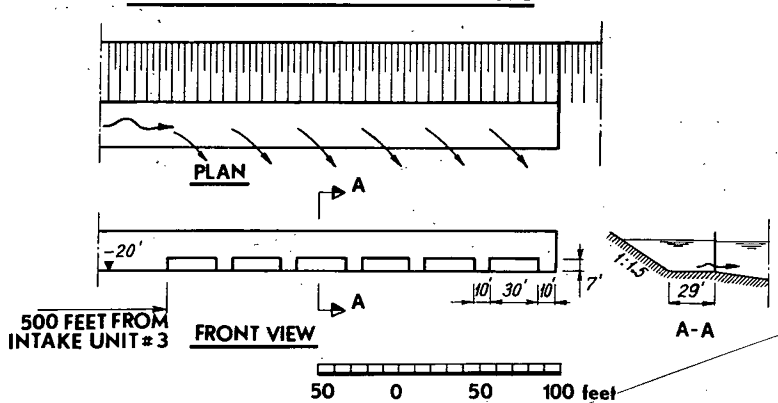
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 529A ; NOV 29 , 1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 51 °F
AIR TEMPERATURE DRY BULB 58.9°F
AIR TEMPERATURE WET BULB 53.5°F
RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 24 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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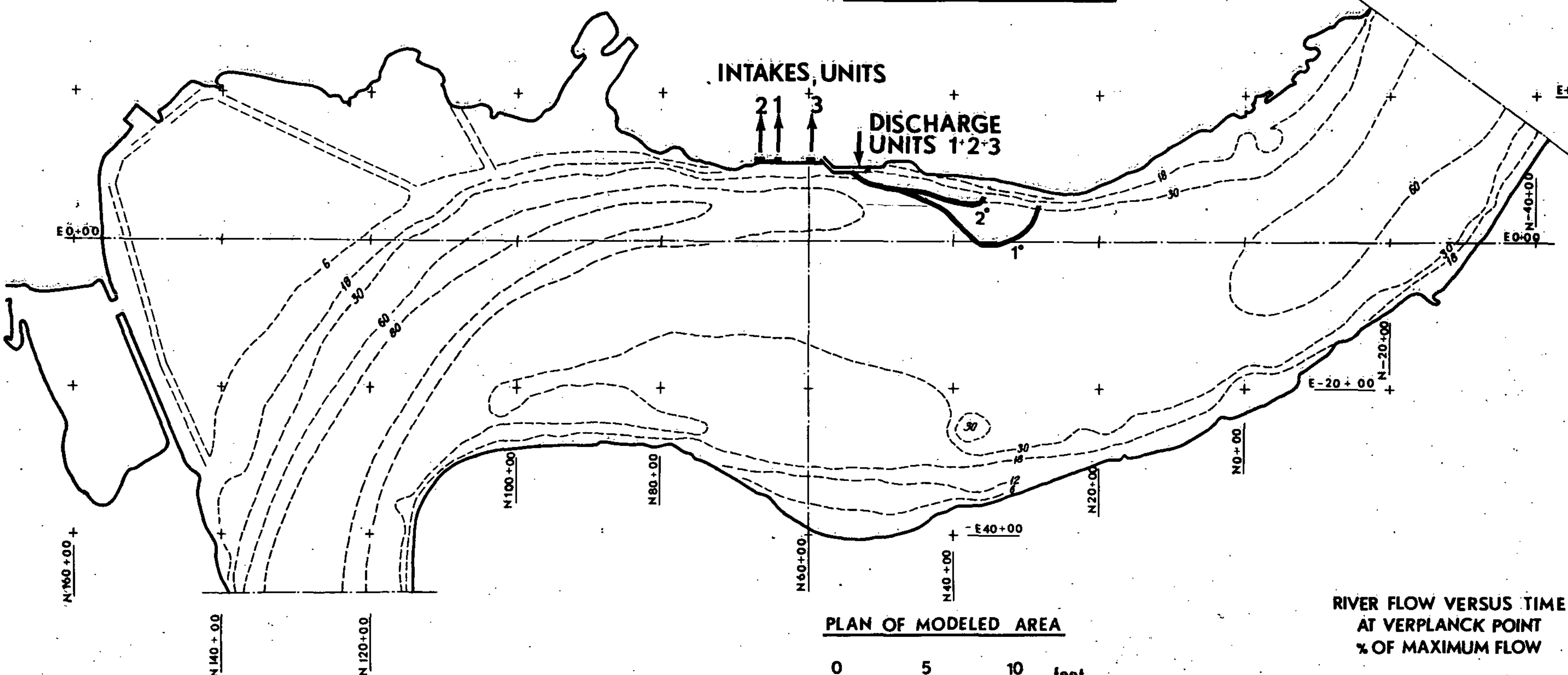
INDIAN POINT II MODEL



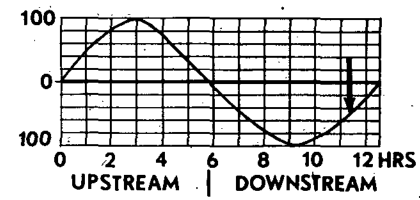
PLAN OF MODELED AREA

SCALES

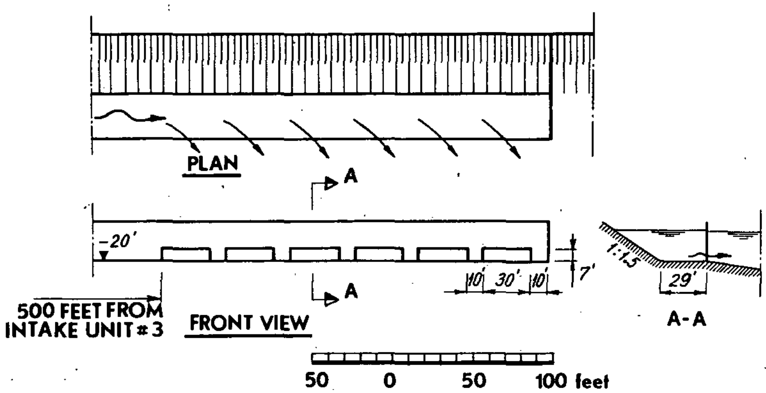
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 529A ; NOV 29 ,1968
UNITS OPERATING AND DISCHARGE 1,2,3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4°F
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DEPTH OF ISOTHERMS 24 feet
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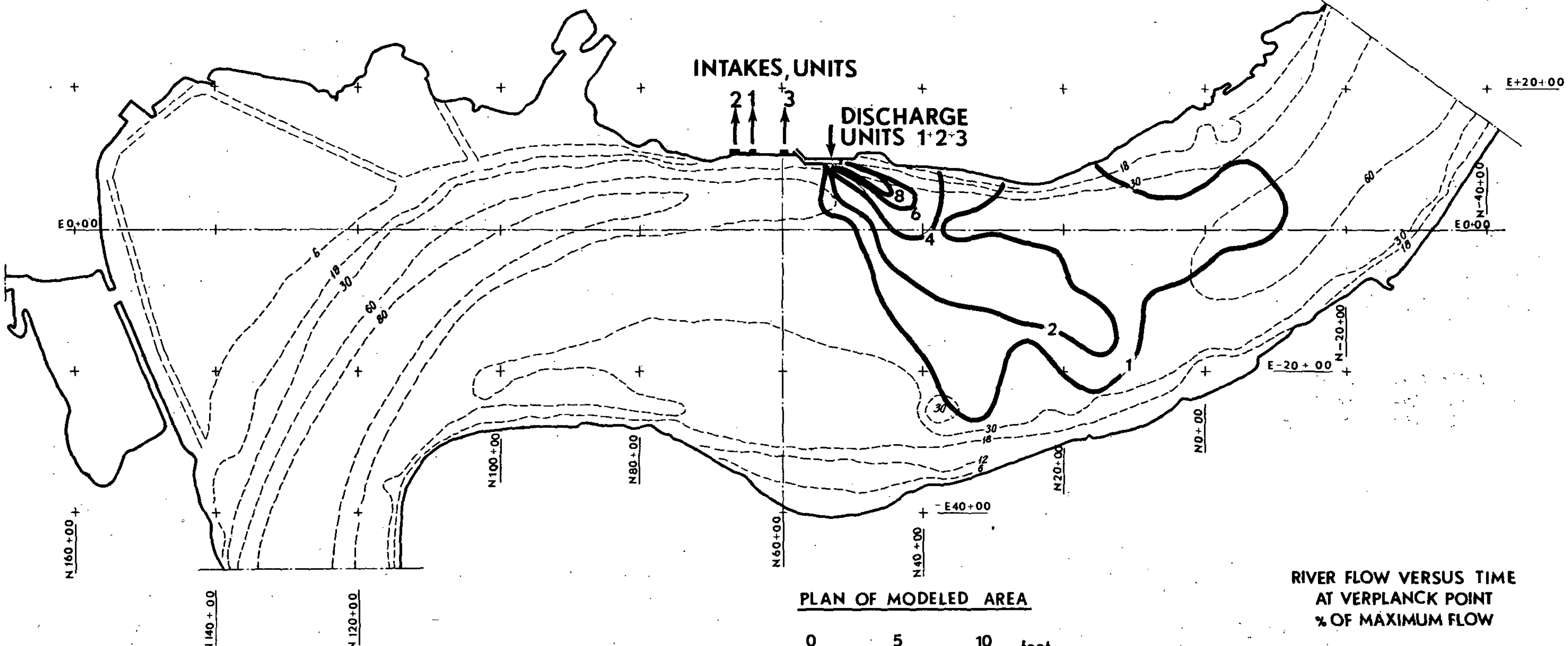
FIG. 54

FIG. 55

INDIAN POINT II MODEL



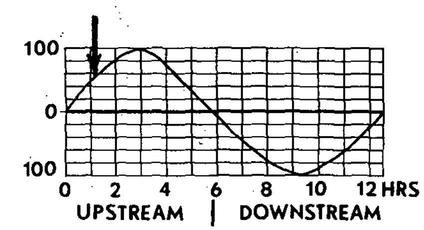
PLAN OF MODELED AREA

SCALES

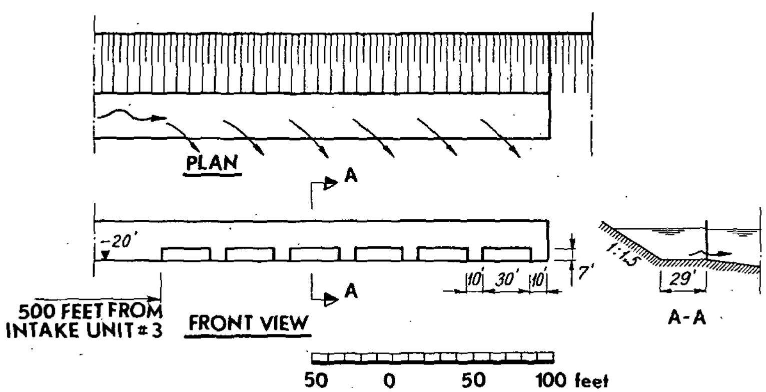
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 533 ; NOV 30, 1968
UNITS OPERATING AND DISCHARGE 3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 80 °F
AIR TEMPERATURE DRY BULB 83.7 °F
AIR TEMPERATURE WET BULB 78 °F
RELATIVE HUMIDITY 77 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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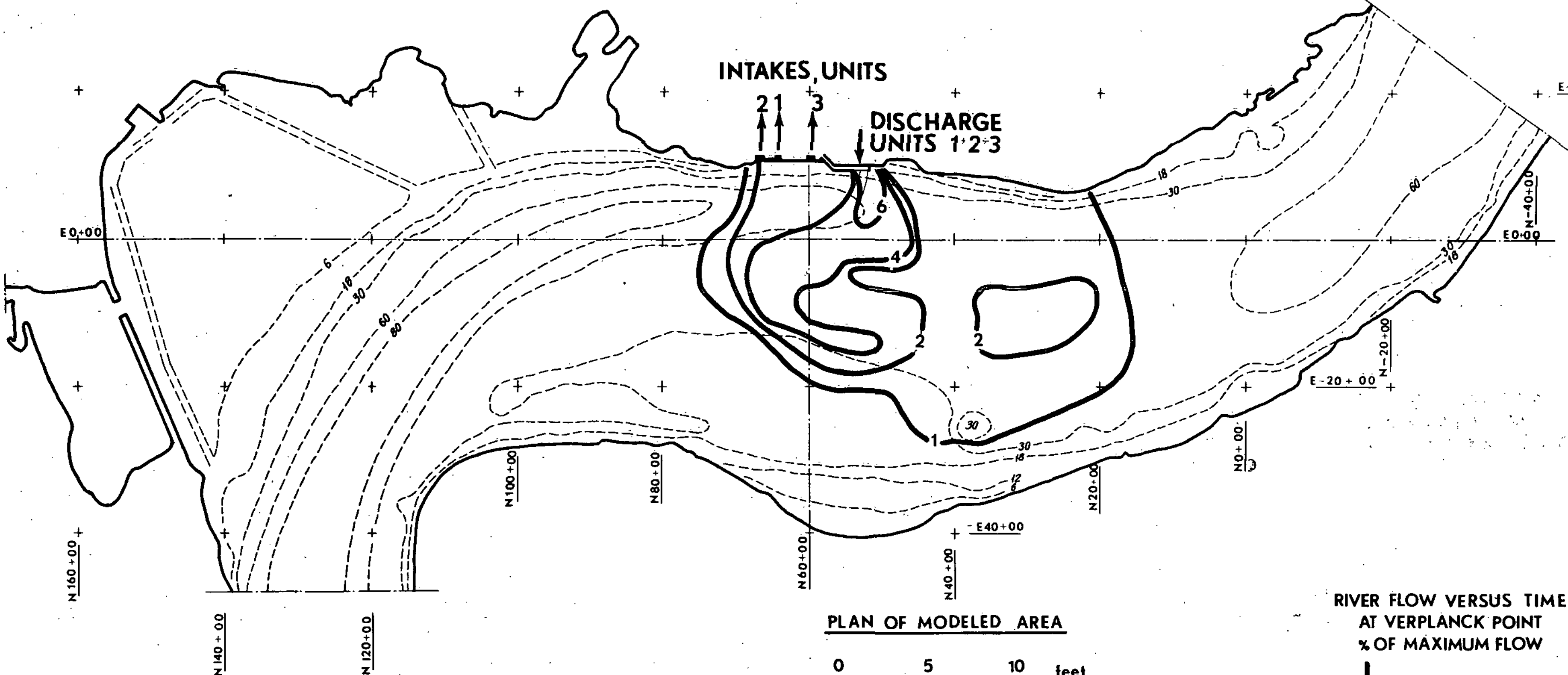
INDIAN POINT II MODEL

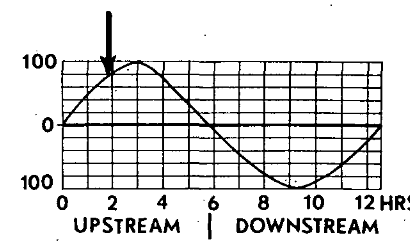


PLAN OF MODELED AREA

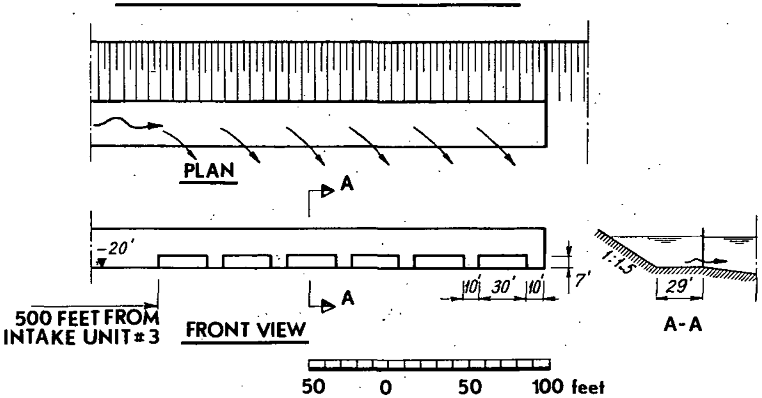
SCALES

0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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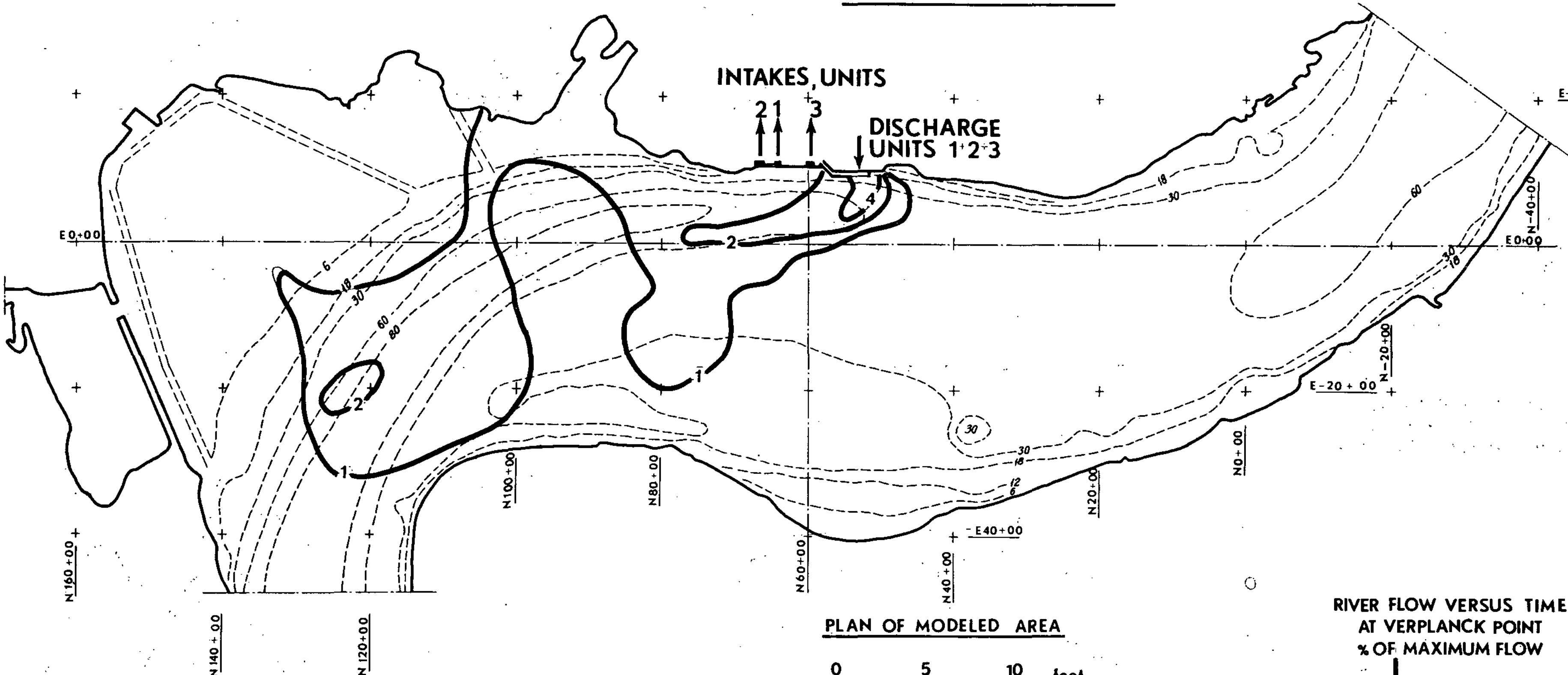
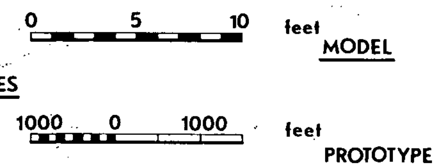
FIG. 56

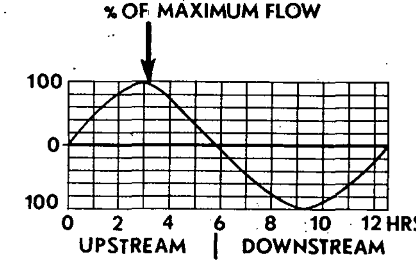
INDIAN POINT II MODEL



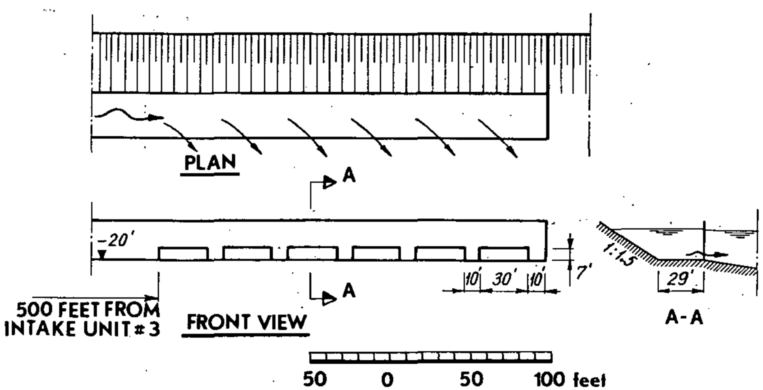
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 533 ; NOV 30, 1968
UNITS OPERATING AND DISCHARGE 3; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 80 °F
AIR TEMPERATURE DRY BULB 83.7 °F
AIR TEMPERATURE WET BULB 78 °F
RELATIVE HUMIDITY 77 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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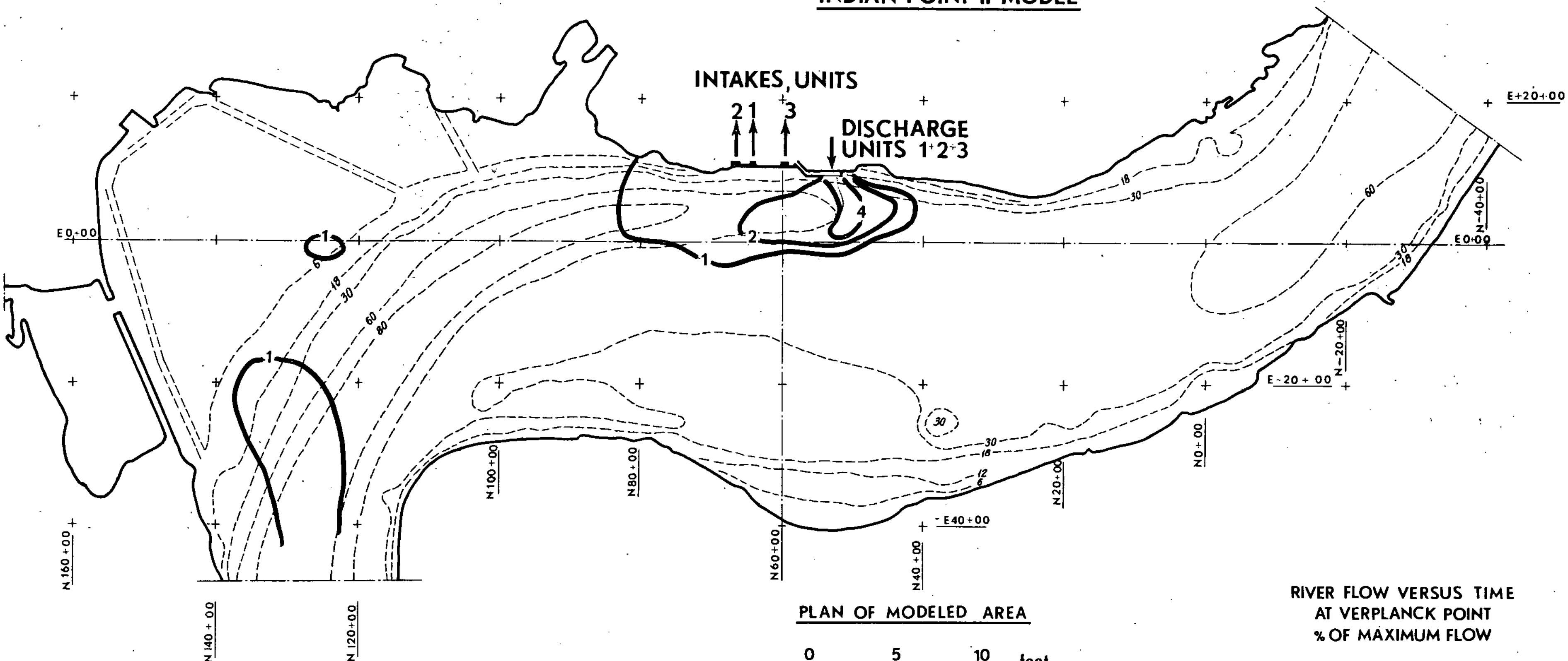
INDIAN POINT II MODEL



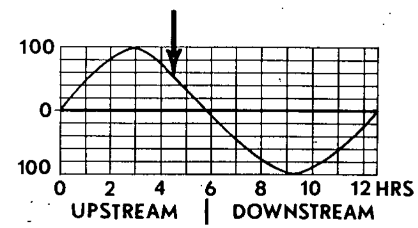
PLAN OF MODELED AREA

SCALES

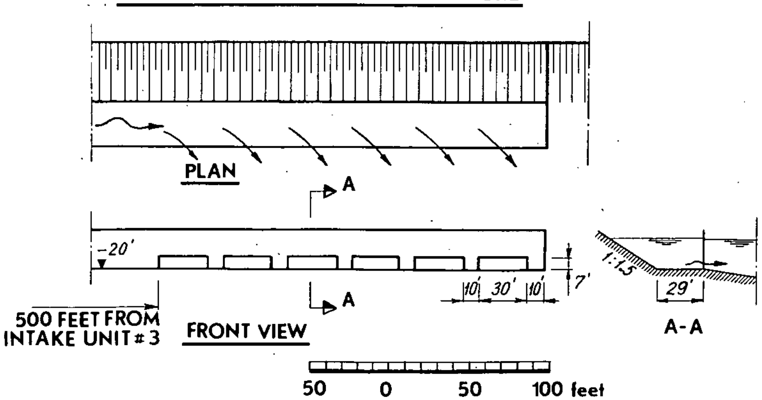
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 533 ; NOV 30, 1968 70

UNITS OPERATING AND DISCHARGE 3; 4670 cfs

DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F

TIME IN TIDE CYCLE SEE DIAGRAM

RIVER AMBIENT TEMPERATURE 80 °F

AIR TEMPERATURE DRY BULB 83.7 °F

AIR TEMPERATURE WET BULB 78 °F

RELATIVE HUMIDITY 77 %

DEPTH OF ISOTHERMS 0 feet

ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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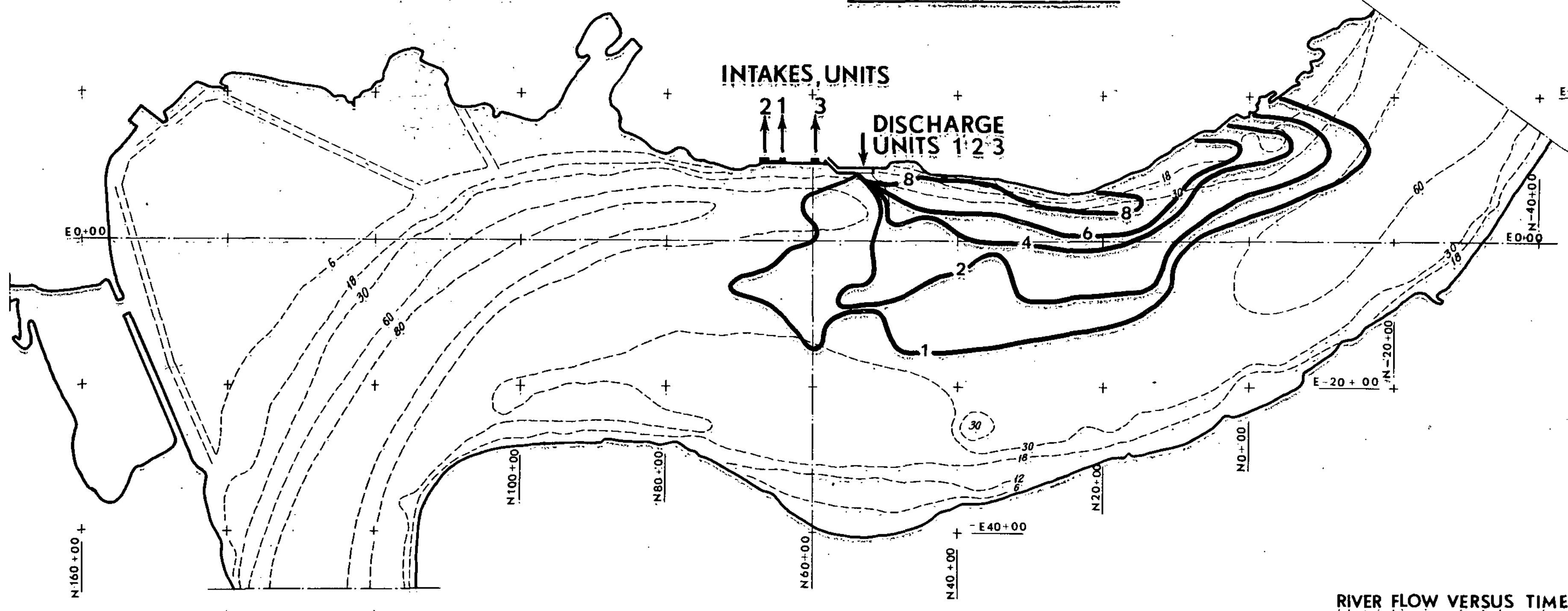
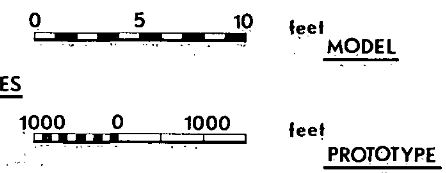
FIG. 58

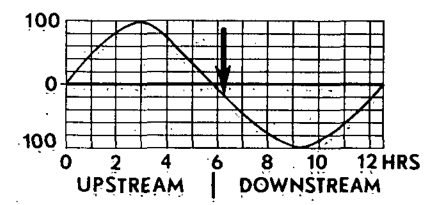
INDIAN POINT II MODEL



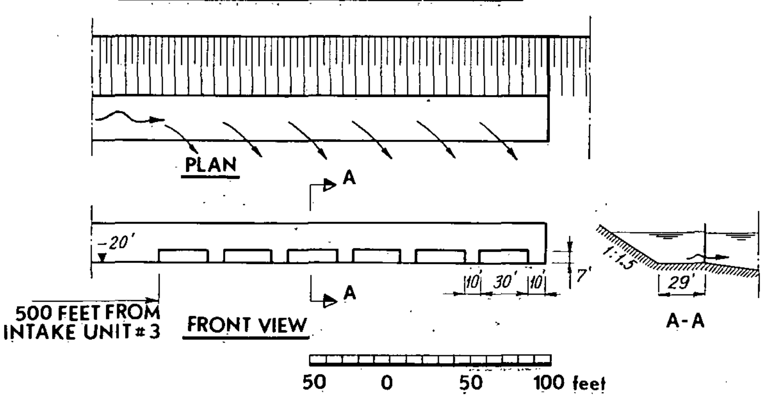
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 533 ; NOV 30, 1968
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TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE DRY BULB 83.7 °F
AIR TEMPERATURE WET BULB 78 °F
RELATIVE HUMIDITY 77 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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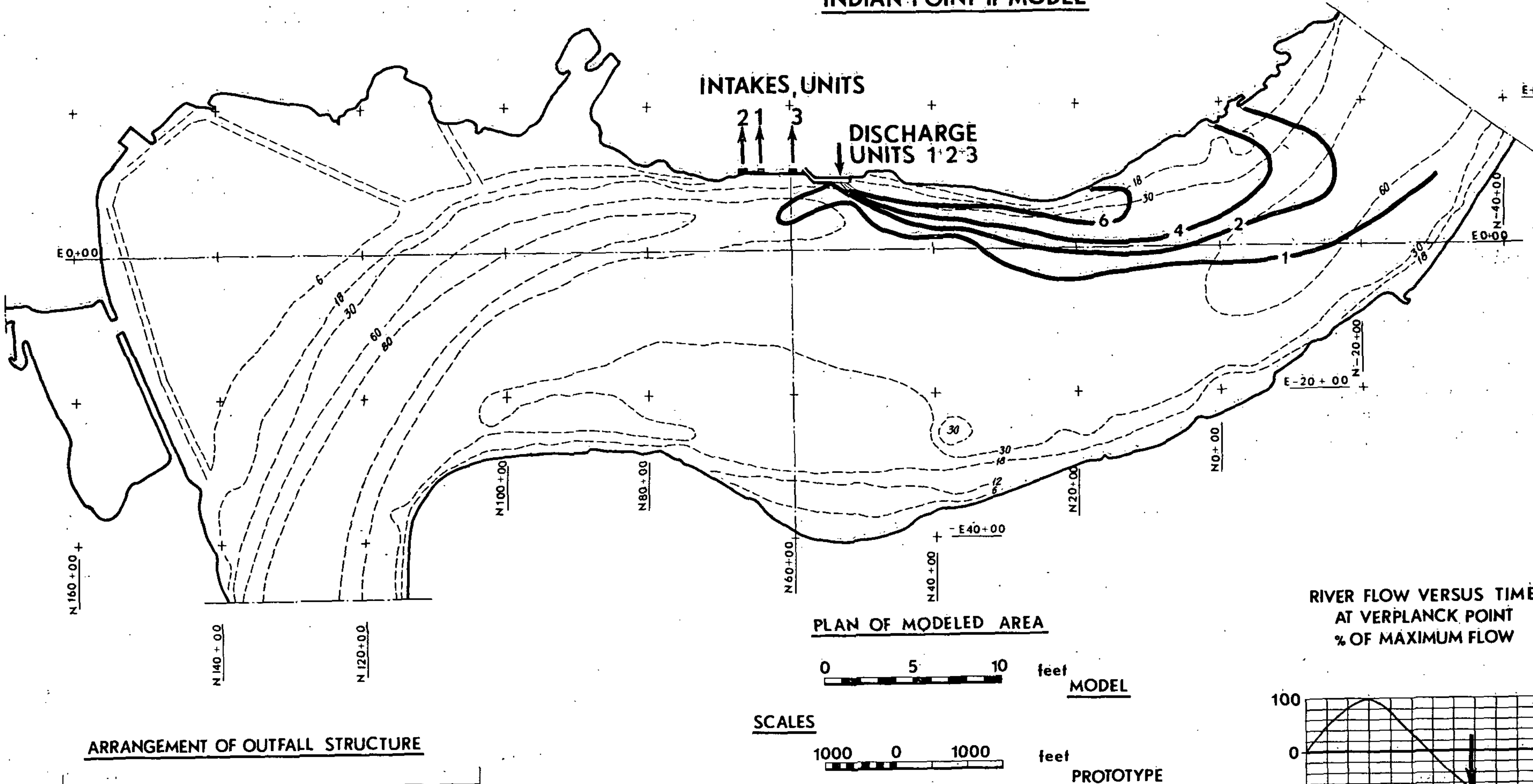
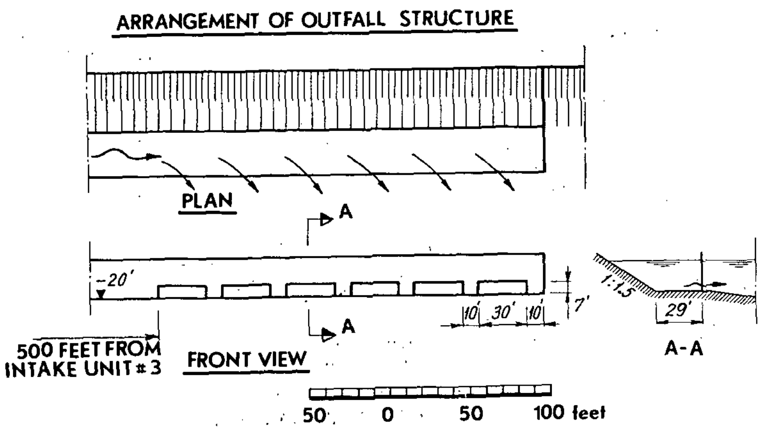
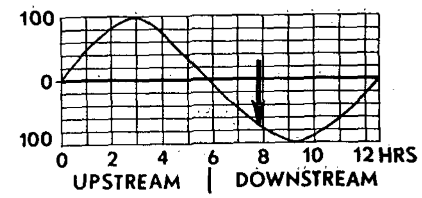
INDIAN POINT II MODEL





RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



TEST CONDITIONS

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DEPTH OF ISOTHERMS 0 feet
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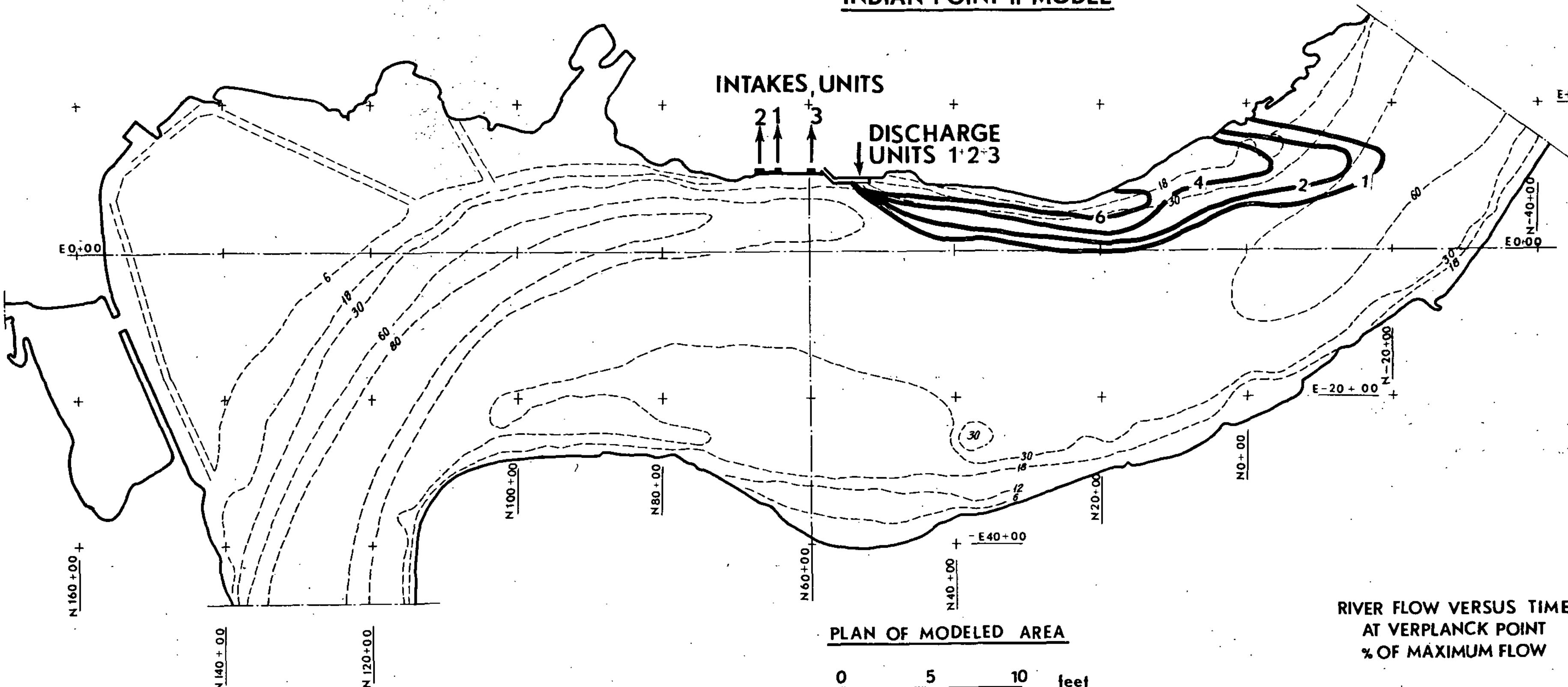
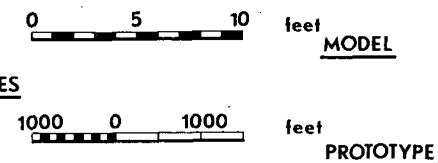
FIG. 60

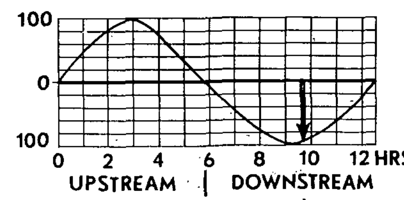
FIG. 61

INDIAN POINT II MODEL

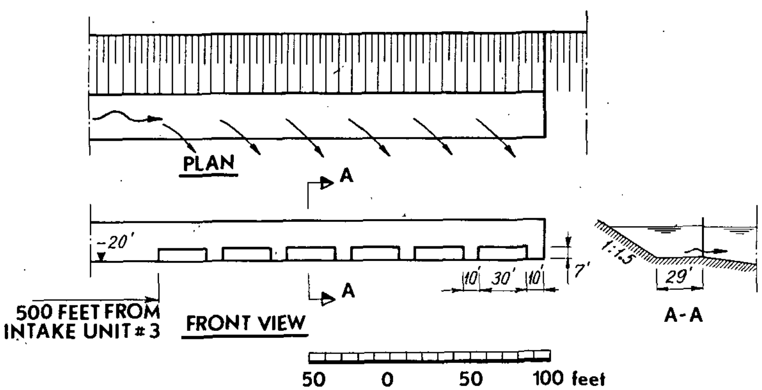


PLAN OF MODELED AREA





ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 533 ; NOV 30 ,1968
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DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE WET BULB 78 °F
RELATIVE HUMIDITY 77 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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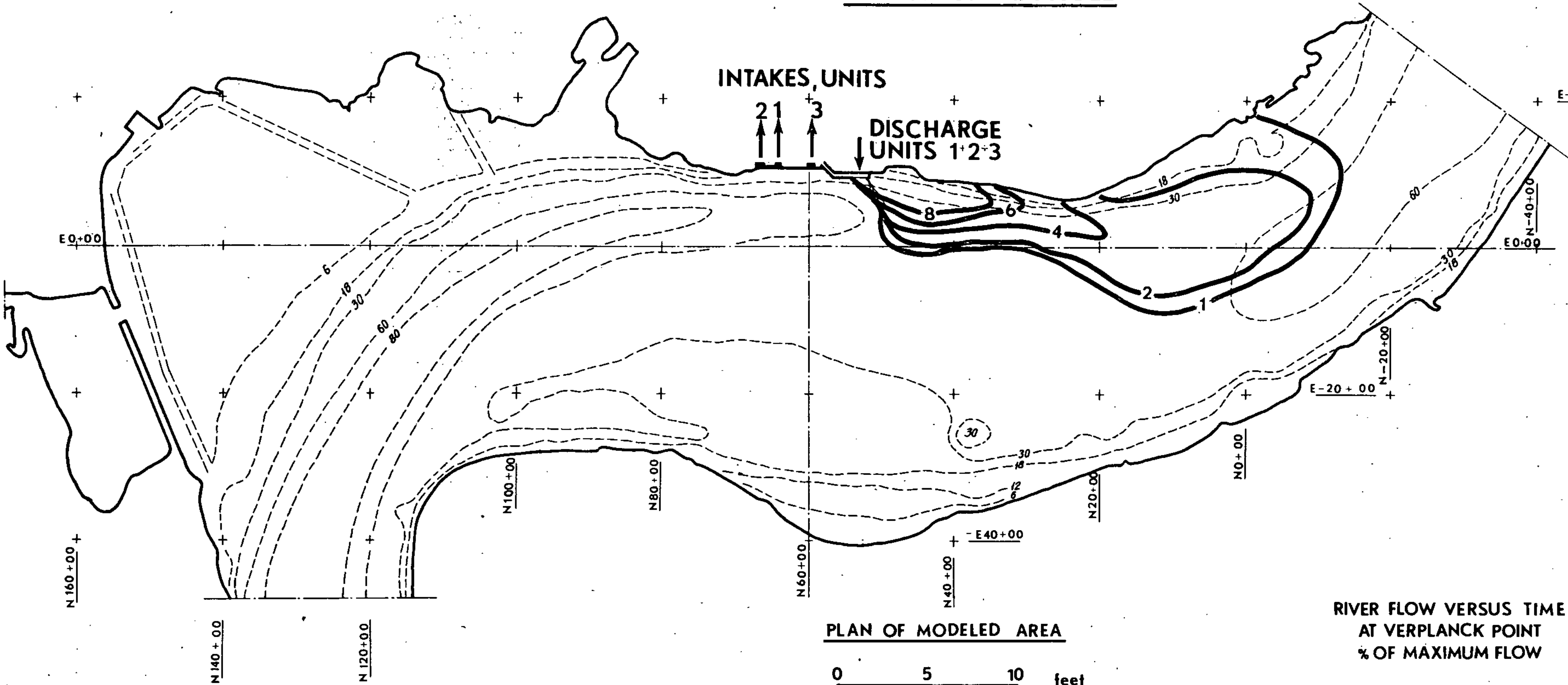
INDIAN POINT II MODEL

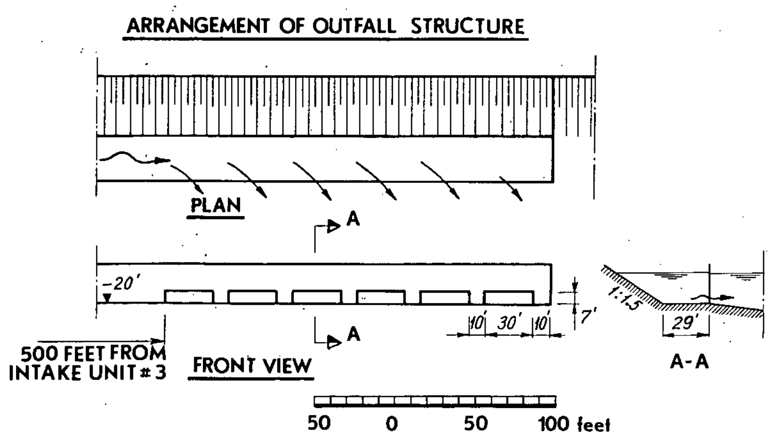


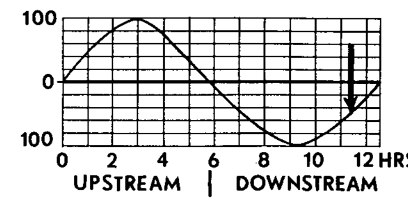
PLAN OF MODELED AREA

SCALES

0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE





TEST CONDITIONS

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DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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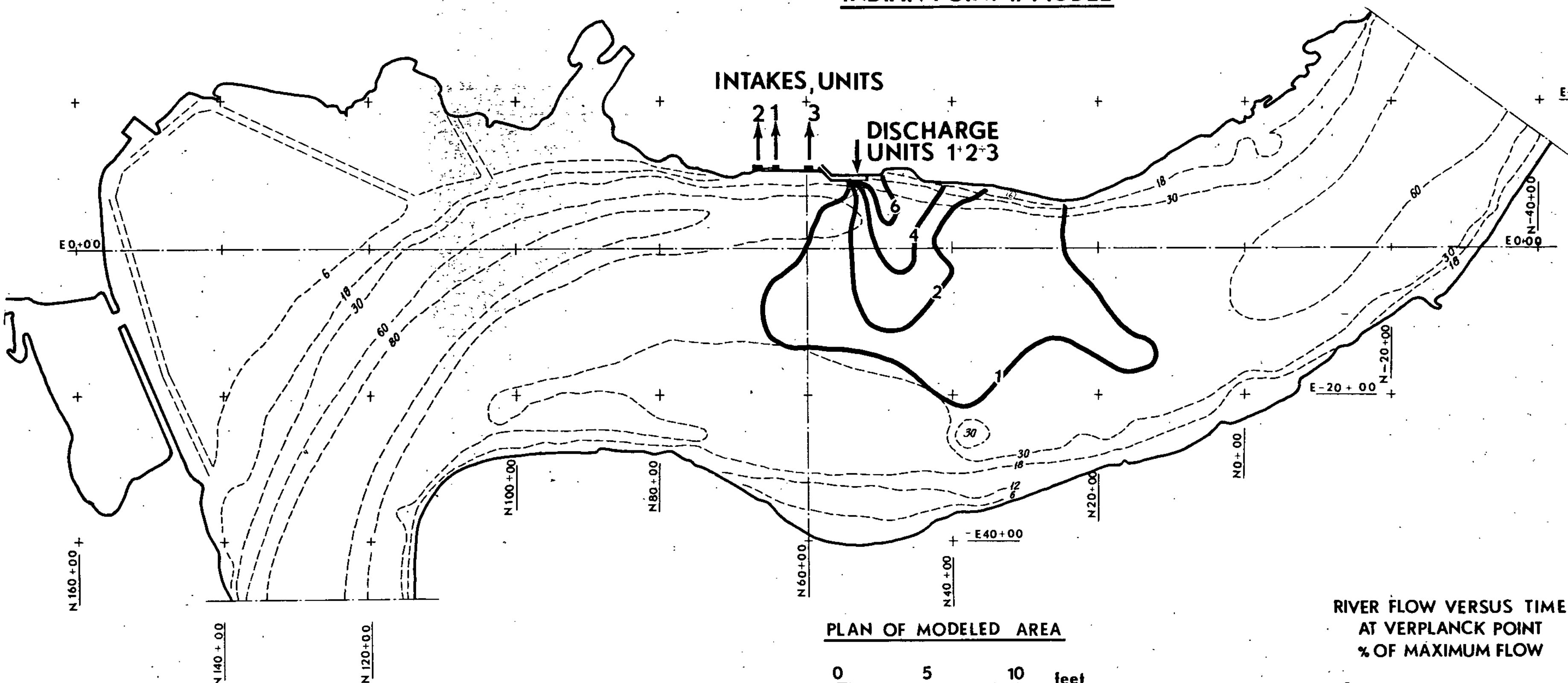
FIG. 62

INDIAN POINT II MODEL



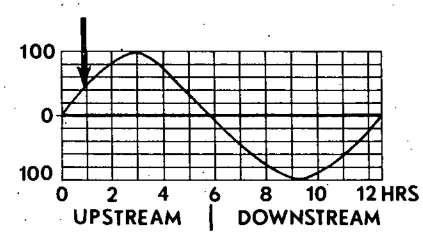
PLAN OF MODELED AREA

SCALES

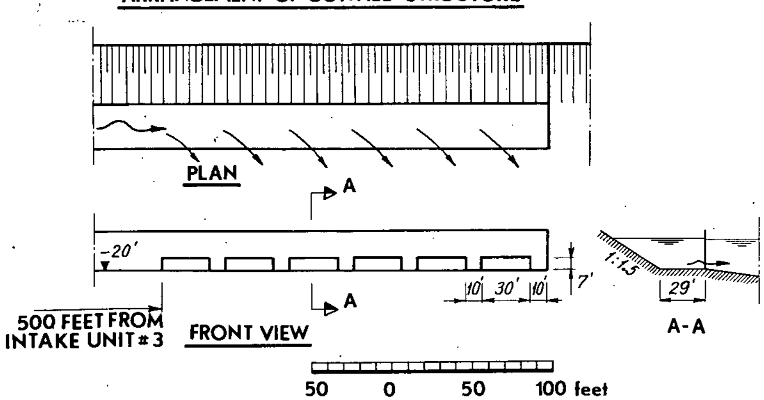
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 534 ; DEC 2,1968
UNITS OPERATING AND DISCHARGE 3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 80.0 °F
AIR TEMPERATURE DRY BULB 87.8 °F
AIR TEMPERATURE WET BULB 84.0 °F
RELATIVE HUMIDITY 84 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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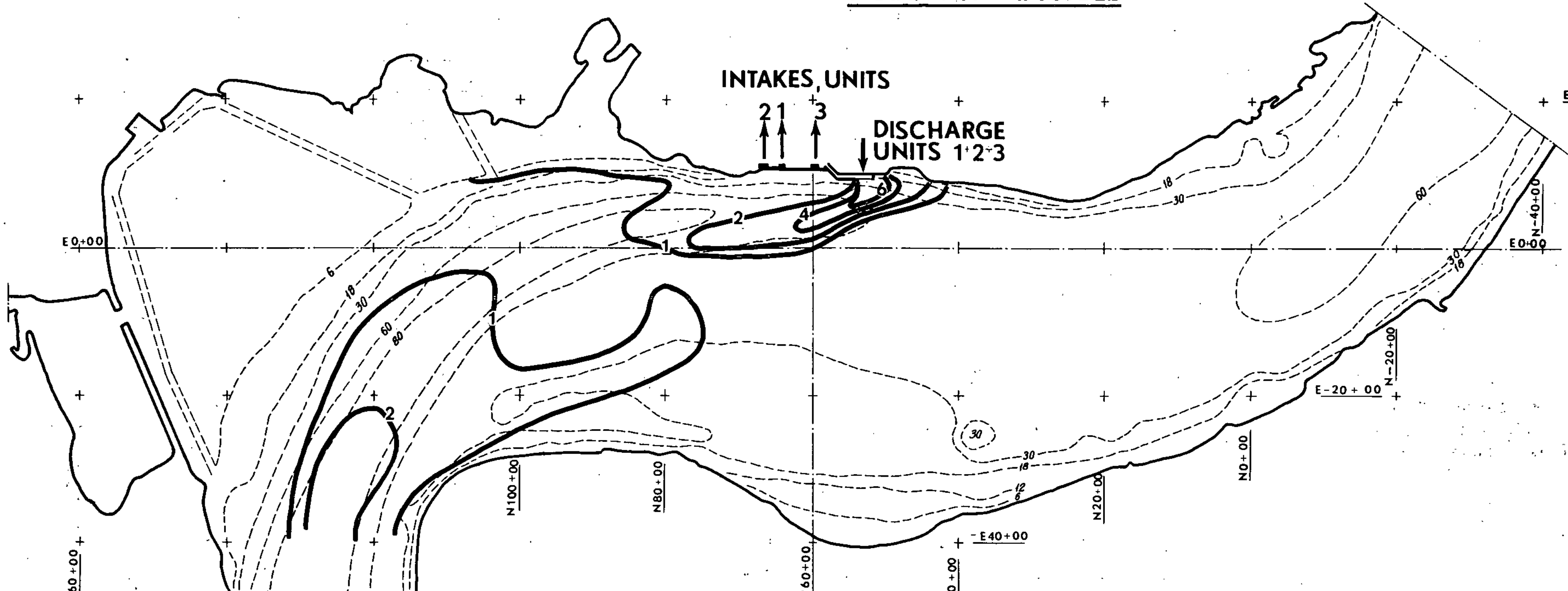
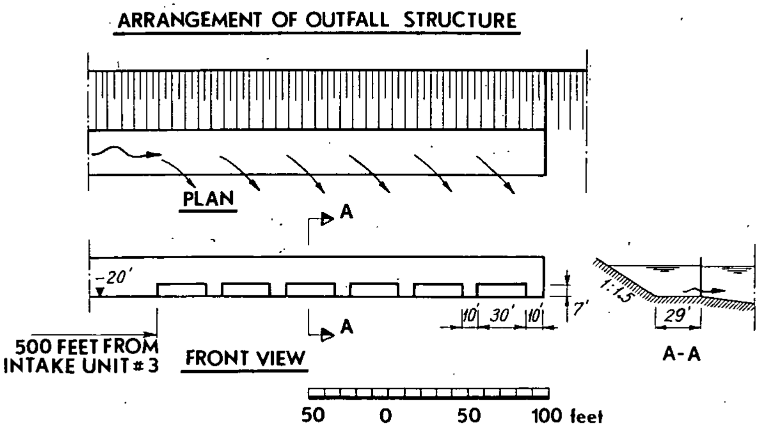
INDIAN POINT II MODEL





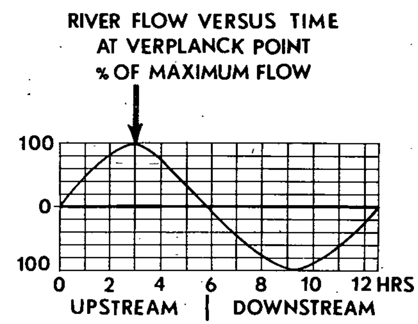


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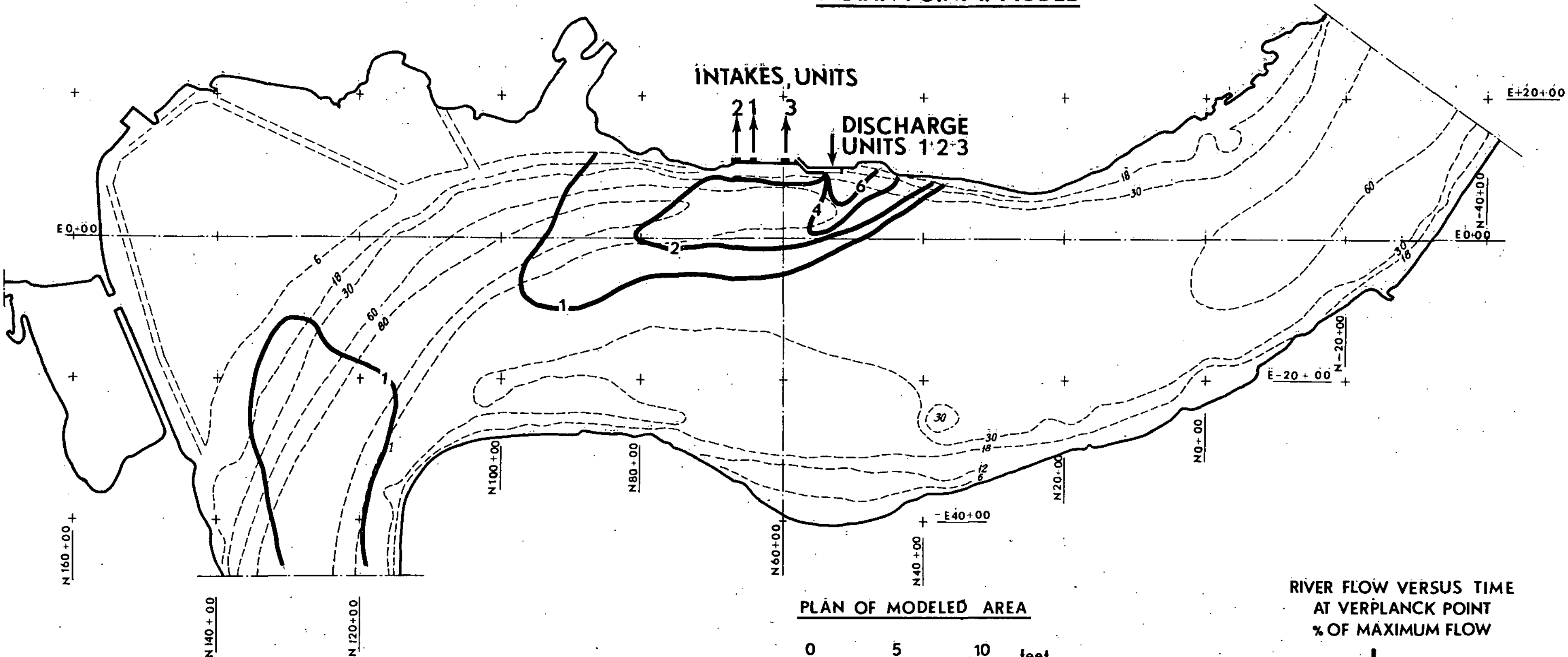
FIG. 64

FIG. 65

INDIAN POINT II MODEL



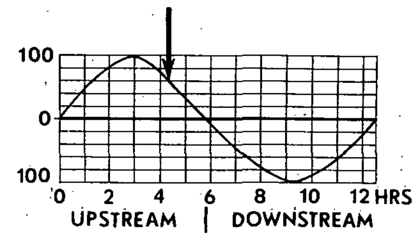
PLAN OF MODELED AREA

SCALES

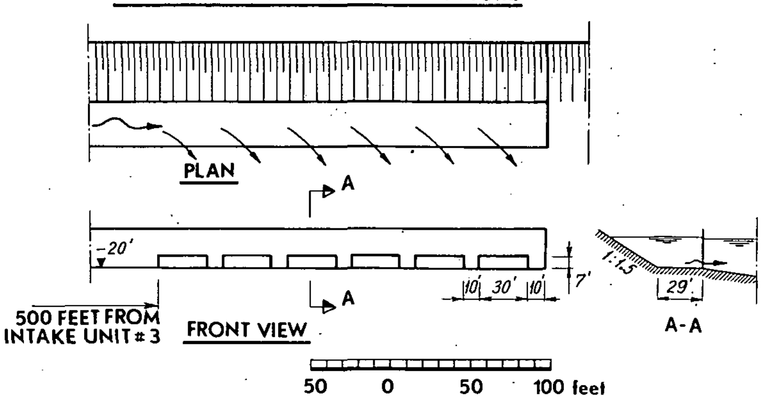
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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RELATIVE HUMIDITY 84 %
DEPTH OF ISOTHERMS 6 feet
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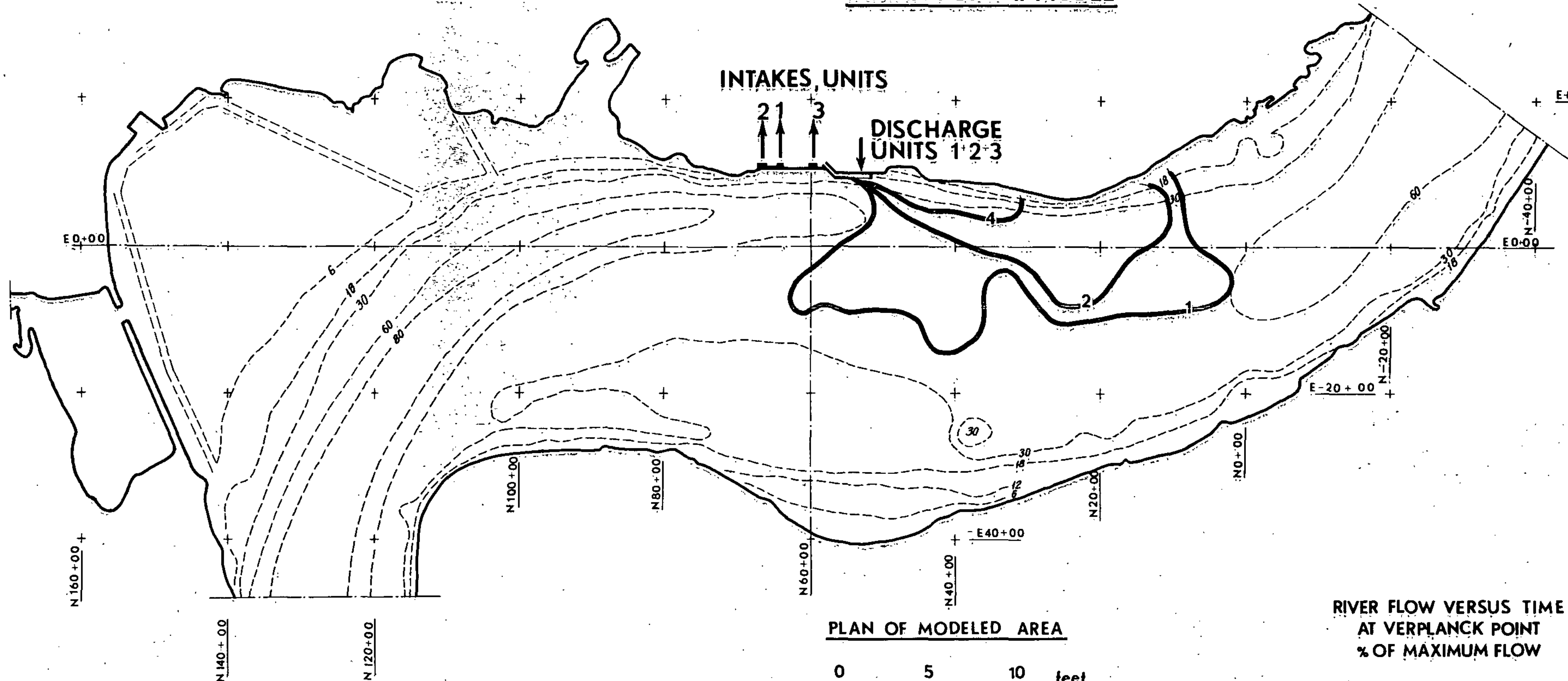
INDIAN POINT II MODEL



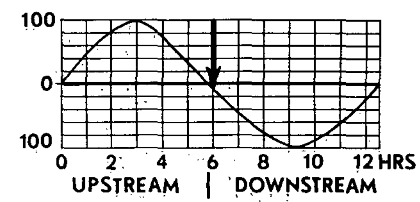
PLAN OF MODELED AREA

SCALES

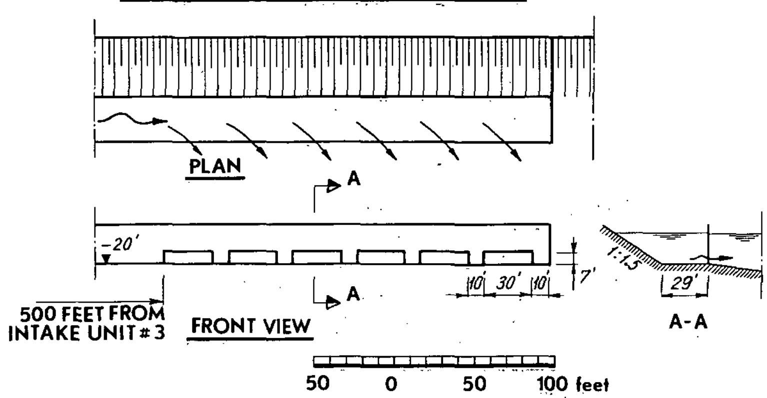
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



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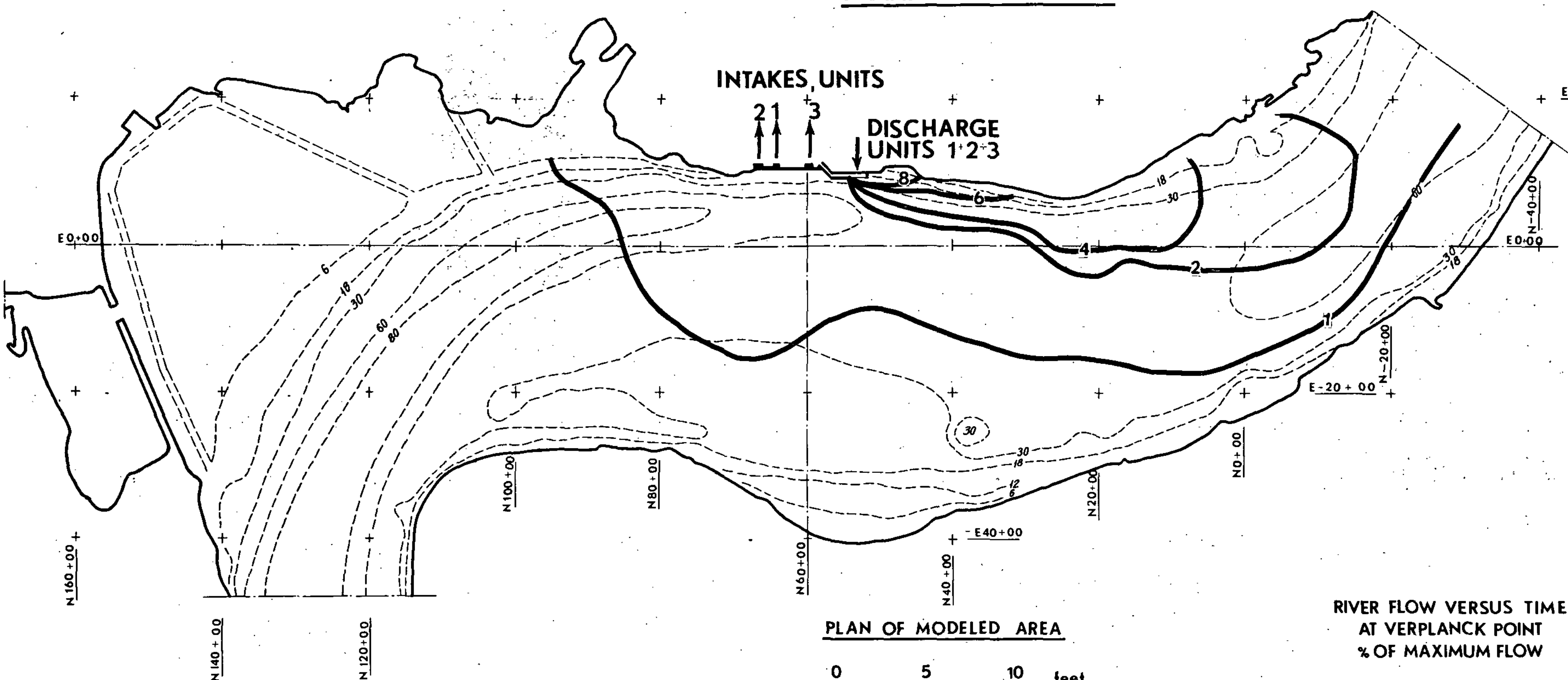
FOR
CONSOLIDATED EDISON COMPANY, N. Y.

FIG. 66

FIG. 67

INDIAN POINT II MODEL



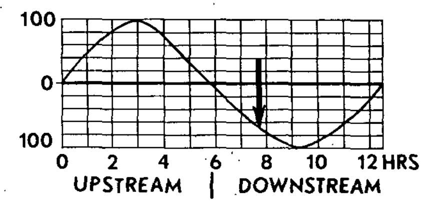
PLAN OF MODELED AREA

SCALES

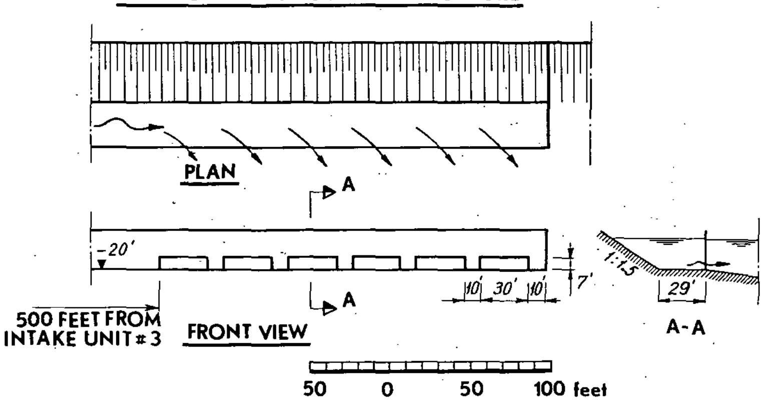
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 534 ; DEC 2, 1968
UNITS OPERATING AND DISCHARGE 3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 80.0 °F
AIR TEMPERATURE DRY BULB 87.8 °F
AIR TEMPERATURE WET BULB 84.0 °F
RELATIVE HUMIDITY 84 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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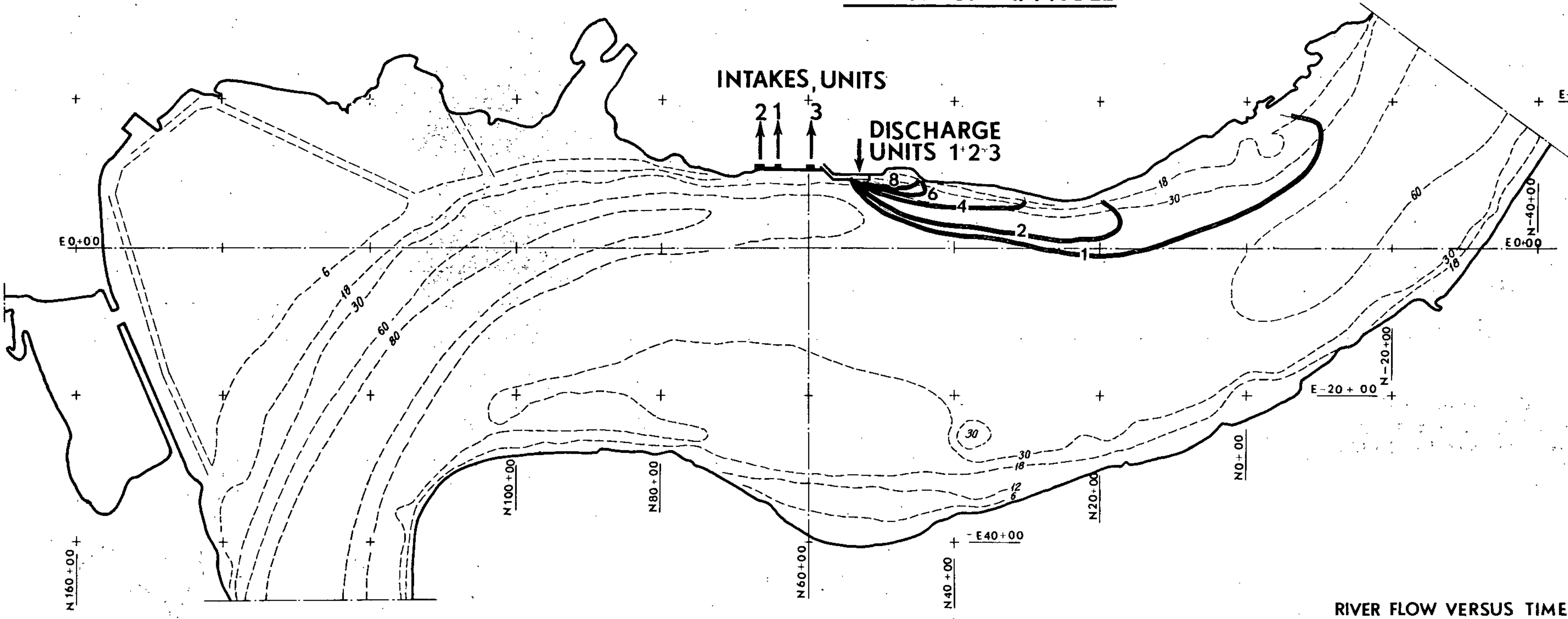
INDIAN POINT II MODEL



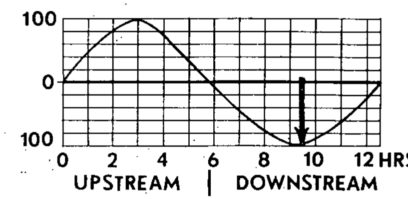
PLAN OF MODELED AREA

SCALES

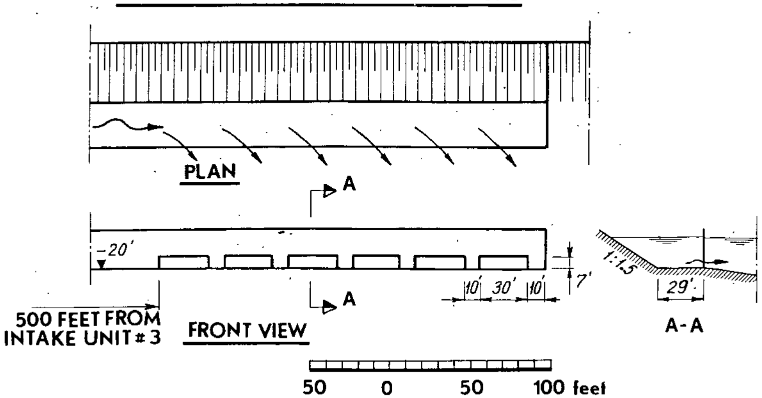
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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TIME IN TIDE CYCLE SEE DIAGRAM
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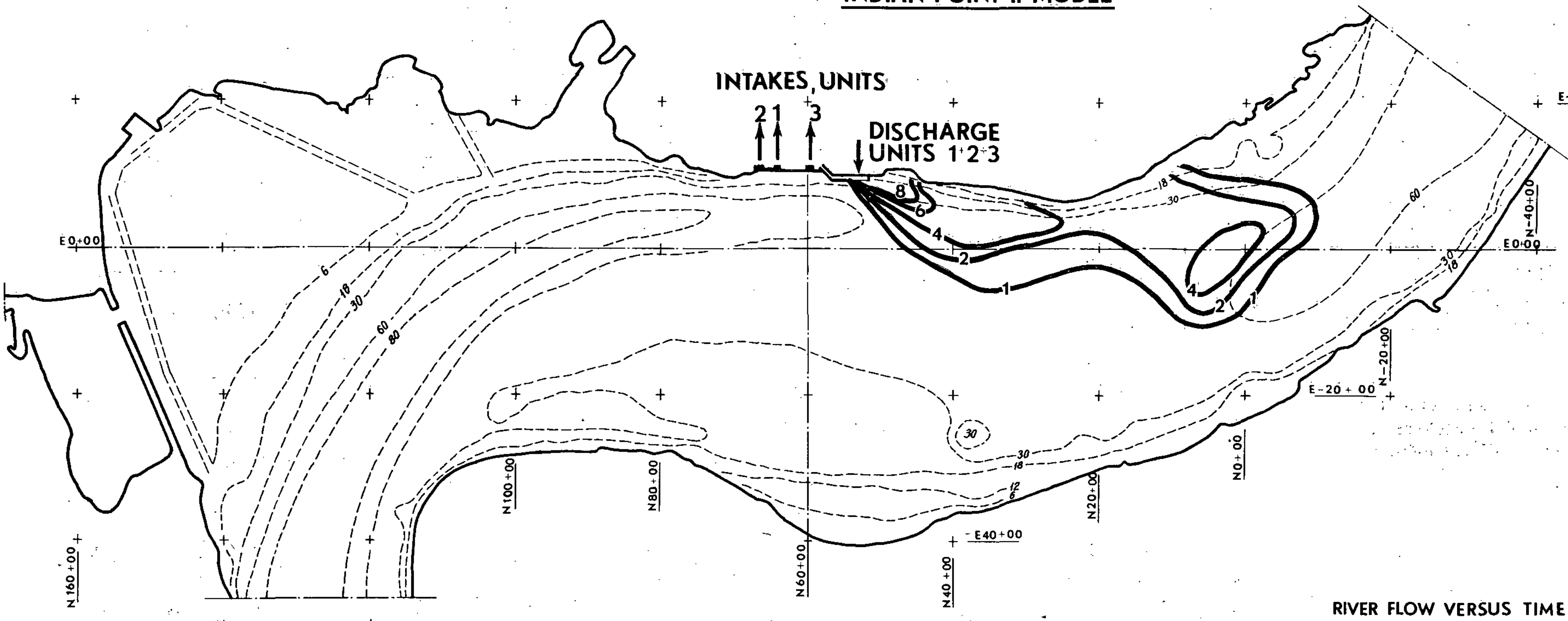
FOR
CONSOLIDATED EDISON COMPANY, N. Y.

FIG. 68

INDIAN POINT II MODEL



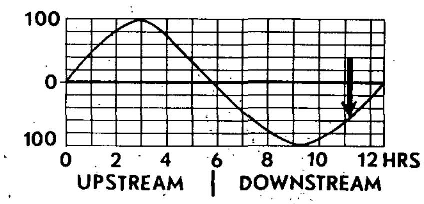
PLAN OF MODELED AREA

SCALES

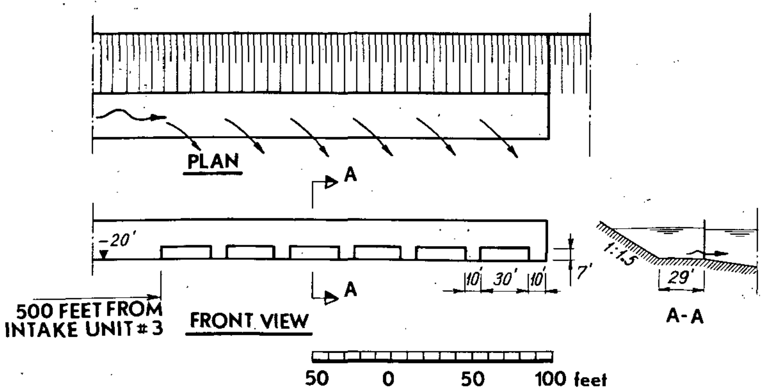
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
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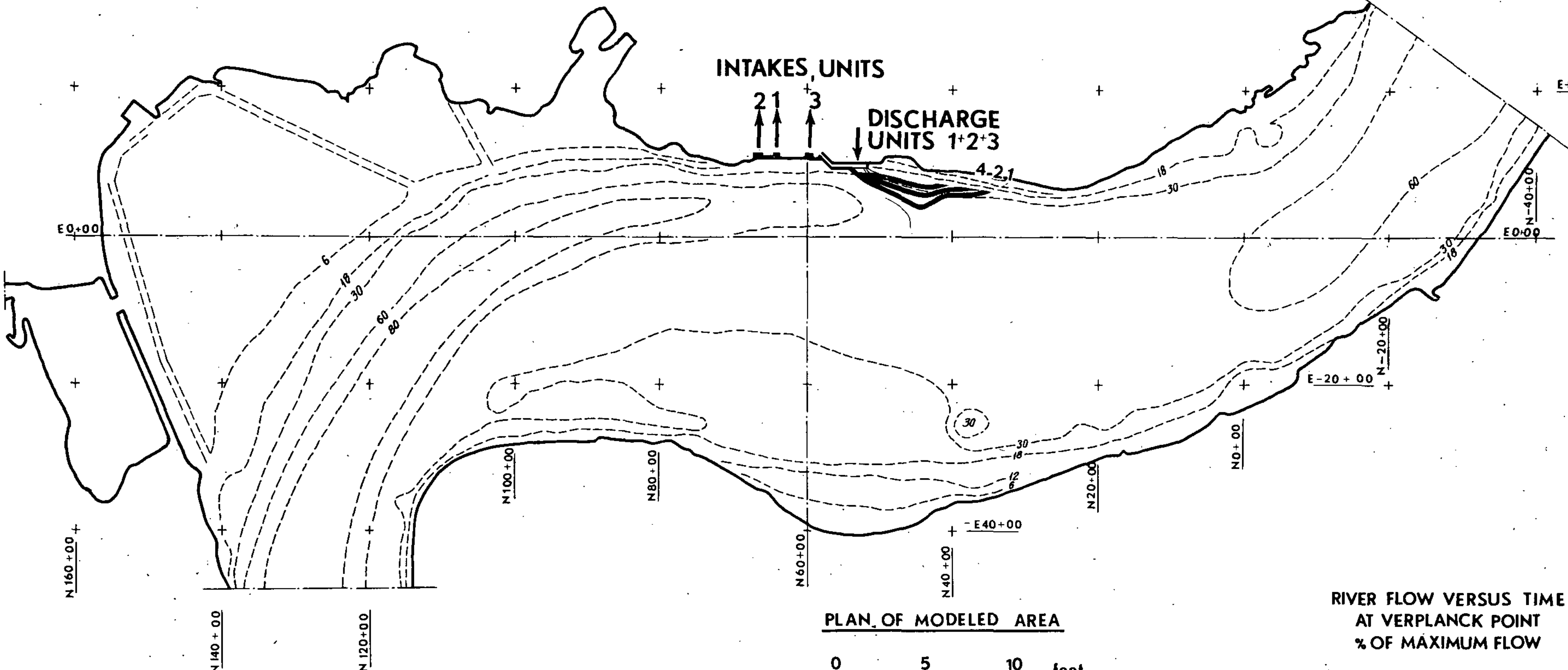
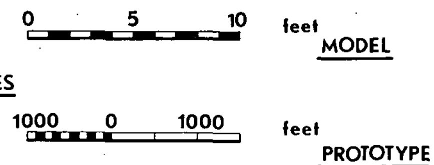
INDIAN POINT II MODEL

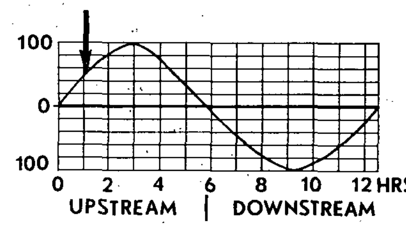


PLAN OF MODELED AREA

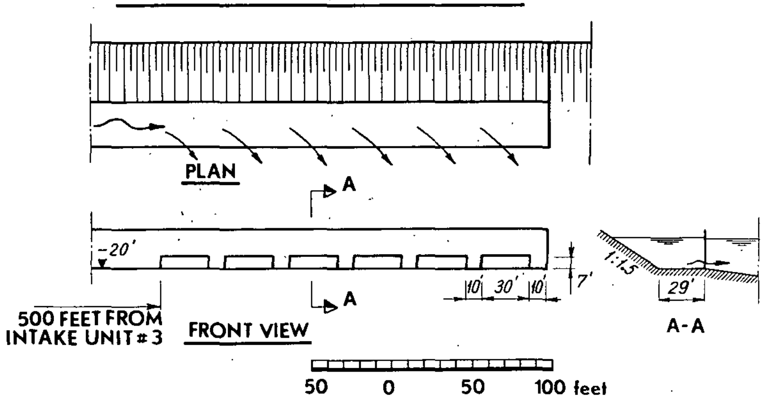
SCALES



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 542 ; DEC 3, 1968
UNITS OPERATING AND DISCHARGE 3; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 80 °F
AIR TEMPERATURE DRY BULB 85 °F
AIR TEMPERATURE WET BULB 77.6 °F
RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 24 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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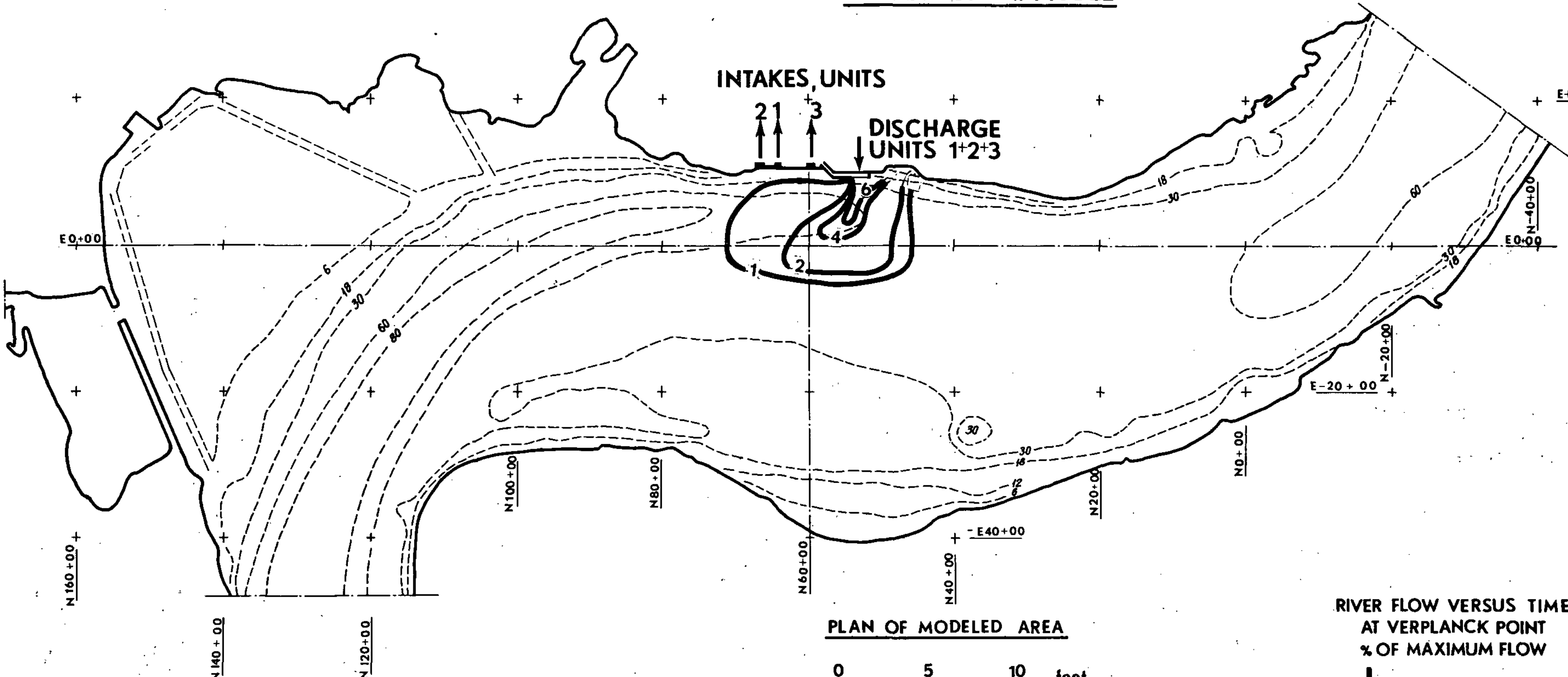
CONSOLIDATED EDISON COMPANY, N. Y.

FIG. 70

FIG. 71

INDIAN POINT II MODEL



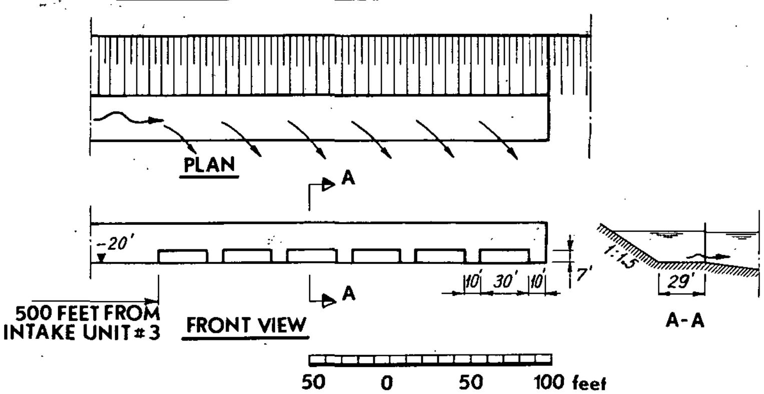
PLAN OF MODELED AREA

SCALES

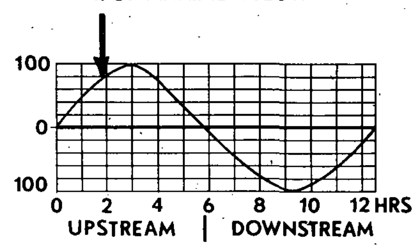
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



TEST CONDITIONS

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DEPTH OF ISOTHERMS 24 feet
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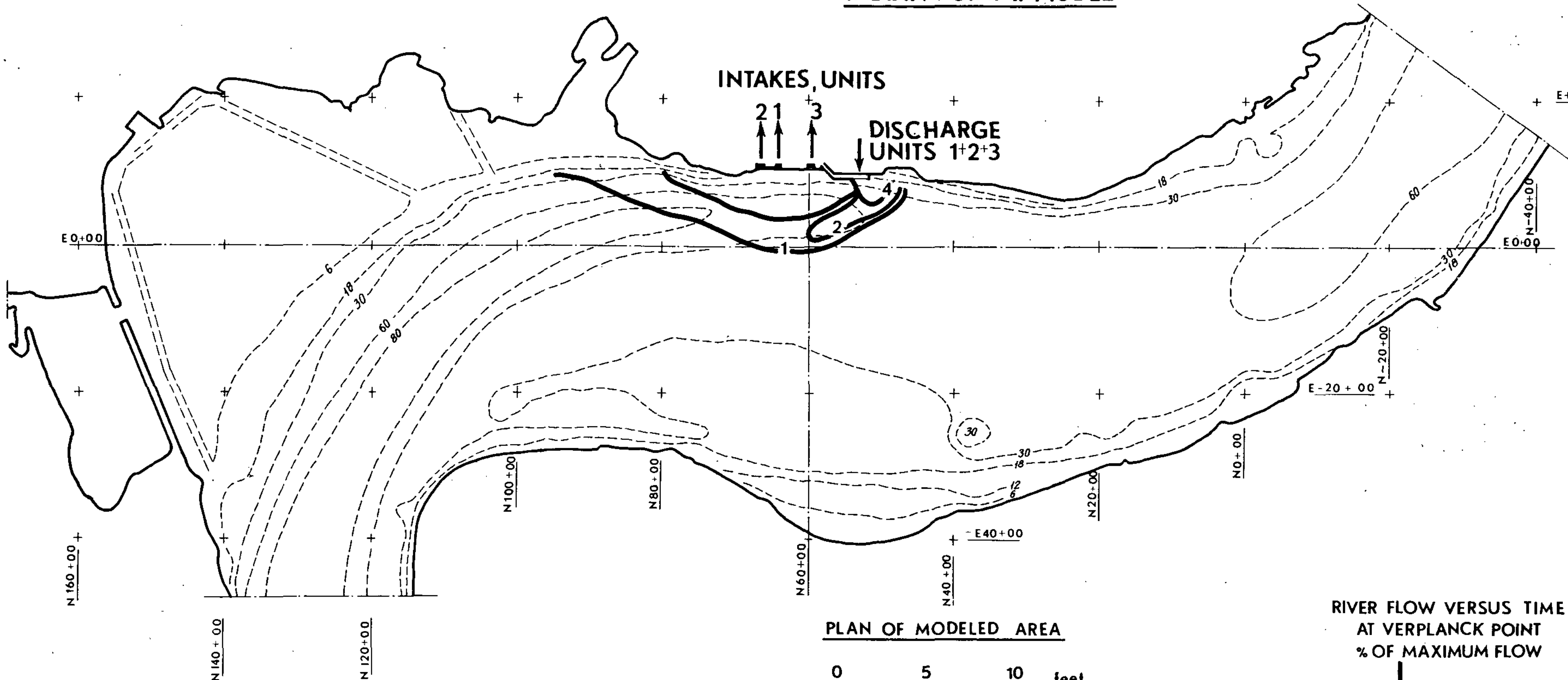
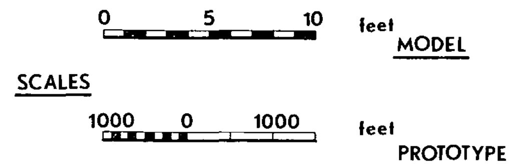
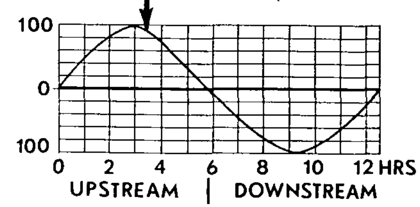
INDIAN POINT II MODEL



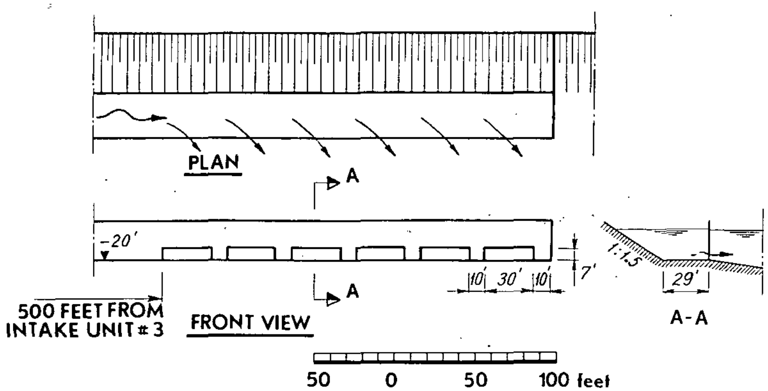
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



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RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 24 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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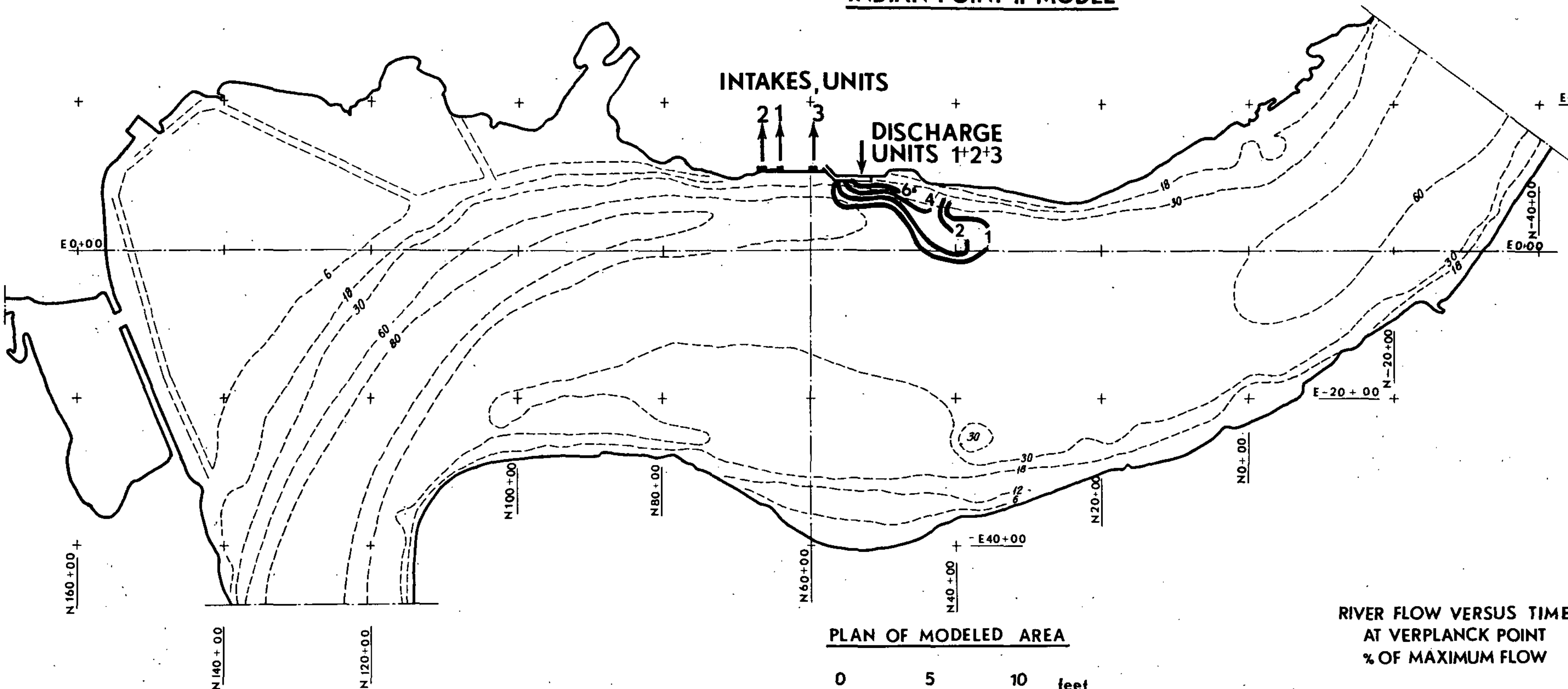
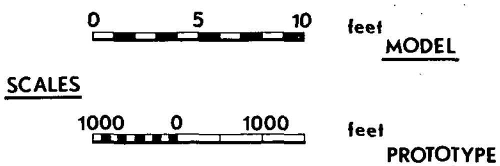
FIG. 72

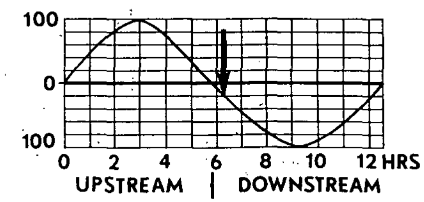
INDIAN POINT II MODEL



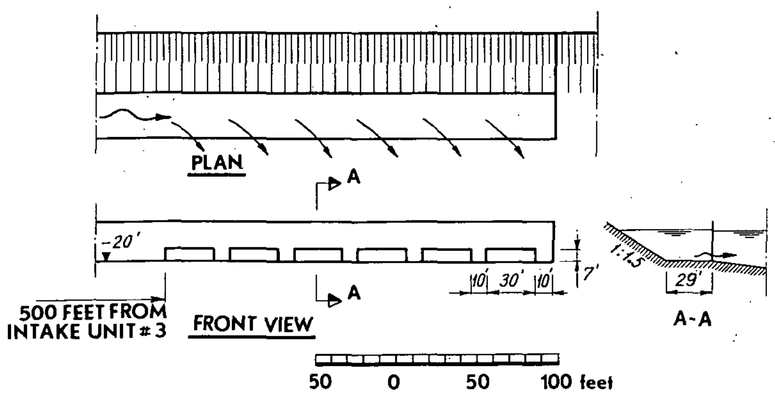
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 542 ; DEC 3, 1968
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TIME IN TIDE CYCLE SEE DIAGRAM
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RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 24 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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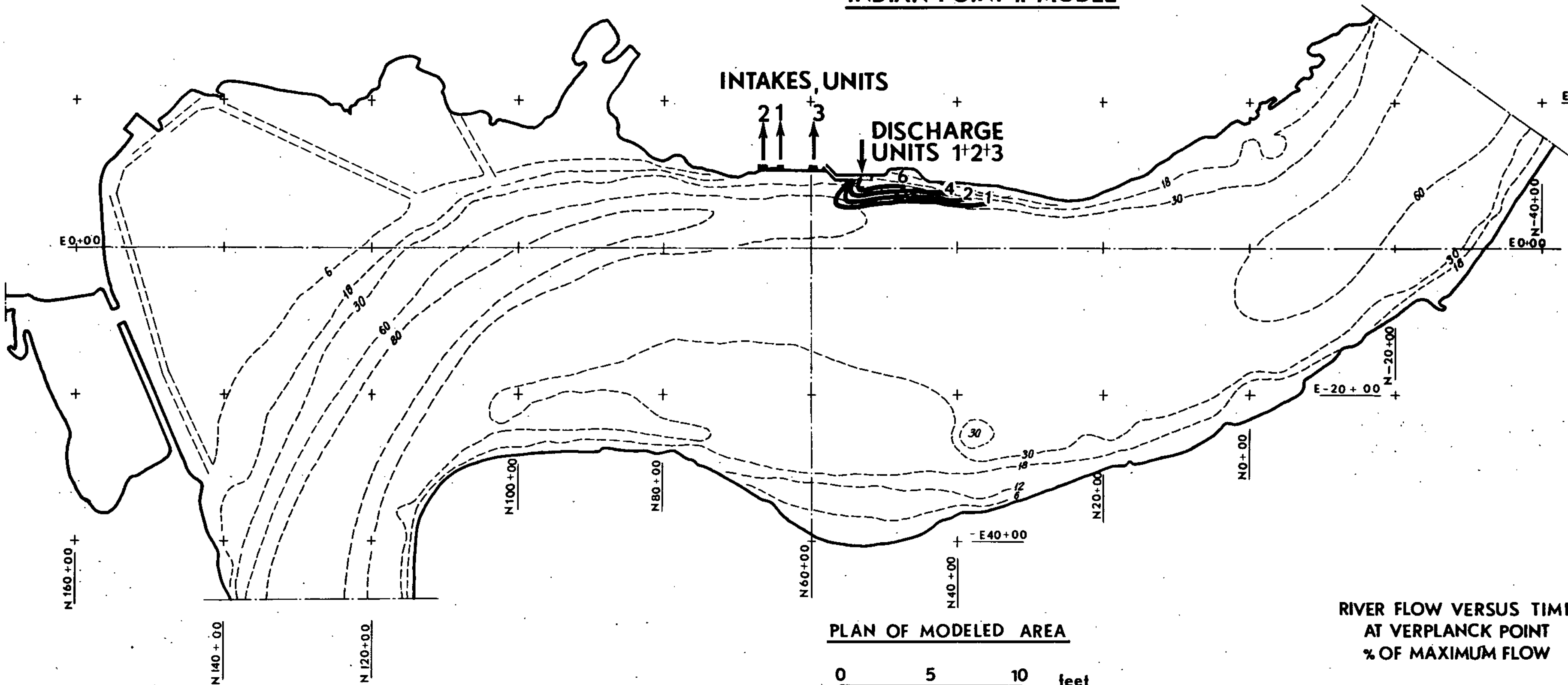
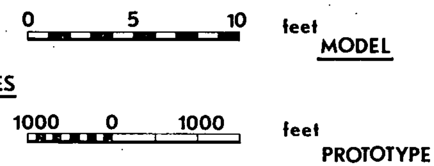
FIG. 74

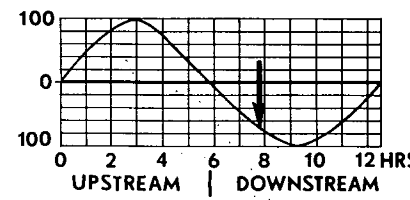
INDIAN POINT II MODEL



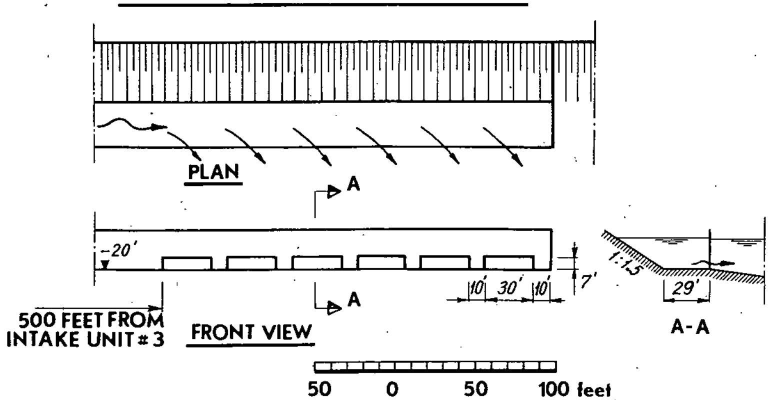
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 542 ; DEC 3, 1968
UNITS OPERATING AND DISCHARGE 3 ; 4670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 16.4 °F
TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE DRY BULB 85 °F
AIR TEMPERATURE WET BULB 77.6 °F
RELATIVE HUMIDITY 72 %
DEPTH OF ISOTHERMS 24 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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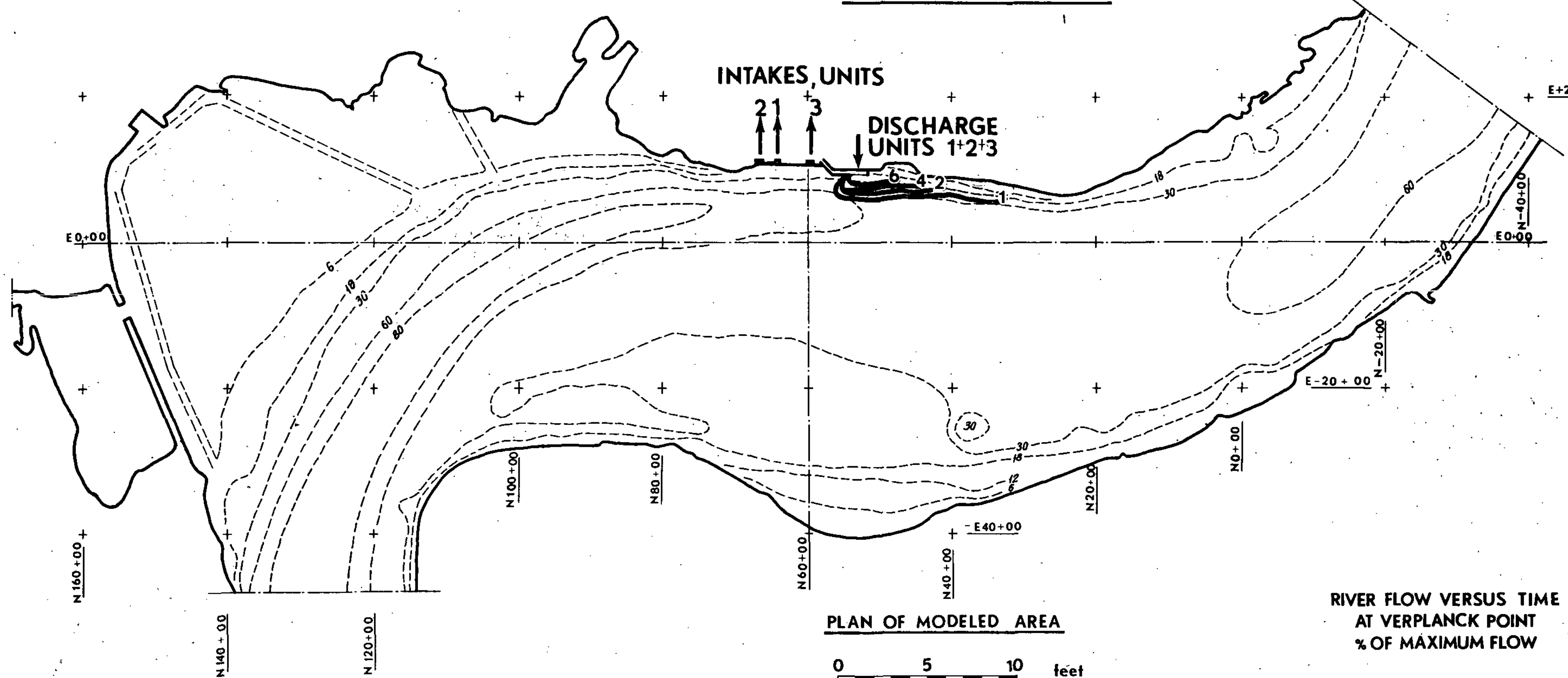
INDIAN POINT II MODEL



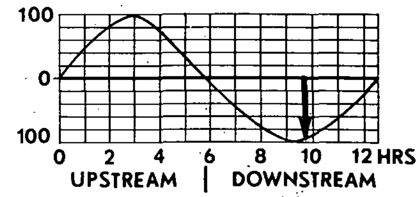
PLAN OF MODELED AREA

SCALES

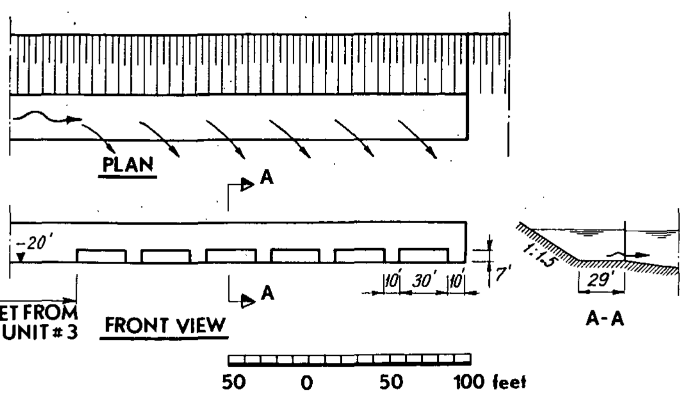
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



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FOR
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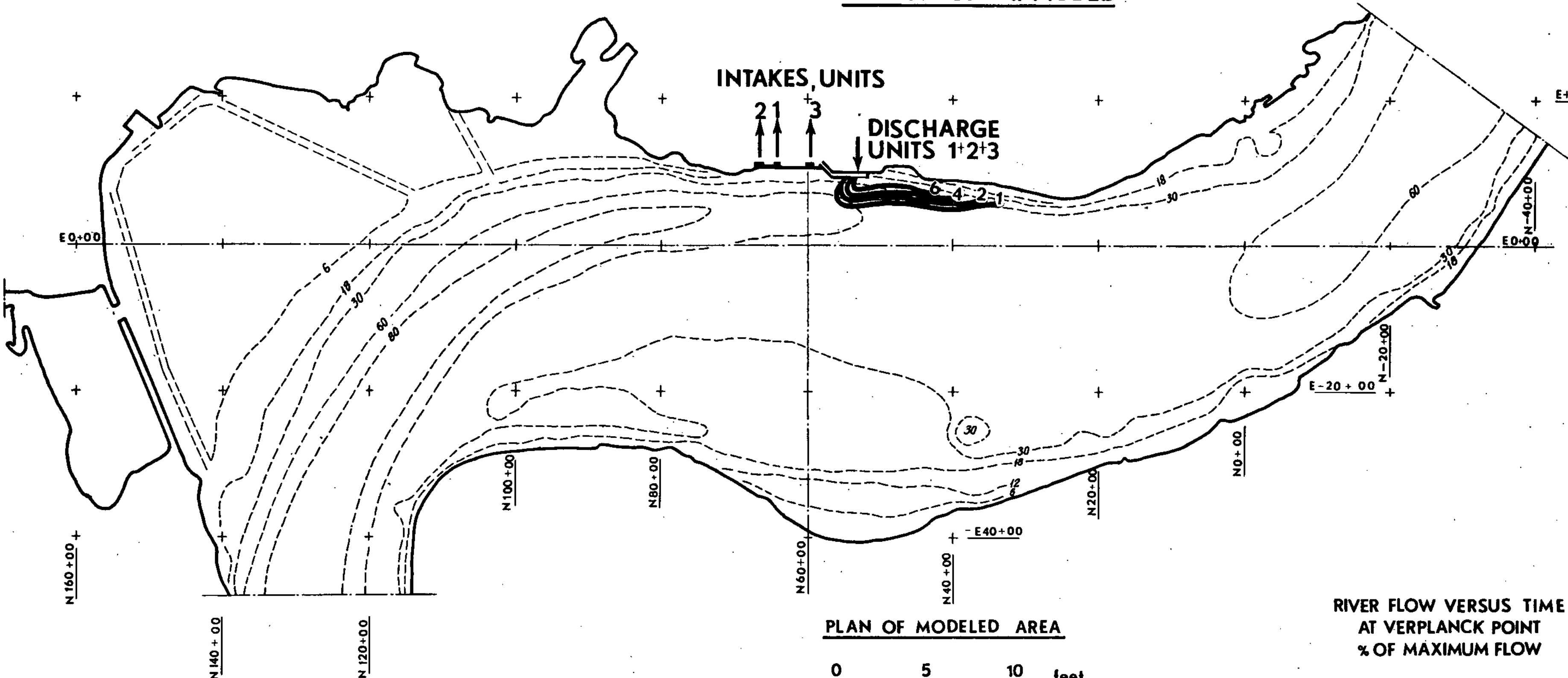
FIG. 76

INDIAN POINT II MODEL



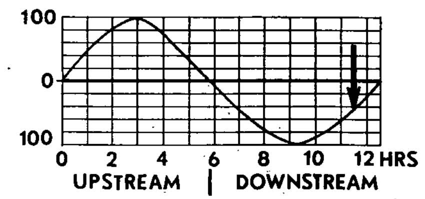
PLAN OF MODELED AREA

SCALES

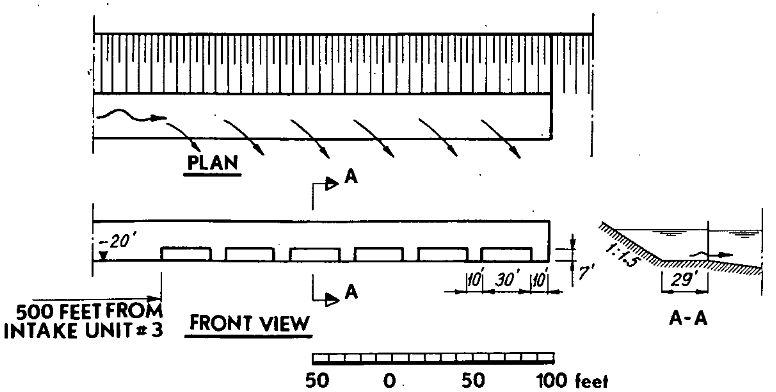
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



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FOR
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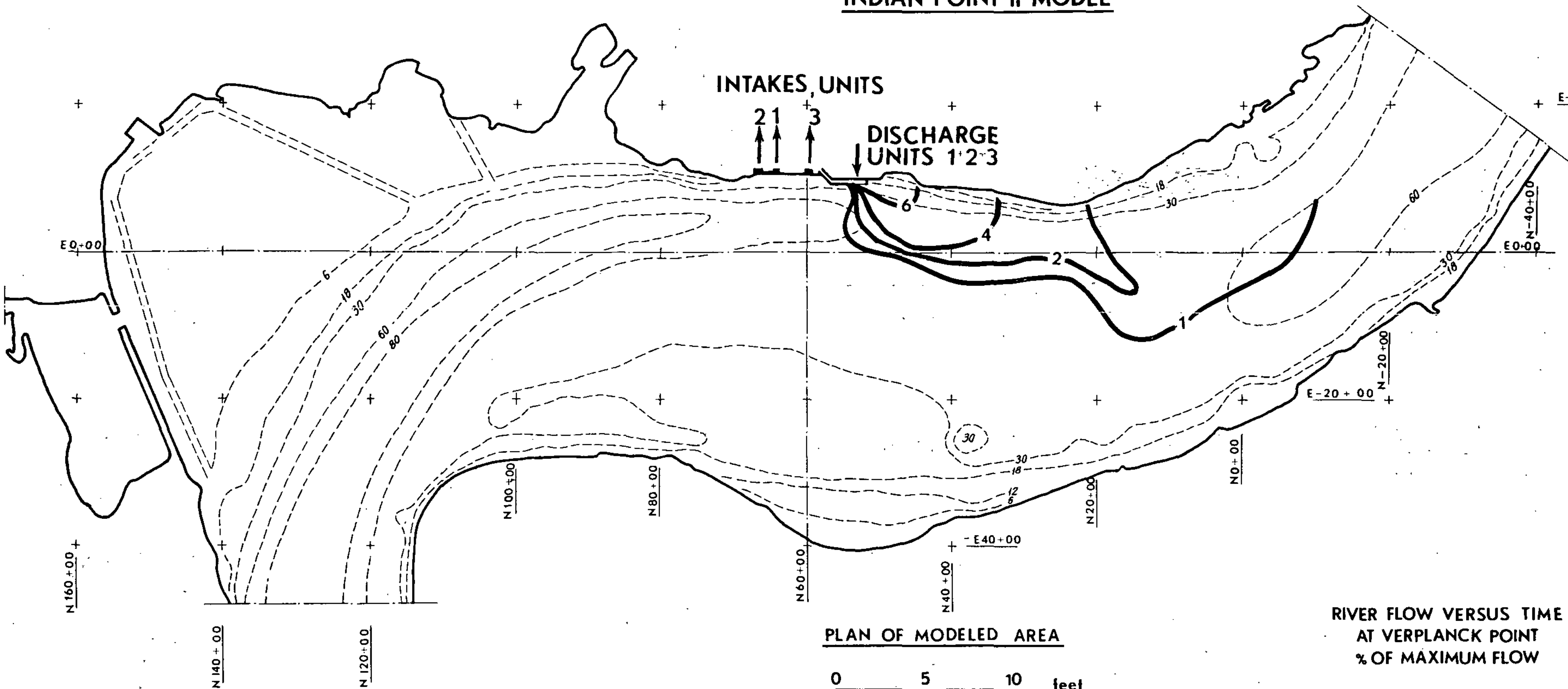
INDIAN POINT II MODEL



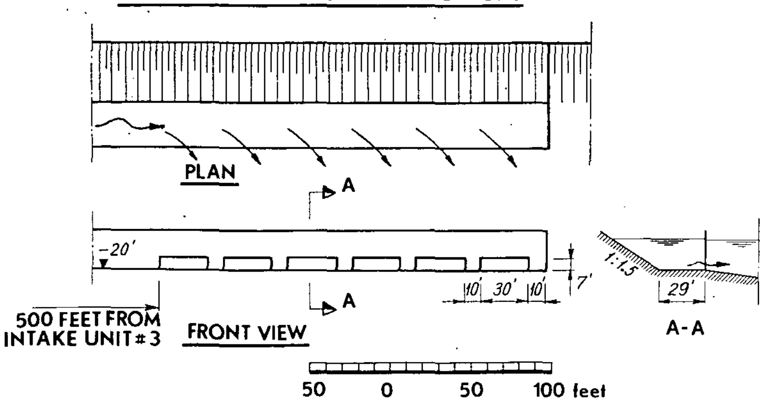
PLAN OF MODELED AREA

SCALES

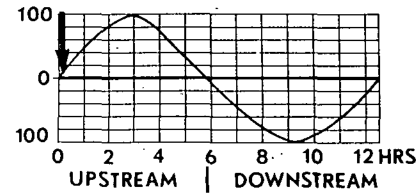
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 410 ; NOV 6, 1968
UNITS OPERATING AND DISCHARGE 2; 2670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 65 °F
AIR TEMPERATURE DRY BULB 64 °F
AIR TEMPERATURE WET BULB 60 °F
RELATIVE HUMIDITY 80%
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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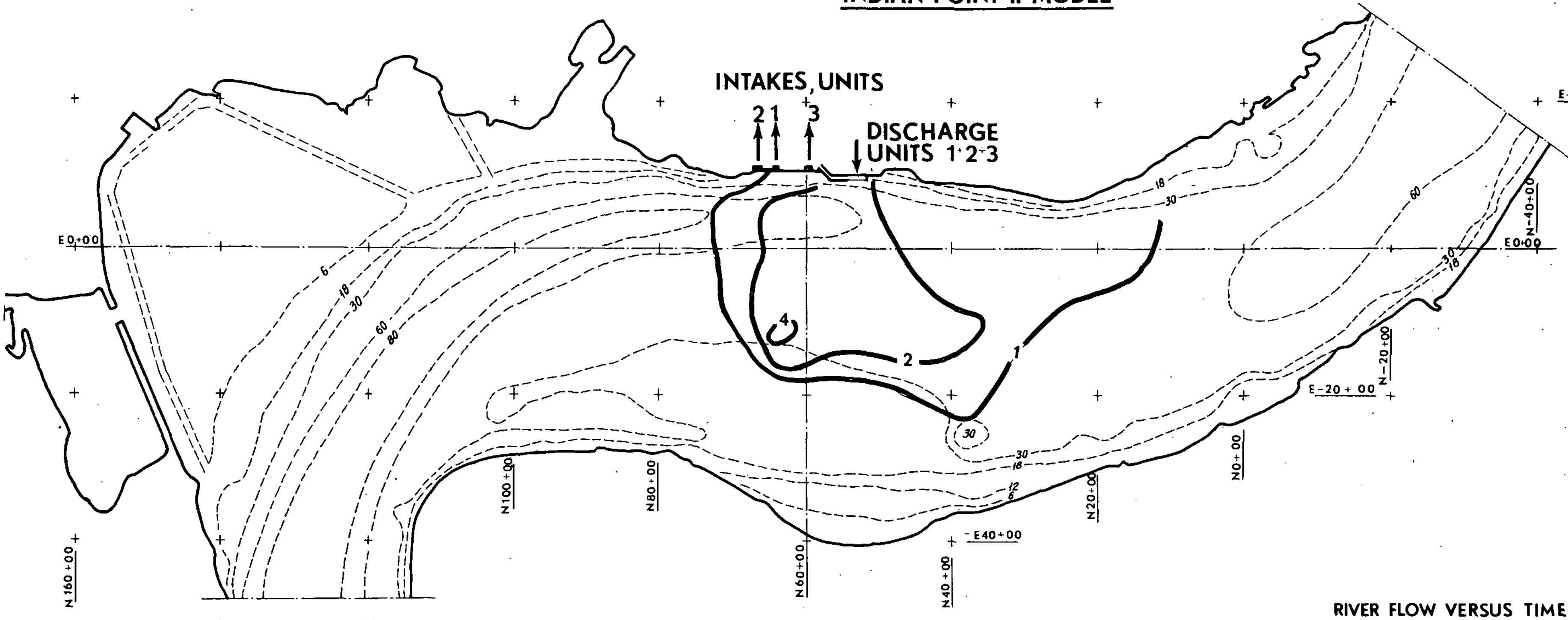
FOR
CONSOLIDATED EDISON COMPANY, N. Y.

FIG. 78

INDIAN POINT II MODEL



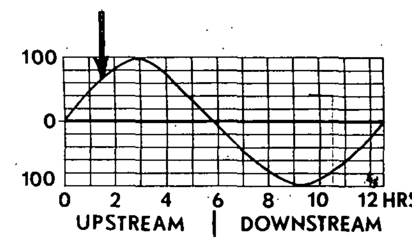
PLAN OF MODELED AREA

SCALES

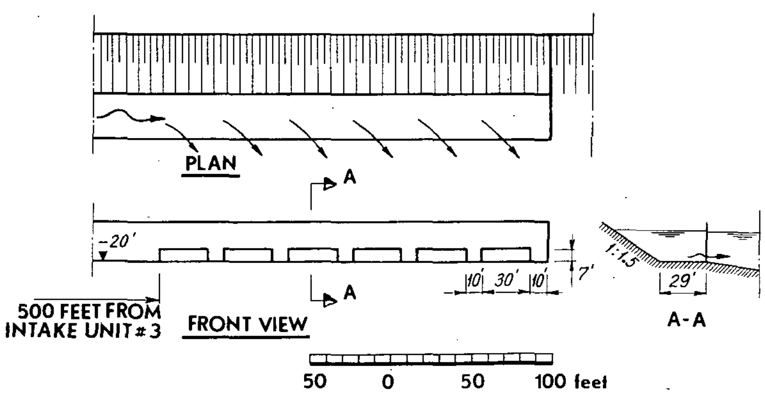
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 410 ; NOV 8, 1968
UNITS OPERATING AND DISCHARGE 2; 2670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE WET BULB 60 °F
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DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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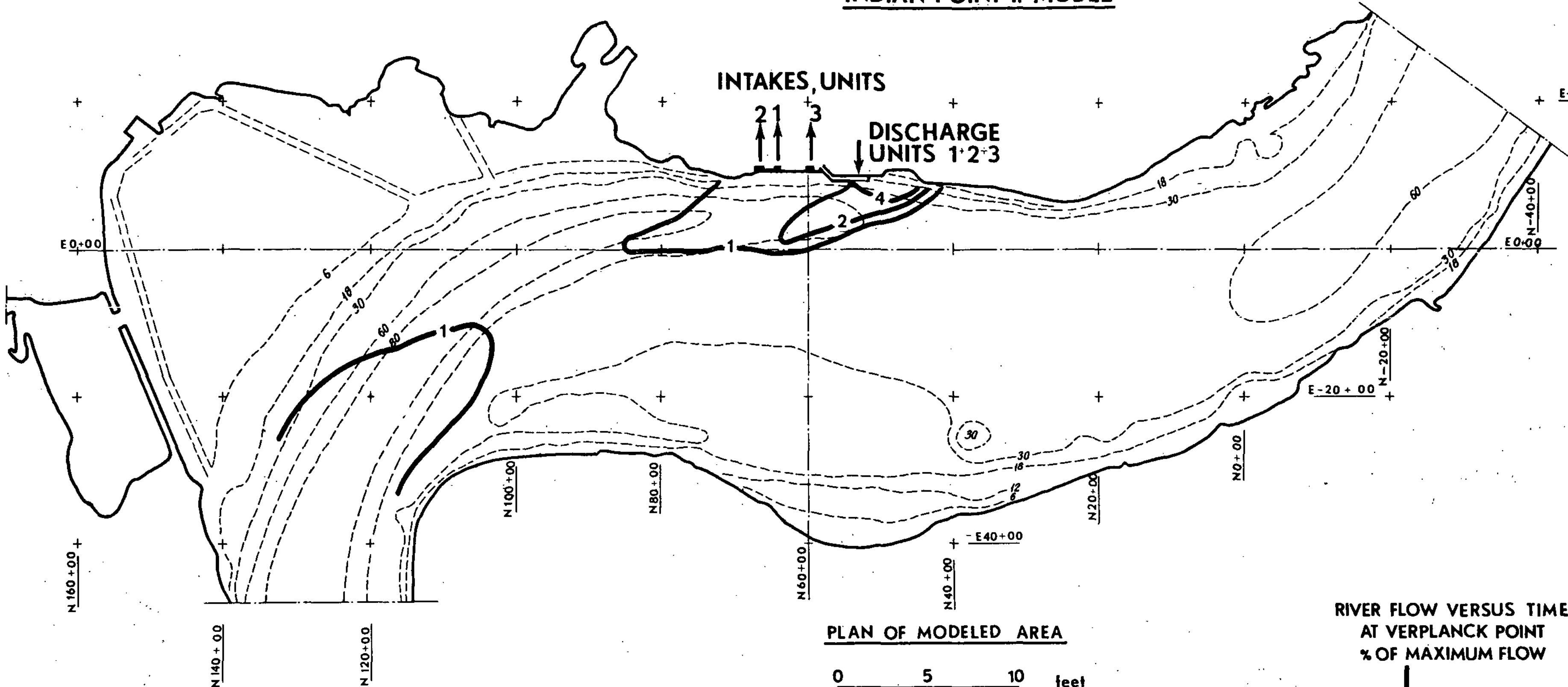
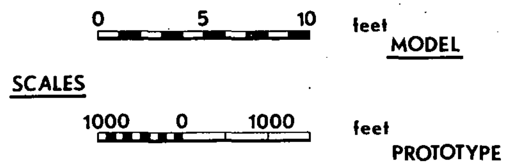
FOR
CONSOLIDATED EDISON COMPANY, N.Y.

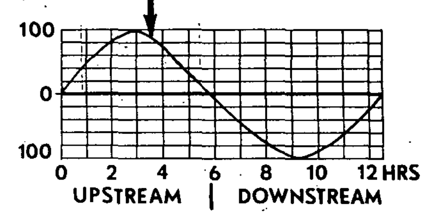
INDIAN POINT II MODEL



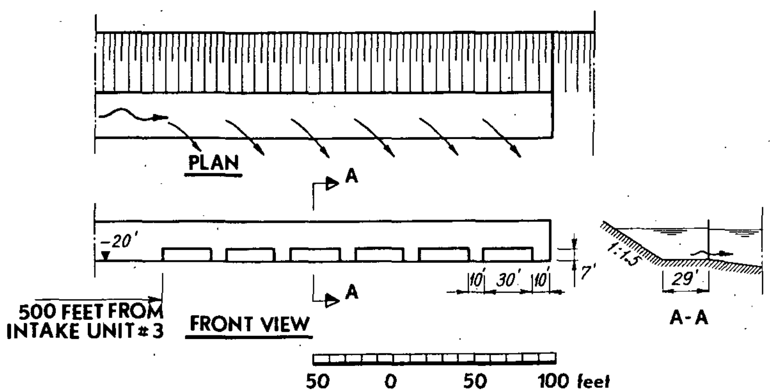
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



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AIR TEMPERATURE WET BULB 60 °F
RELATIVE HUMIDITY 80%
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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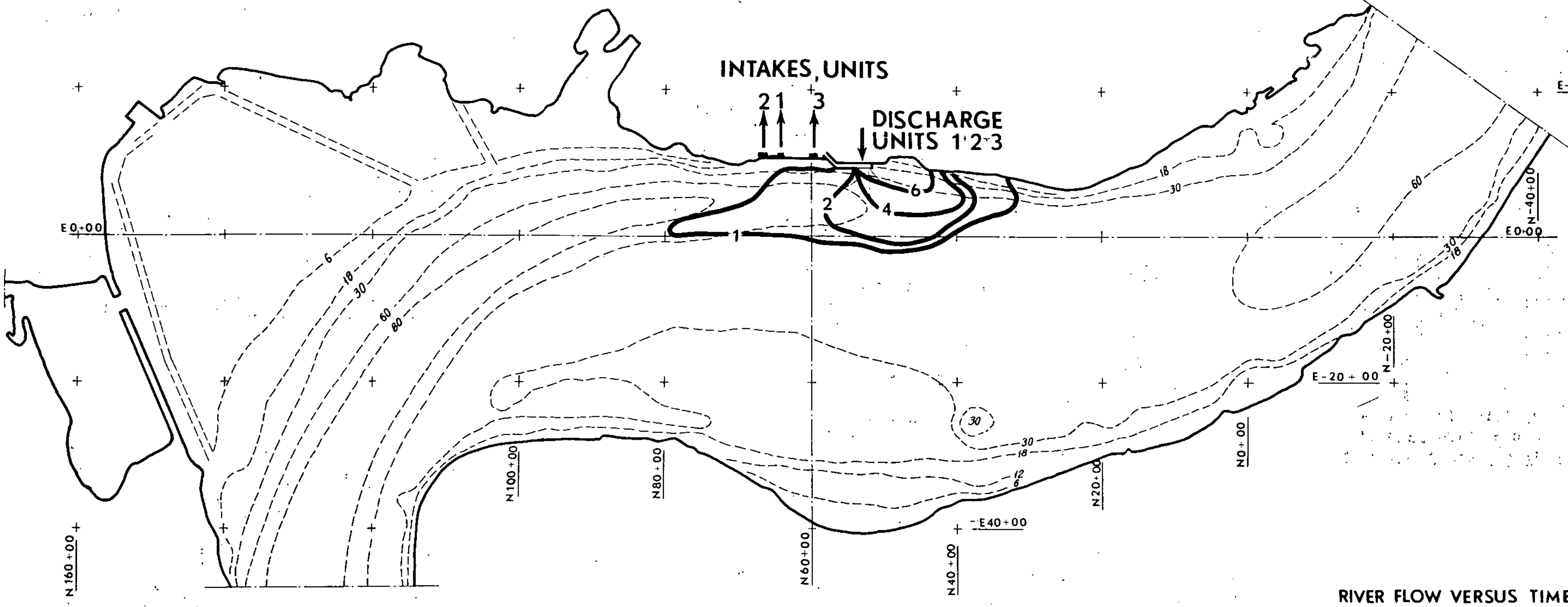
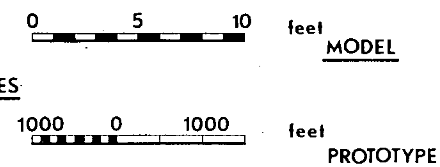
FIG. 80

FIG. 81

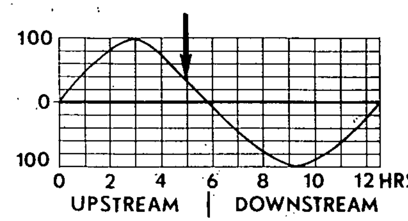
INDIAN POINT II MODEL



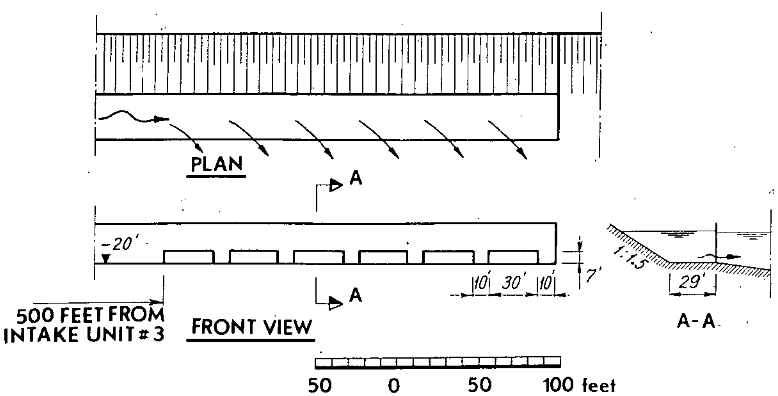
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 410 ; NOV 8, 1968
UNITS OPERATING AND DISCHARGE 2 ; 2670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 65 °F
AIR TEMPERATURE DRY BULB 64 °F
AIR TEMPERATURE WET BULB 60 °F
RELATIVE HUMIDITY 80%
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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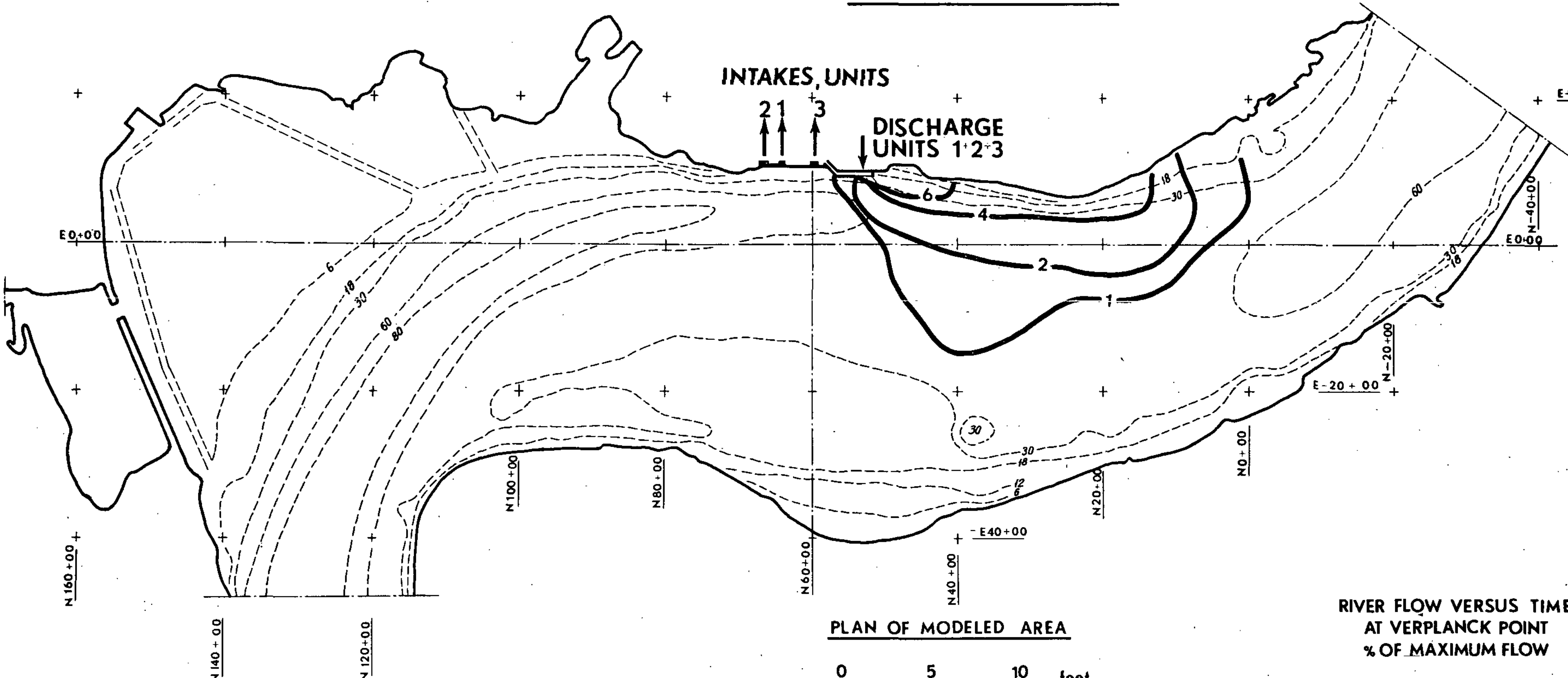
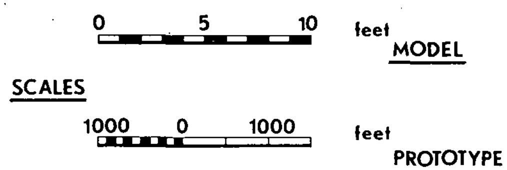
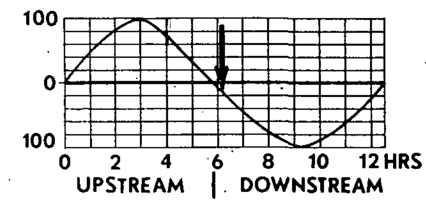
INDIAN POINT II MODEL



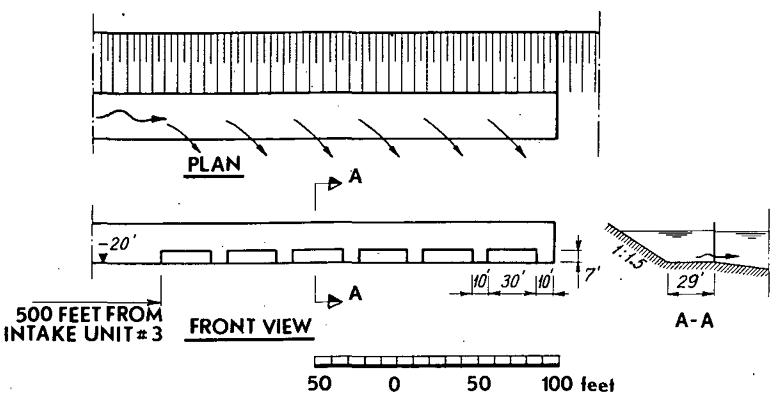
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 410 ; NOV 8, 1968
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DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE WET BULB 60 °F
RELATIVE HUMIDITY 80 %
DEPTH OF ISOTHERMS 0 feet
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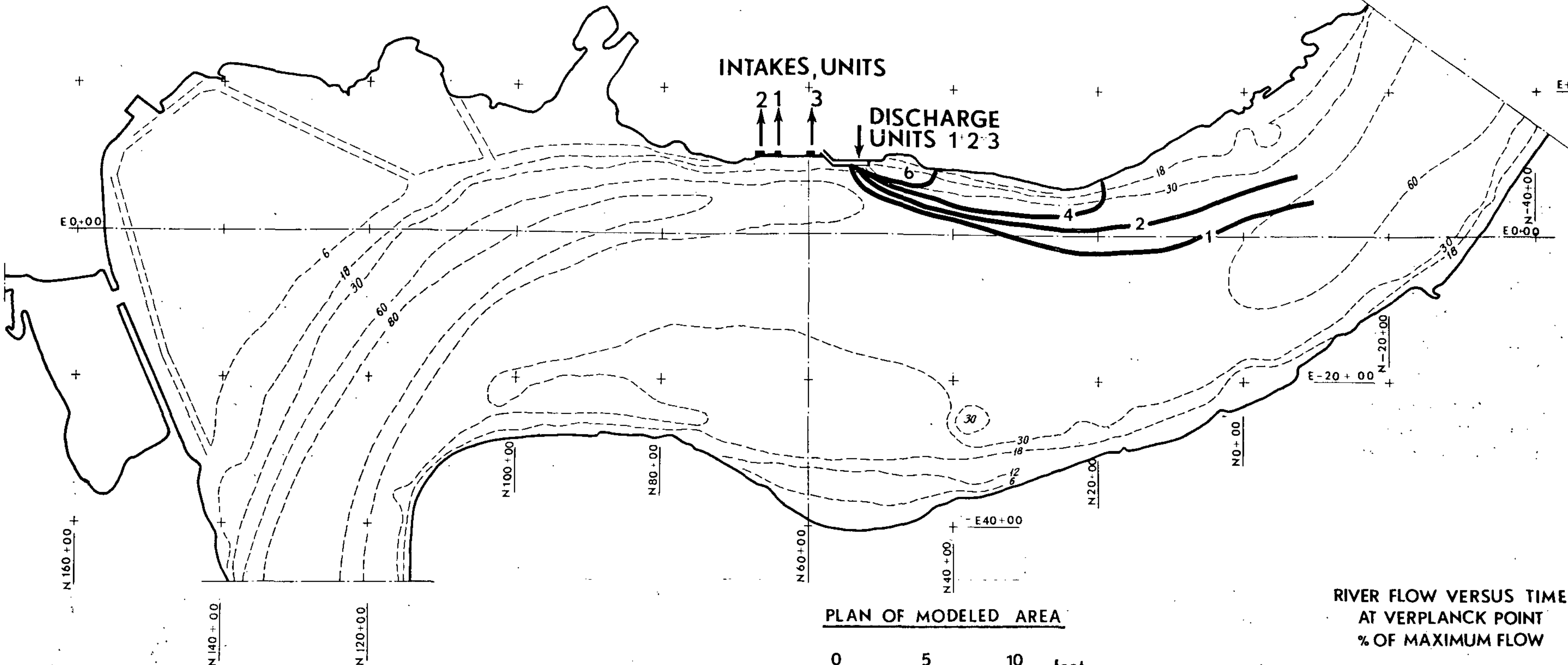
FIG. 82

FIG. 83

INDIAN POINT II MODEL



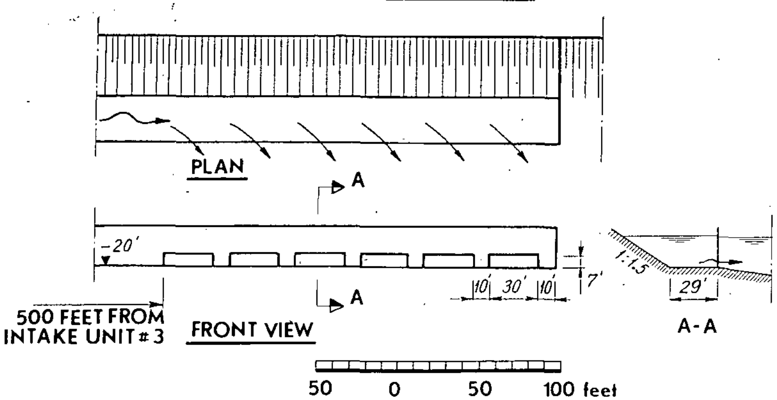
PLAN OF MODELED AREA

SCALES

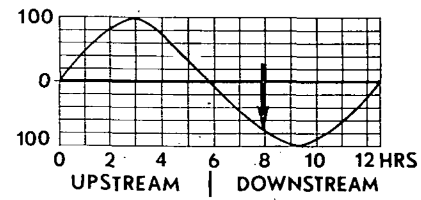
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 410 ; NOV 8, 1968
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TIME IN TIDE CYCLE SEE DIAGRAM
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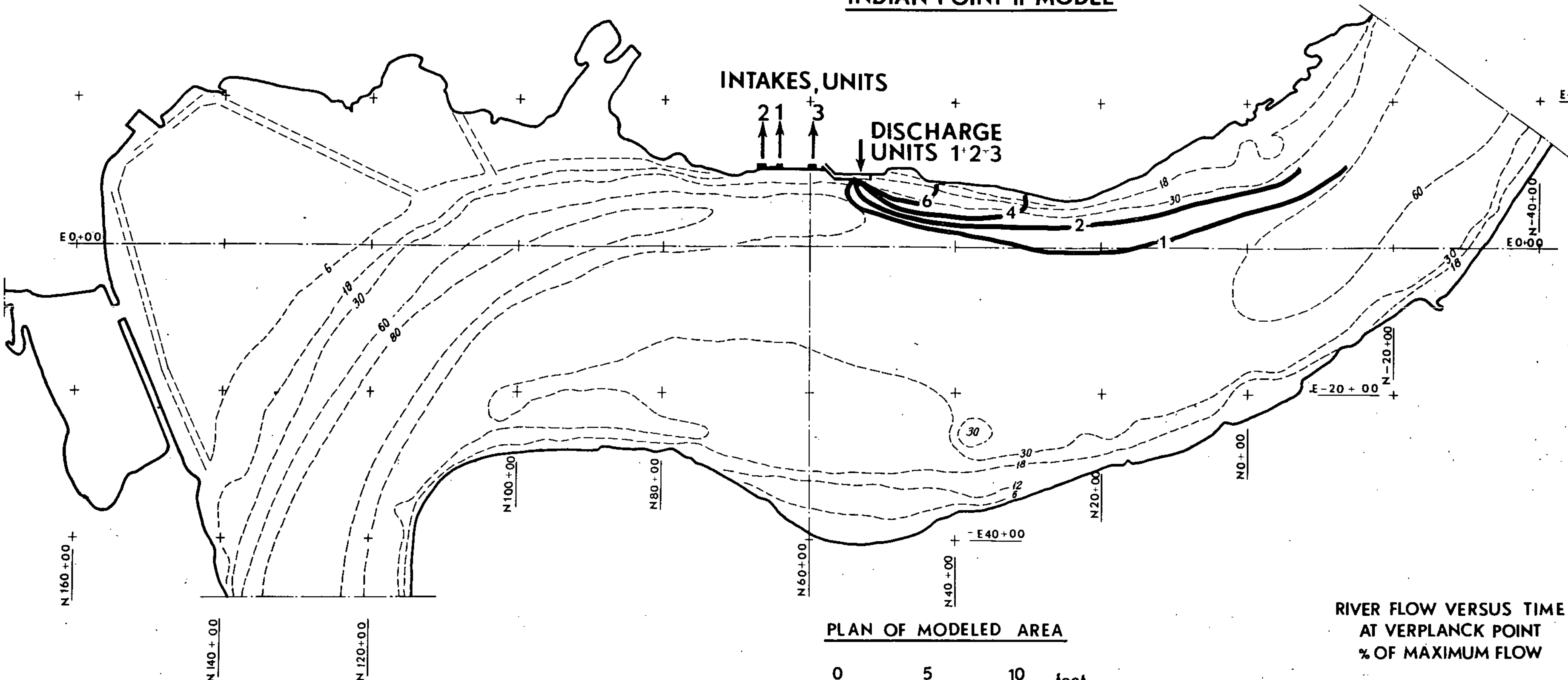
INDIAN POINT II MODEL



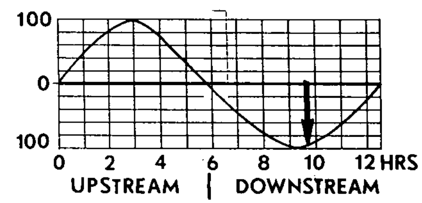
PLAN OF MODELED AREA

SCALES

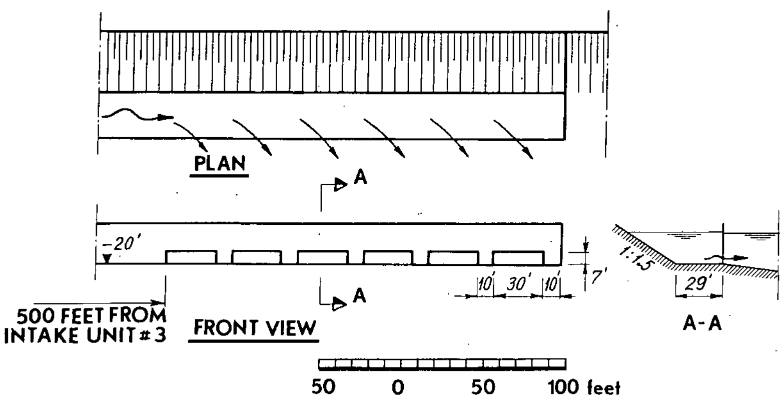
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE WET BULB 60 °F
RELATIVE HUMIDITY 80%
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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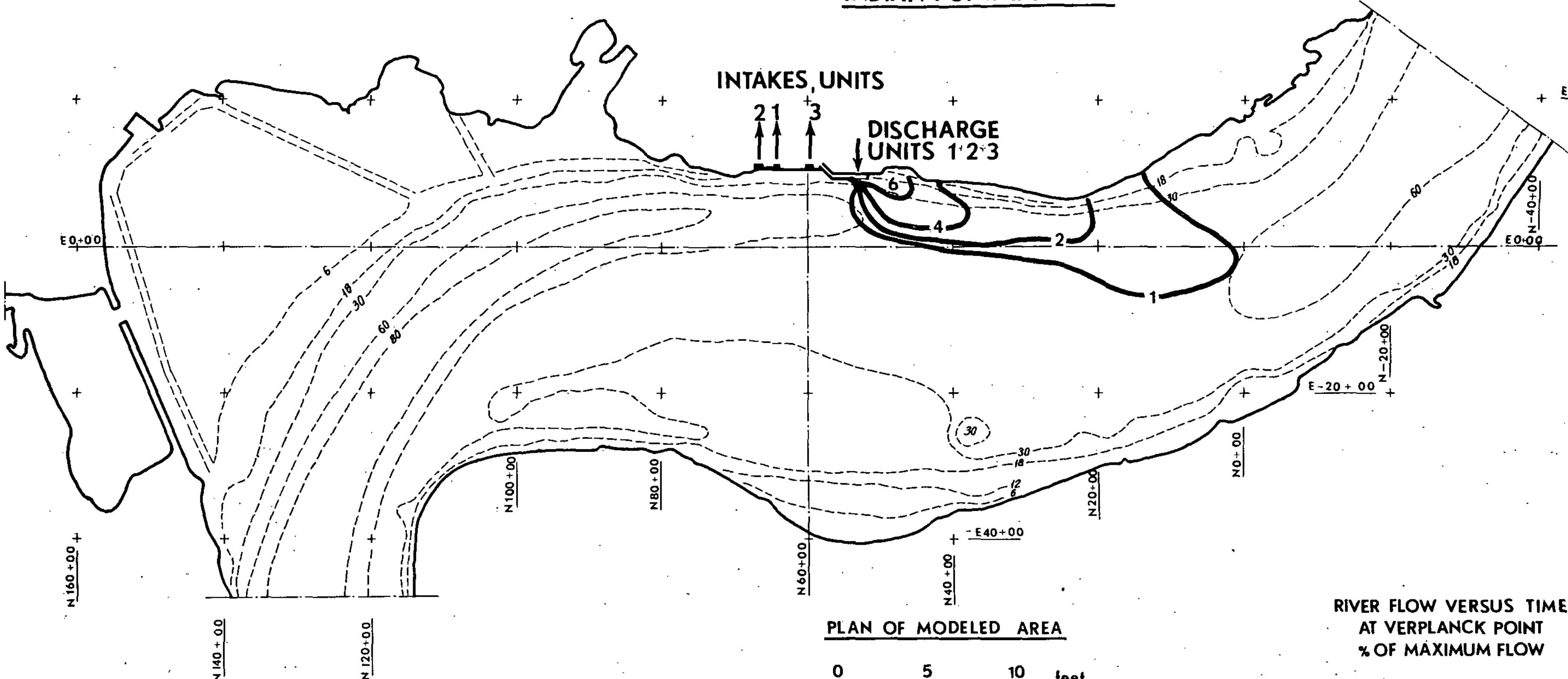
FIG. 84

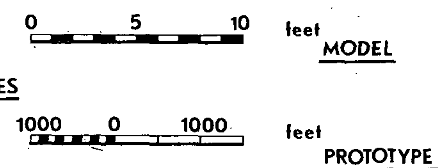
FIG. 85

INDIAN POINT II MODEL

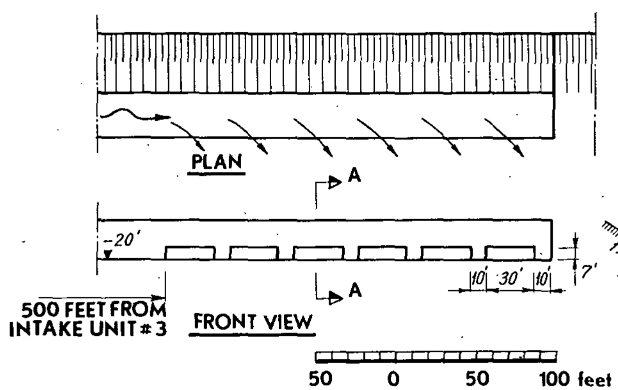


PLAN OF MODELED AREA

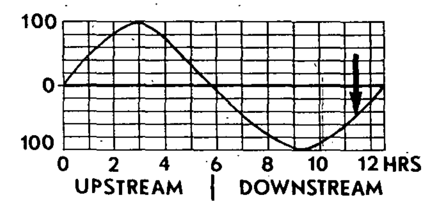
SCALES



ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 410 ; NOV 8, 1968
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DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 65 °F
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AIR TEMPERATURE WET BULB 60 °F
RELATIVE HUMIDITY 80%
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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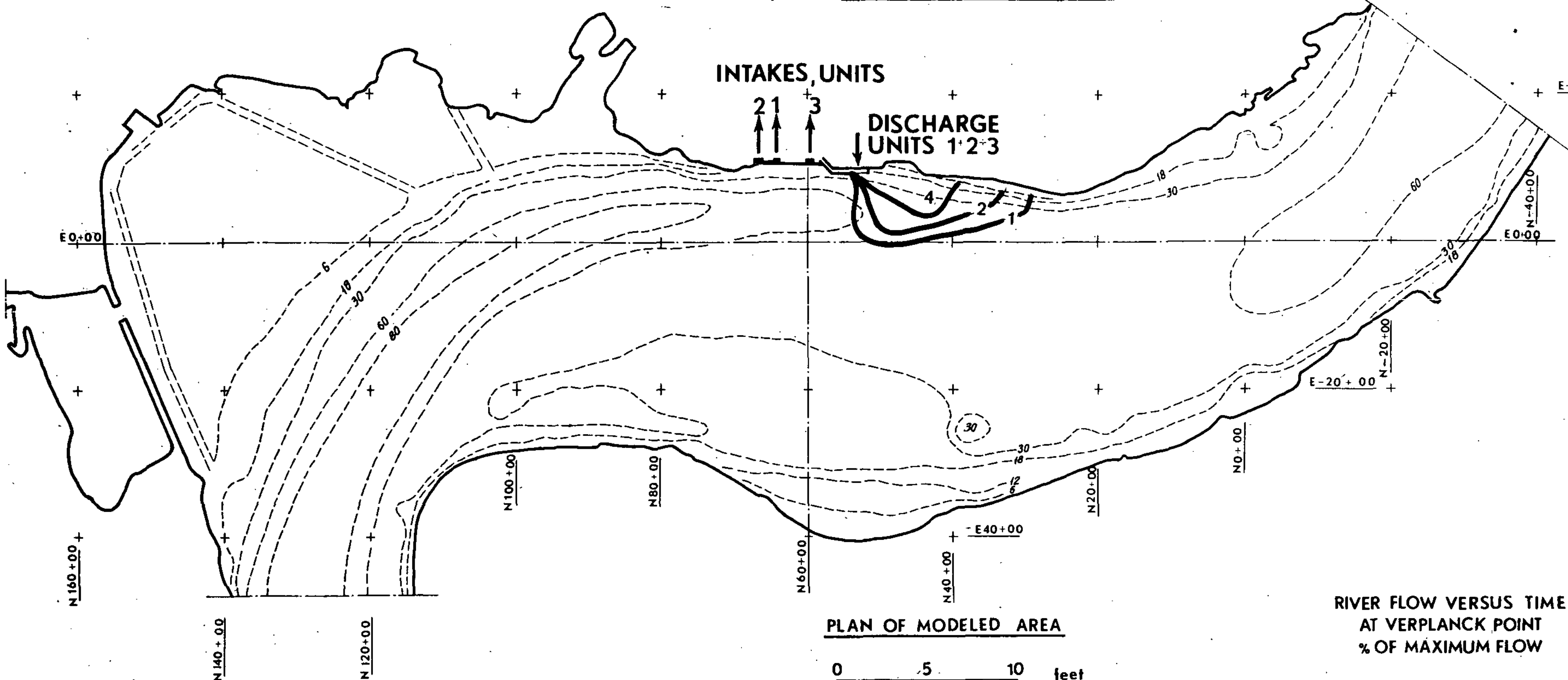
INDIAN POINT II MODEL



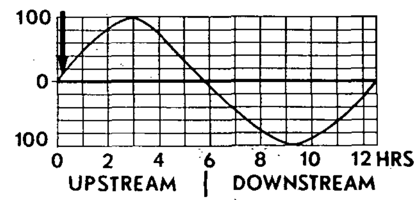
PLAN OF MODELED AREA

SCALES

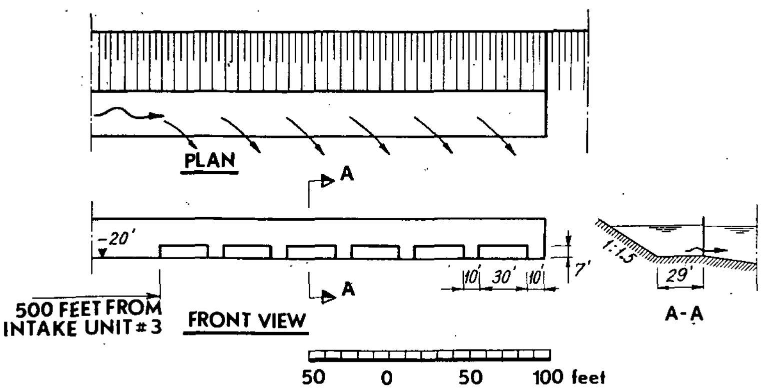
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 416 ; NOV 9, 1968
UNITS OPERATING AND DISCHARGE 2 ; 2670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 56 °F
AIR TEMPERATURE DRY BULB 61 °F
AIR TEMPERATURE WET BULB 57 °F
RELATIVE HUMIDITY 78 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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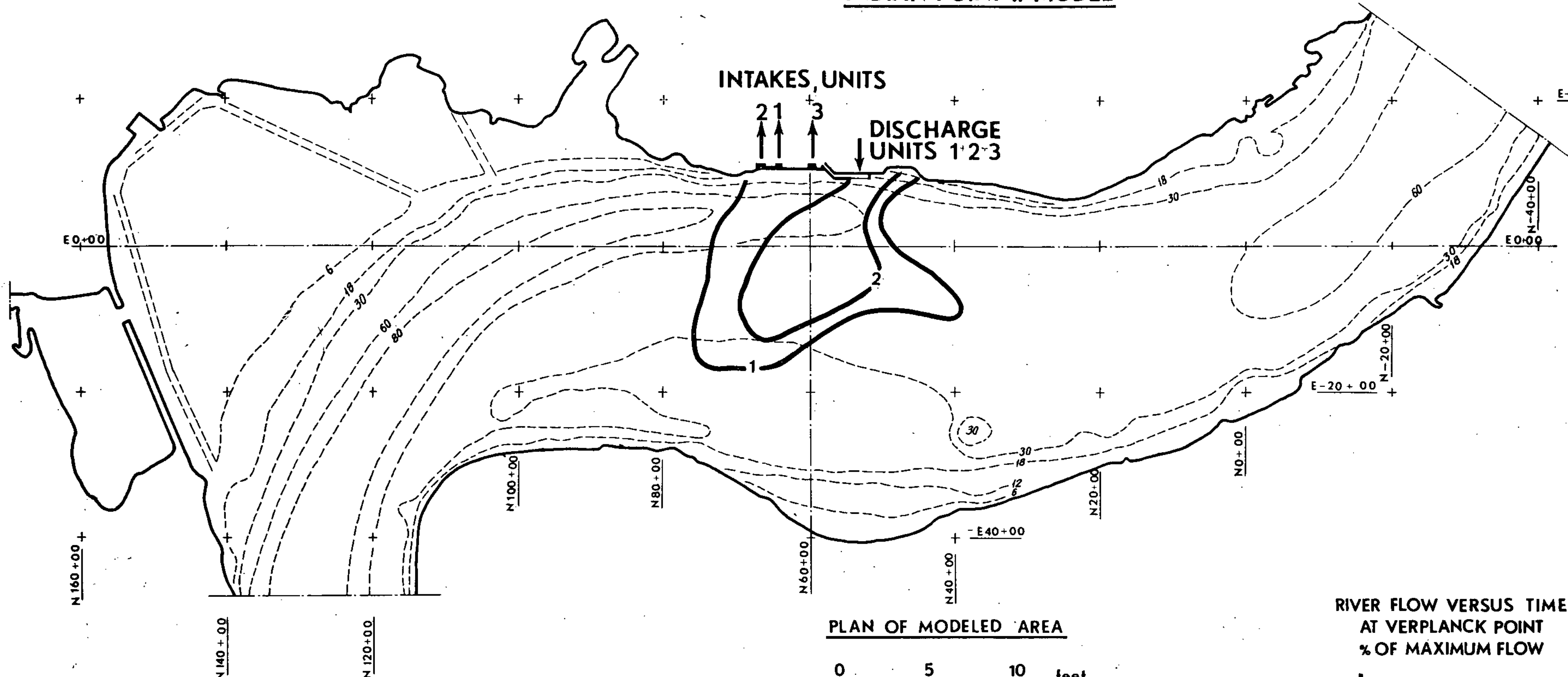
FIG. 86

FIG. 87

INDIAN POINT II MODEL



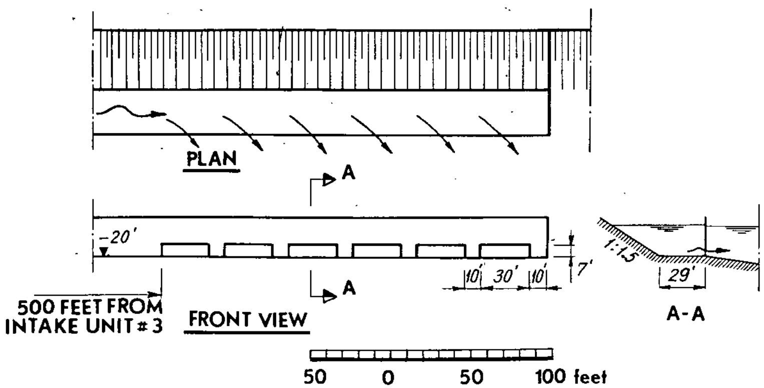
PLAN OF MODELED AREA

SCALES

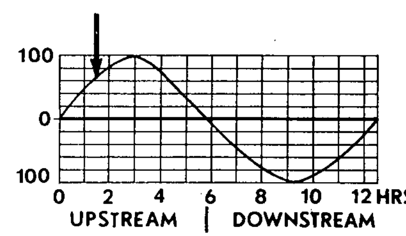
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 416 ; NOV 9, 1968
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TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE WET BULB 57 °F
RELATIVE HUMIDITY 78 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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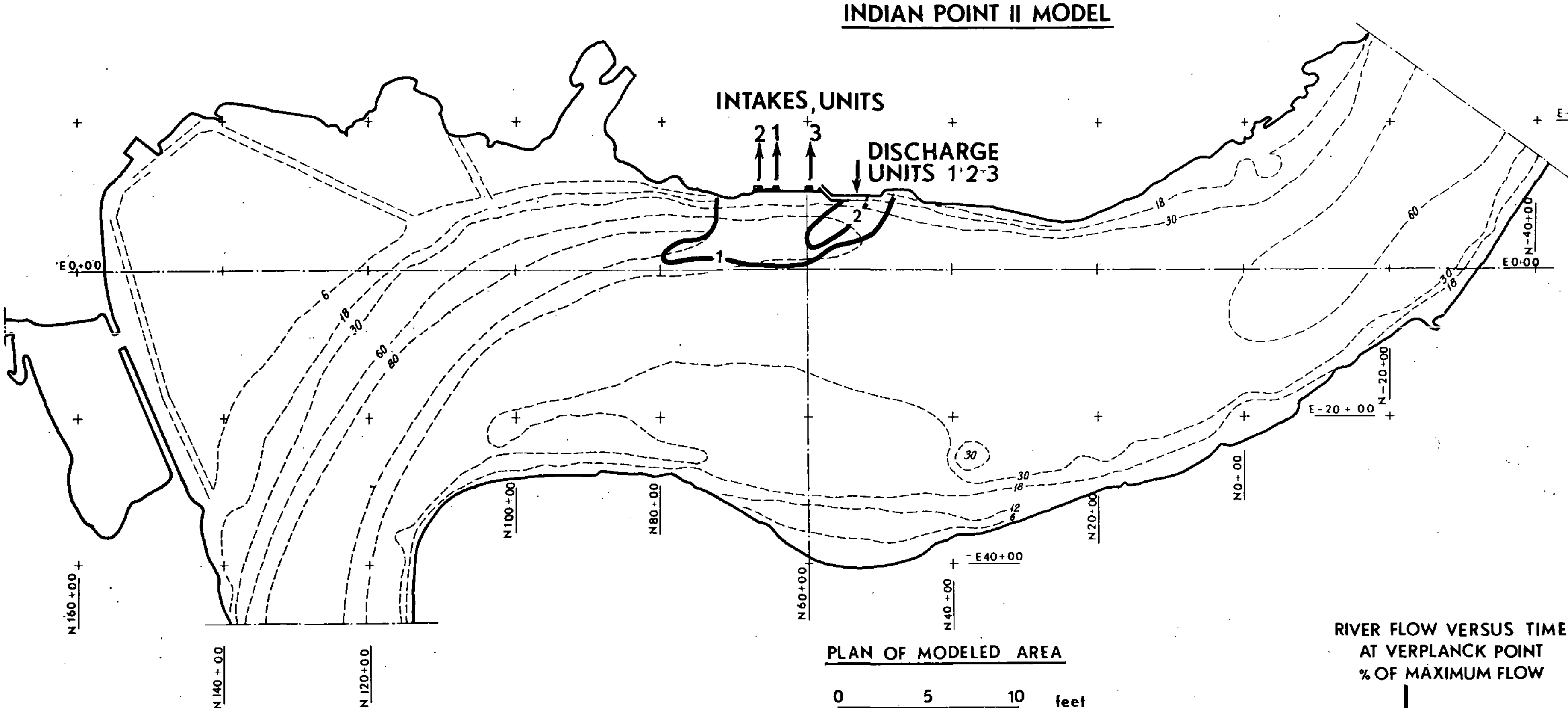
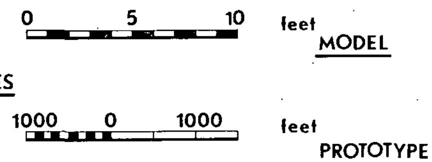
INDIAN POINT II MODEL

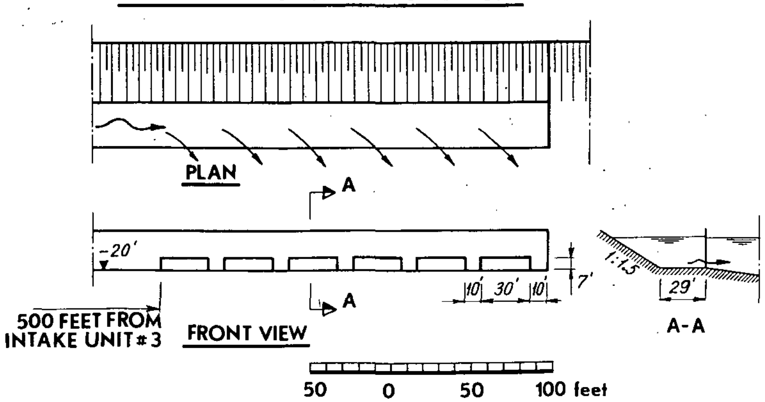


PLAN OF MODELED AREA

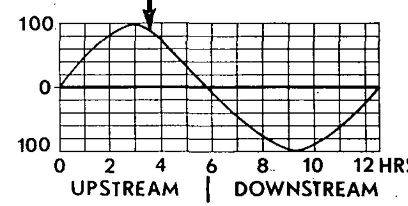
SCALES



ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 416 ; NOV 9, 1968
UNITS OPERATING AND DISCHARGE 2 ; 2670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 56 °F
AIR TEMPERATURE DRY BULB 61 °F
AIR TEMPERATURE WET BULB 57 °F
RELATIVE HUMIDITY 78 %
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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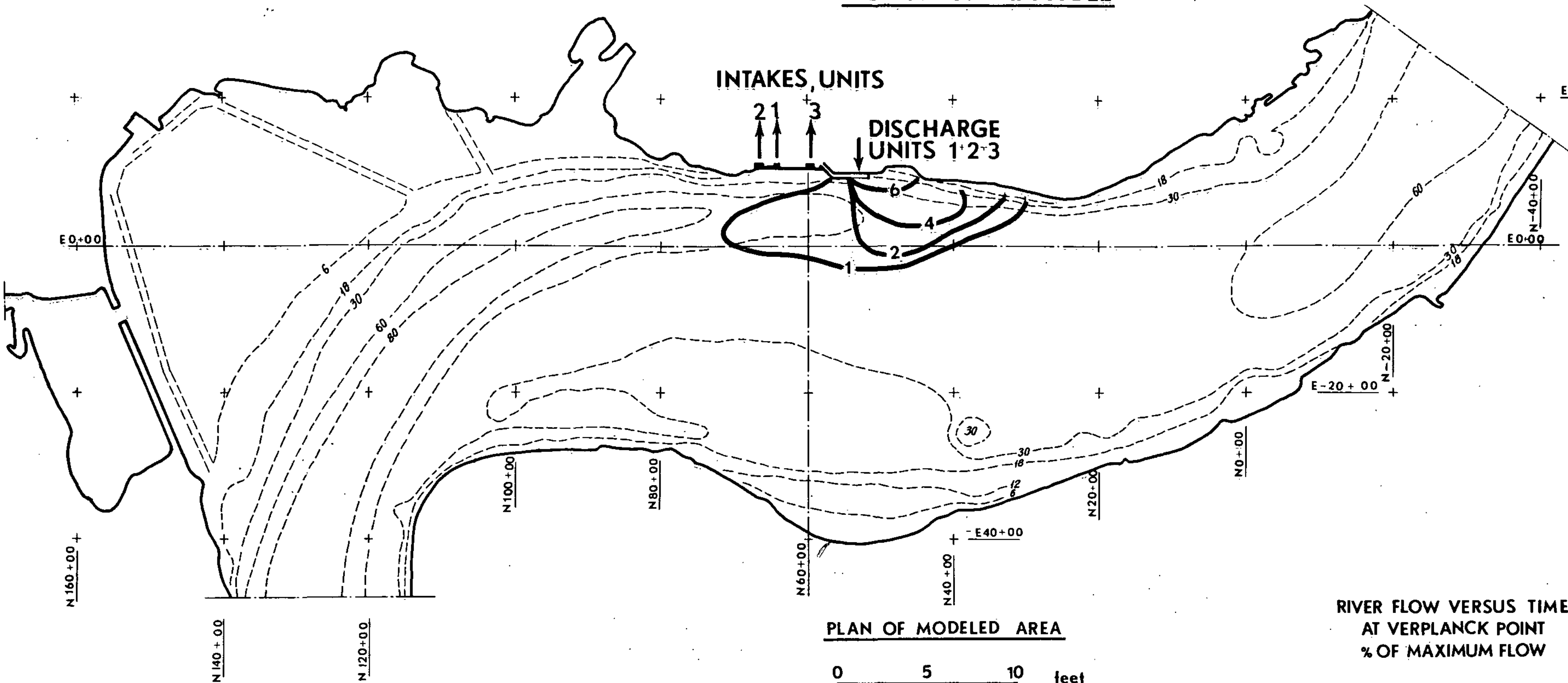
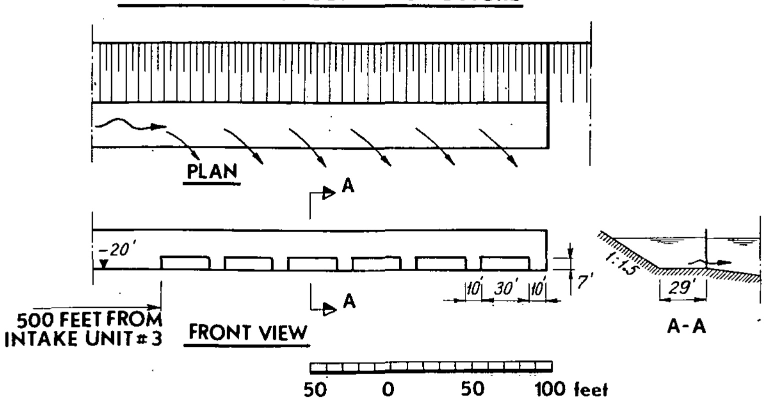
FIG. 88

INDIAN POINT II MODEL

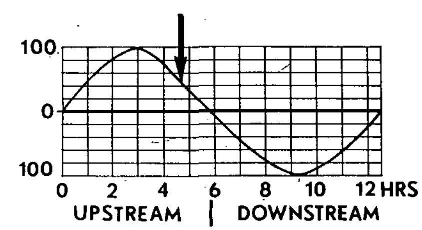


PLAN OF MODELED AREA

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



TEST CONDITIONS

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TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE WET BULB 57 °F
RELATIVE HUMIDITY 78 %
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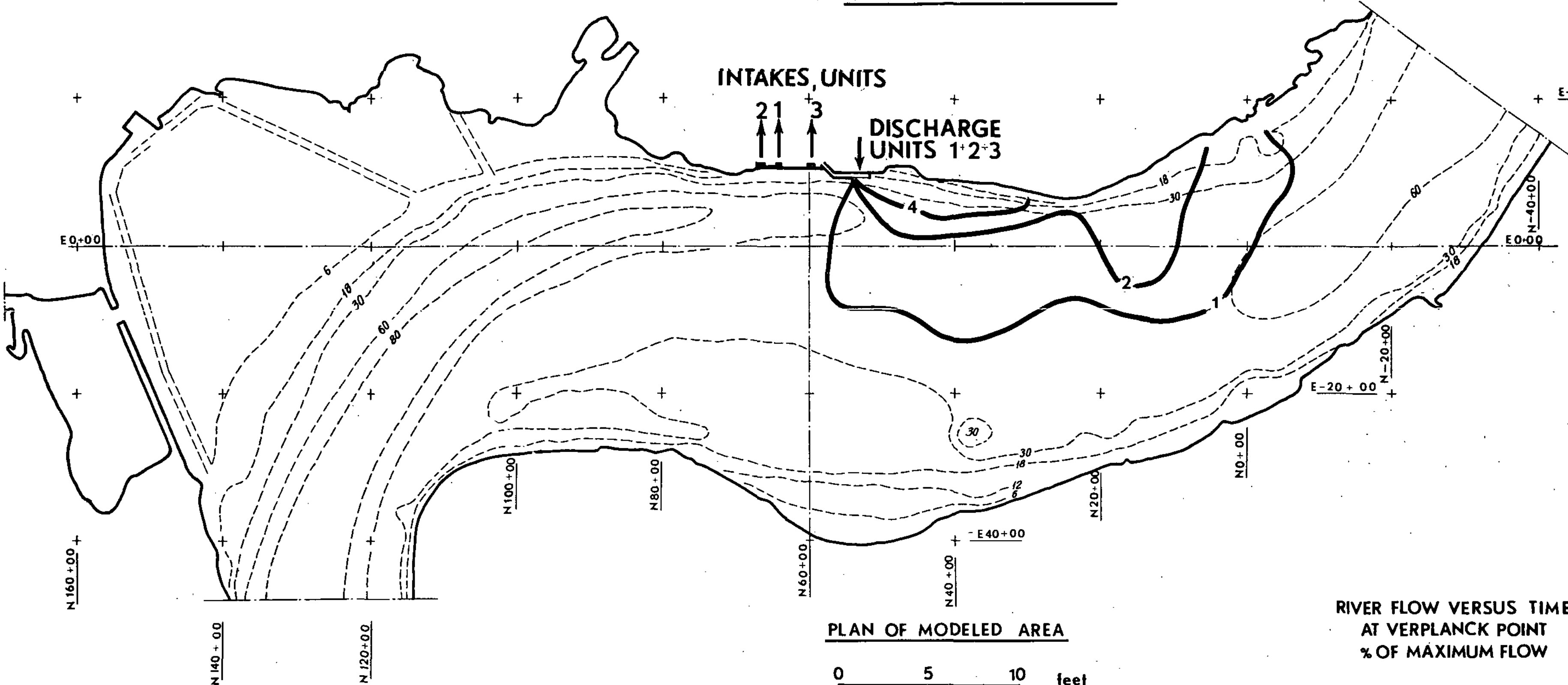
INDIAN POINT II MODEL

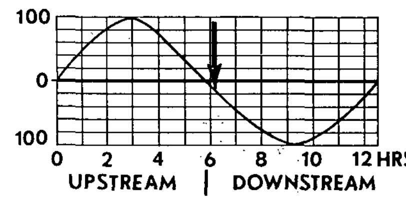


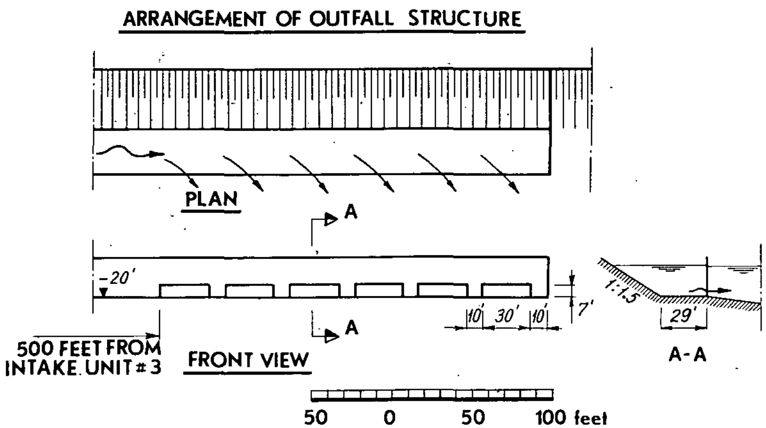
PLAN OF MODELED AREA

SCALES

0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE





TEST CONDITIONS

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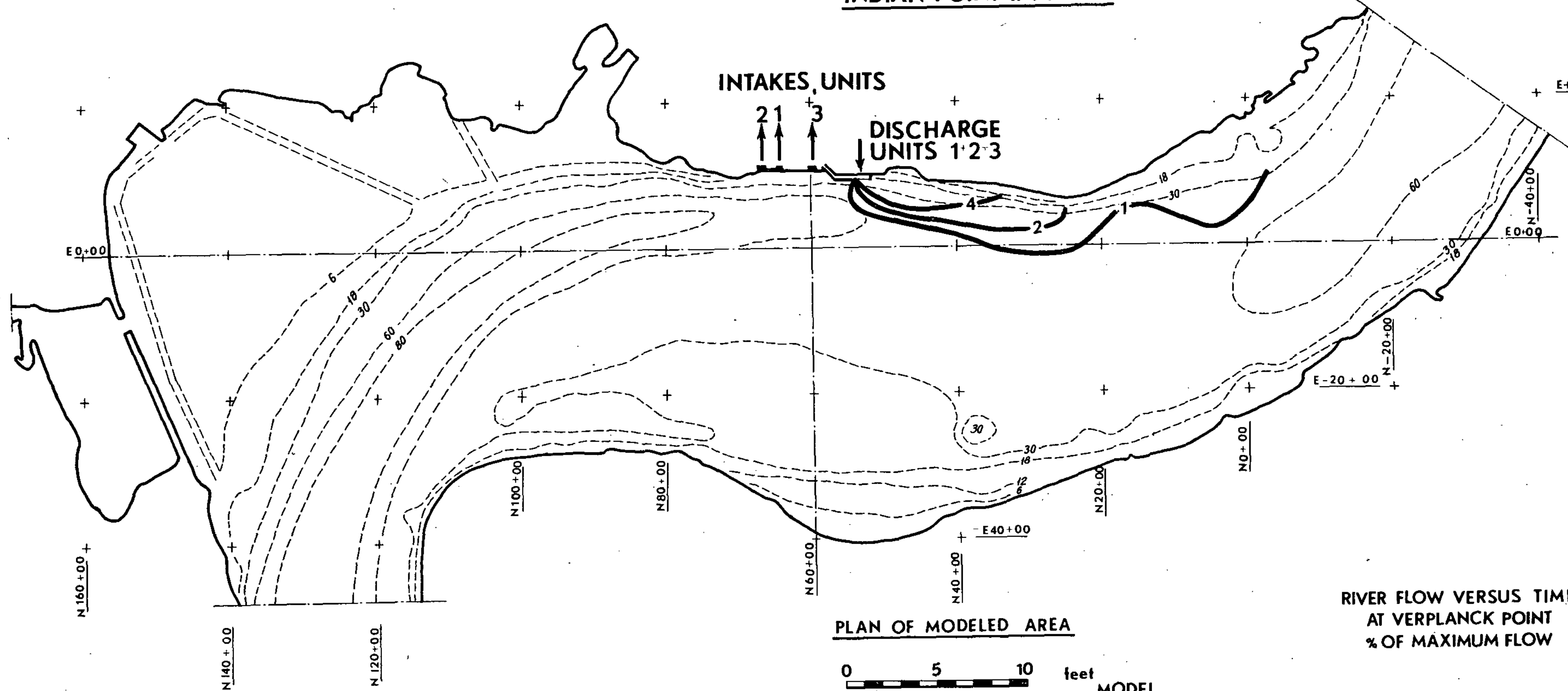
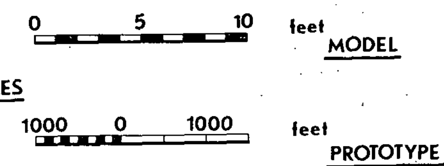
FIG. 90

FIG. 91

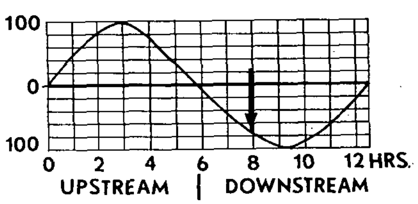
INDIAN POINT II MODEL



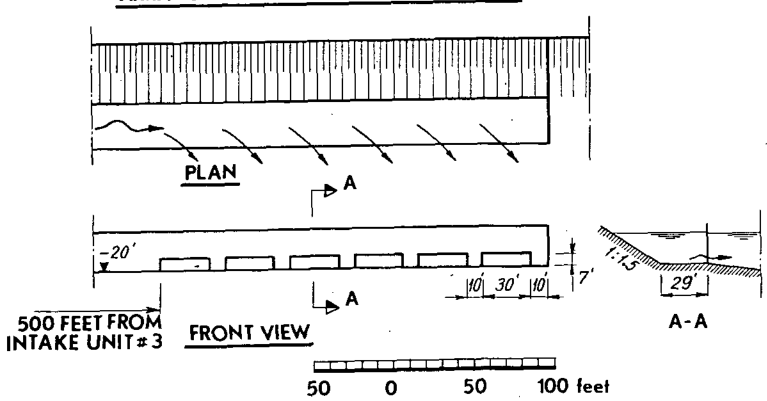
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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DEPTH OF ISOTHERMS 6 feet
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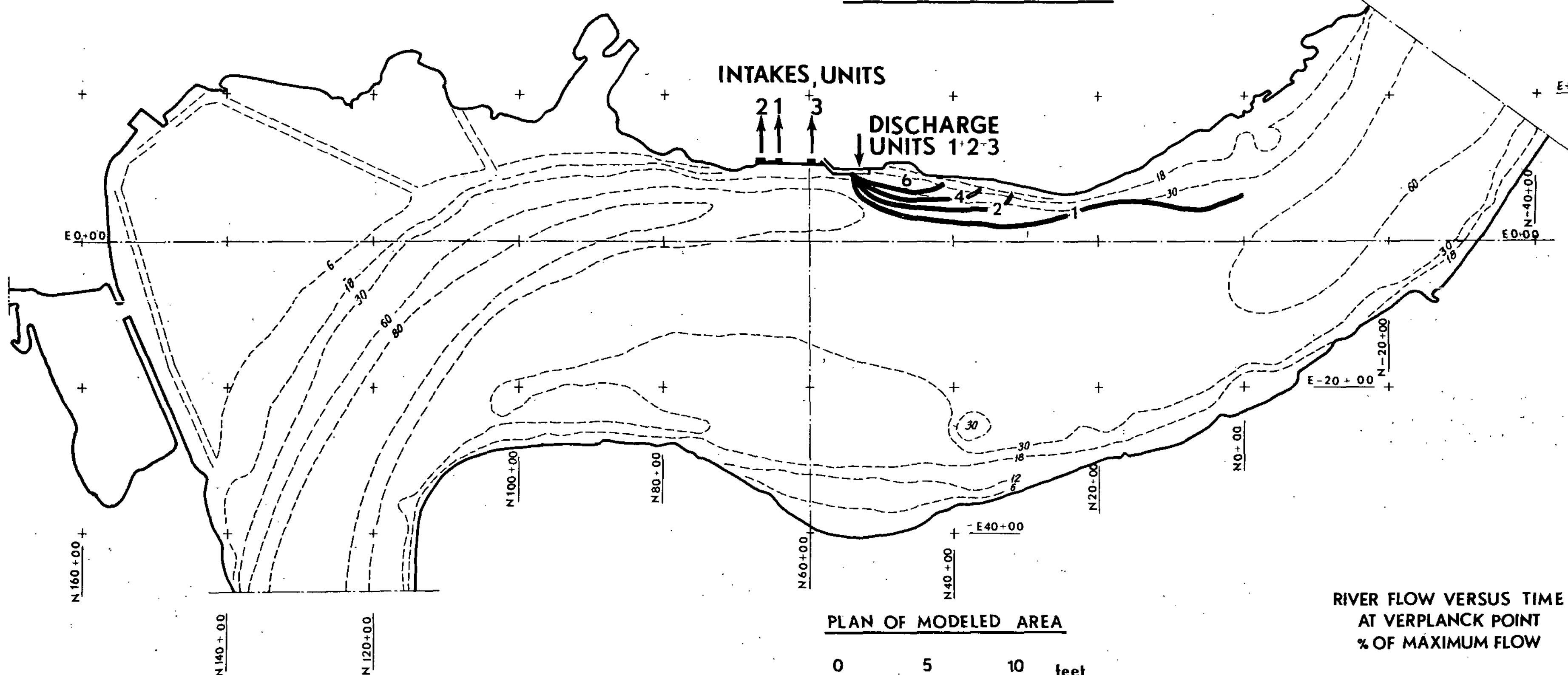
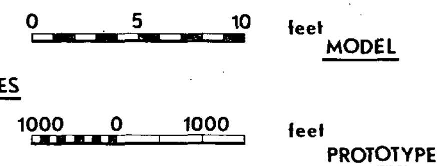
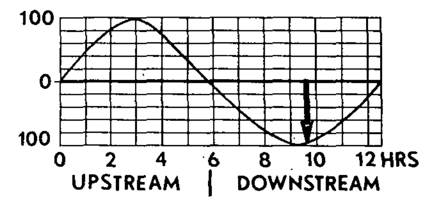
INDIAN POINT II MODEL



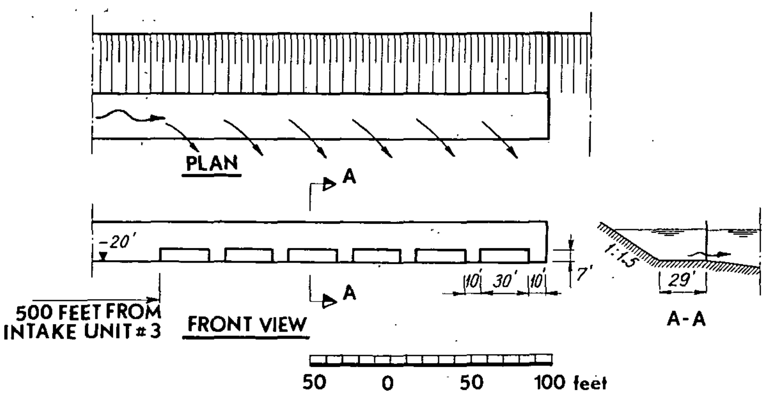
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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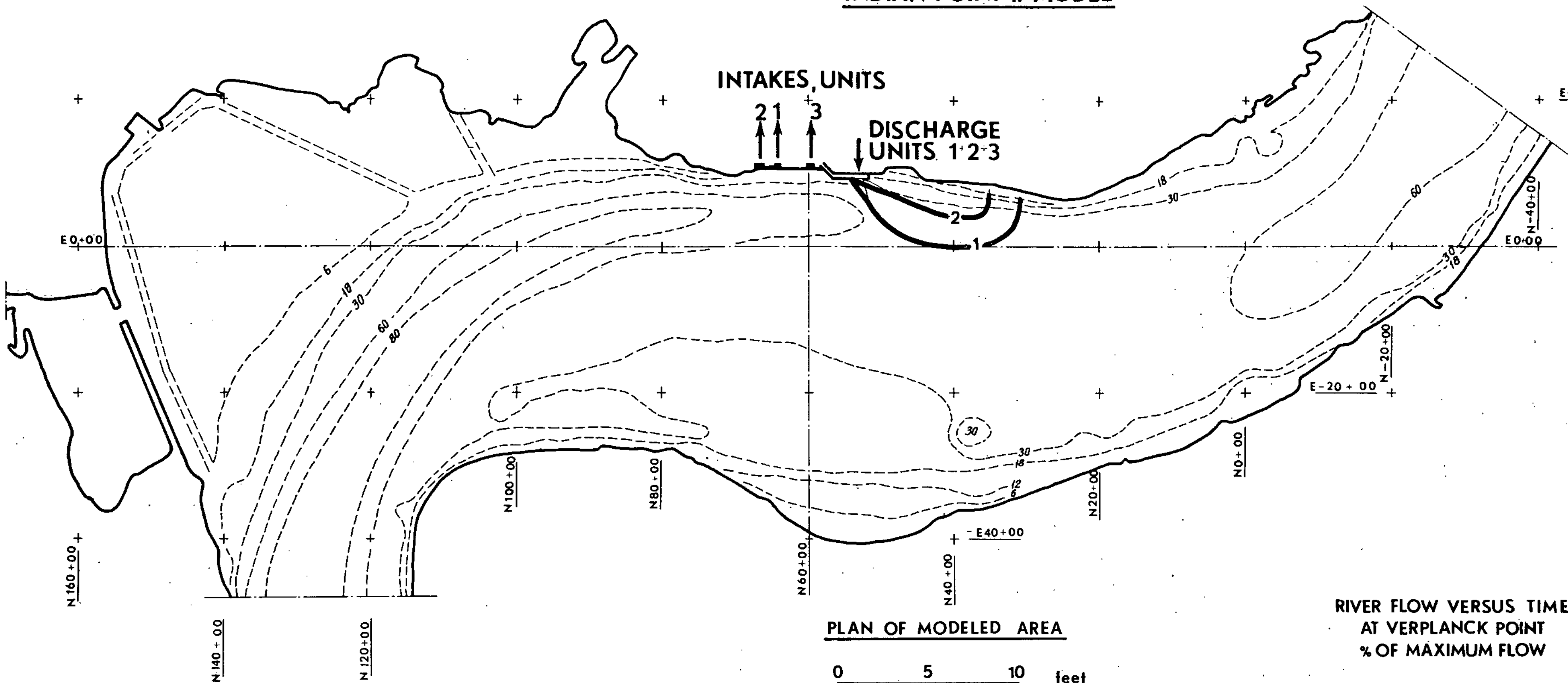
FIG. 92

FIG. 93

INDIAN POINT II MODEL



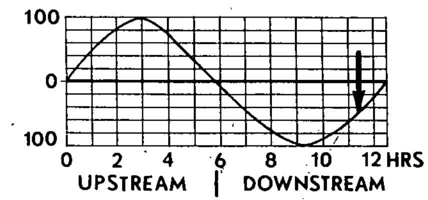
PLAN OF MODELED AREA

SCALES

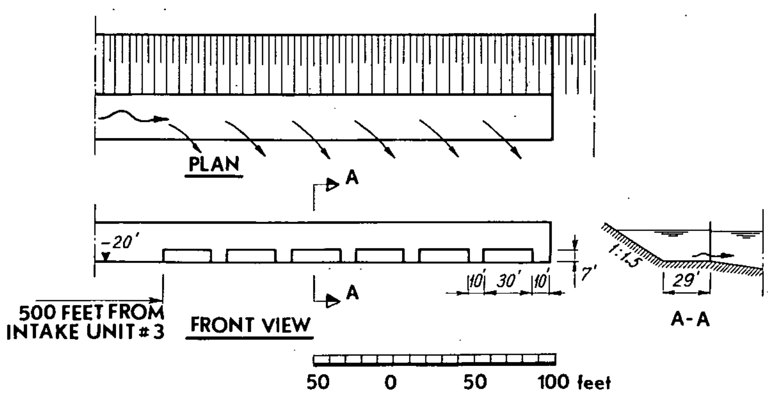
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 416 ; NOV 9,1968
UNITS OPERATING AND DISCHARGE 2; 2670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 56 °F
AIR TEMPERATURE DRY BULB 61 °F
AIR TEMPERATURE WET BULB 67 °F
RELATIVE HUMIDITY 78%
DEPTH OF ISOTHERMS 6 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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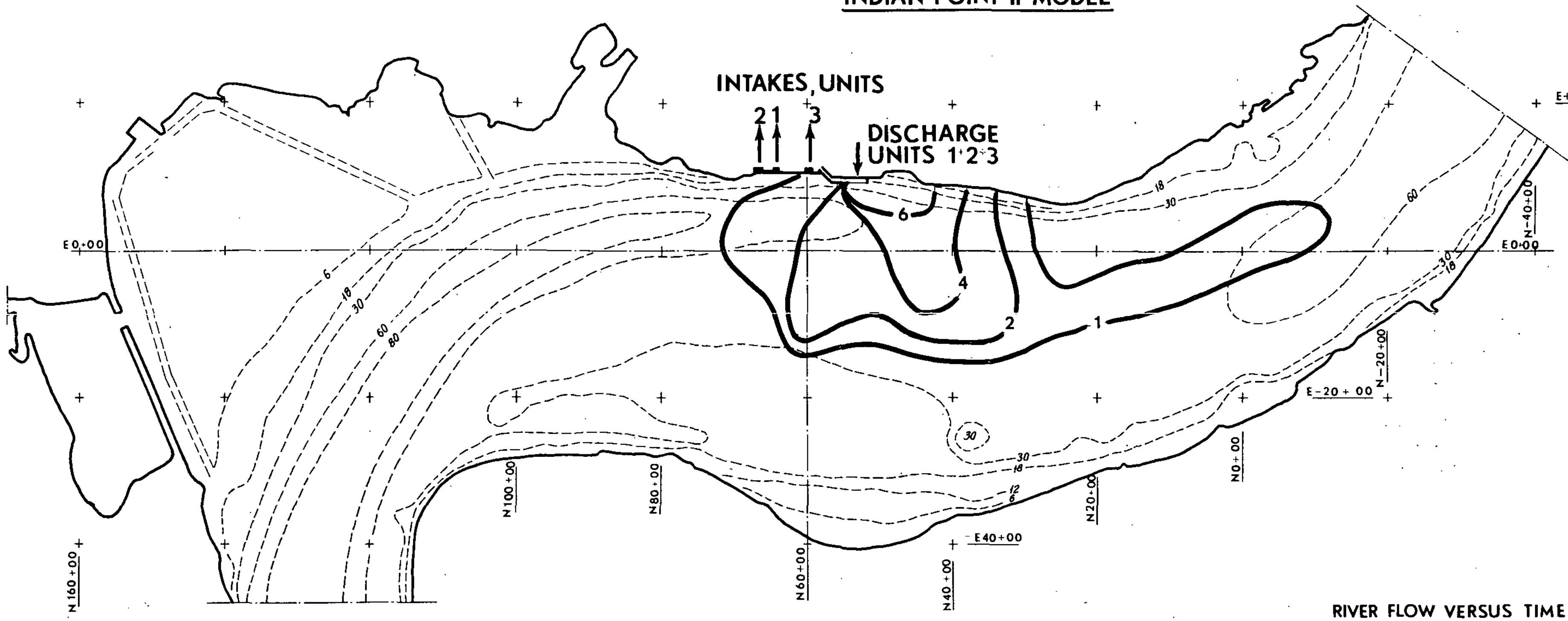
INDIAN POINT II MODEL



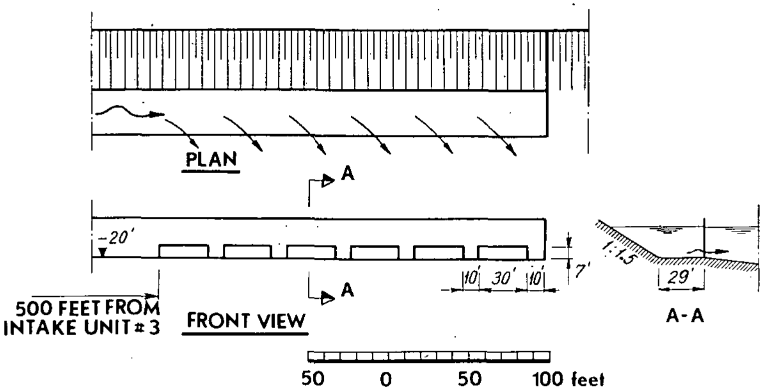
PLAN OF MODELED AREA

SCALES

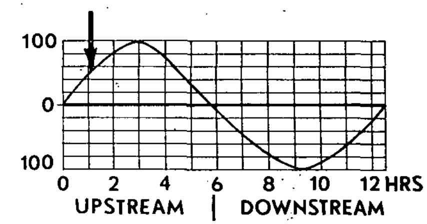
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 420 ; DEC 6, 1968
UNITS OPERATING AND DISCHARGE 2; 2670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 80 °F
AIR TEMPERATURE DRY BULB 77.7 °F
AIR TEMPERATURE WET BULB 71 °F
RELATIVE HUMIDITY 73 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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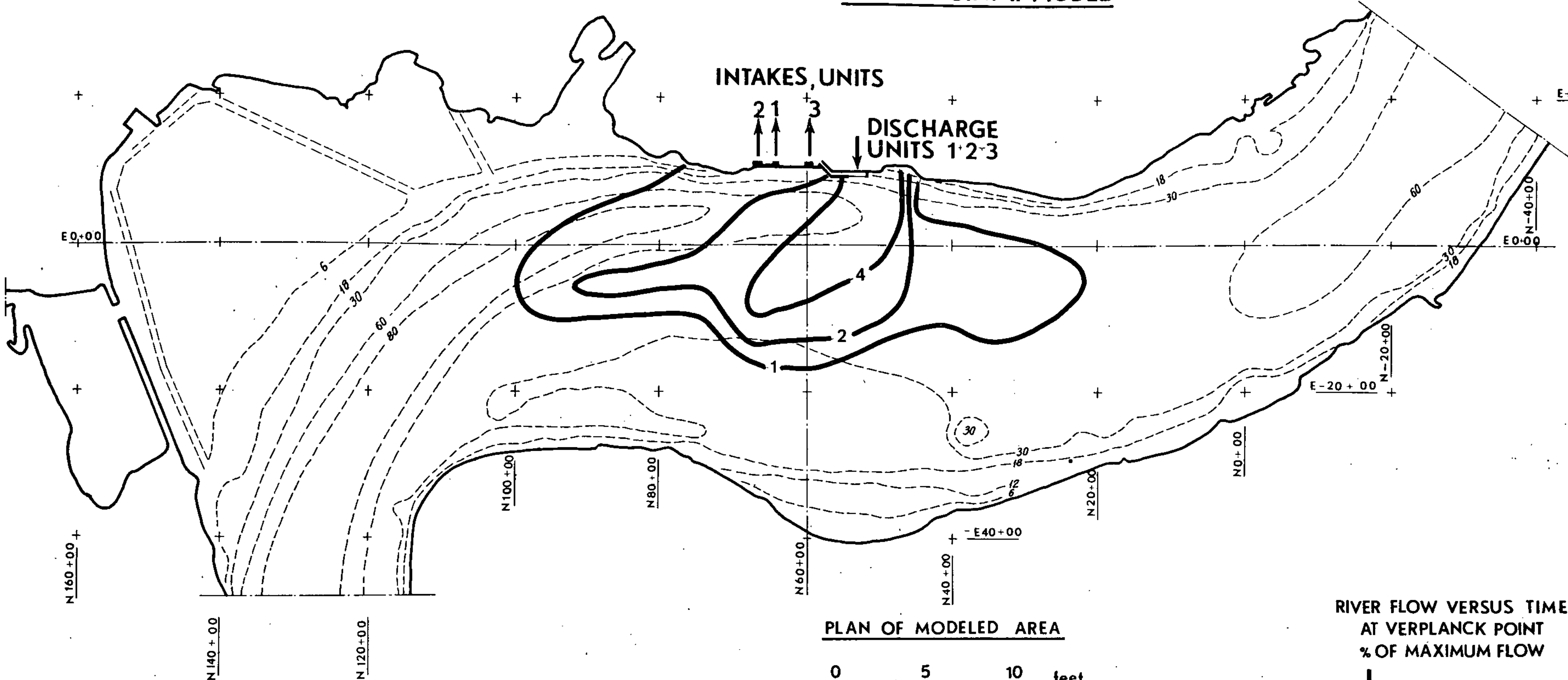
FIG. 94

FIG. 95

INDIAN POINT II MODEL



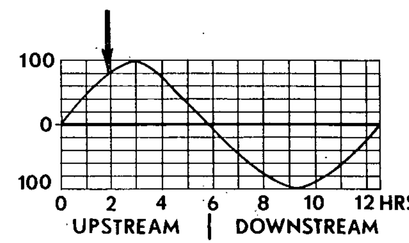
PLAN OF MODELED AREA

SCALES

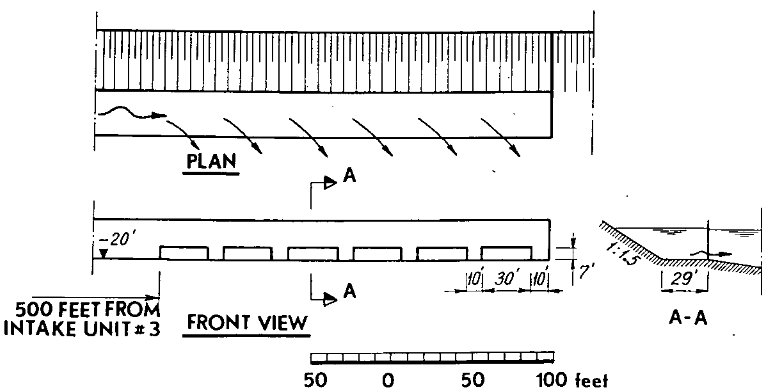
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 420 ; DEC 6, 1968
UNITS OPERATING AND DISCHARGE 2 ; 2670 cfs
DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE DRY BULB 77.7 °F
AIR TEMPERATURE WET BULB 71 °F
RELATIVE HUMIDITY 73 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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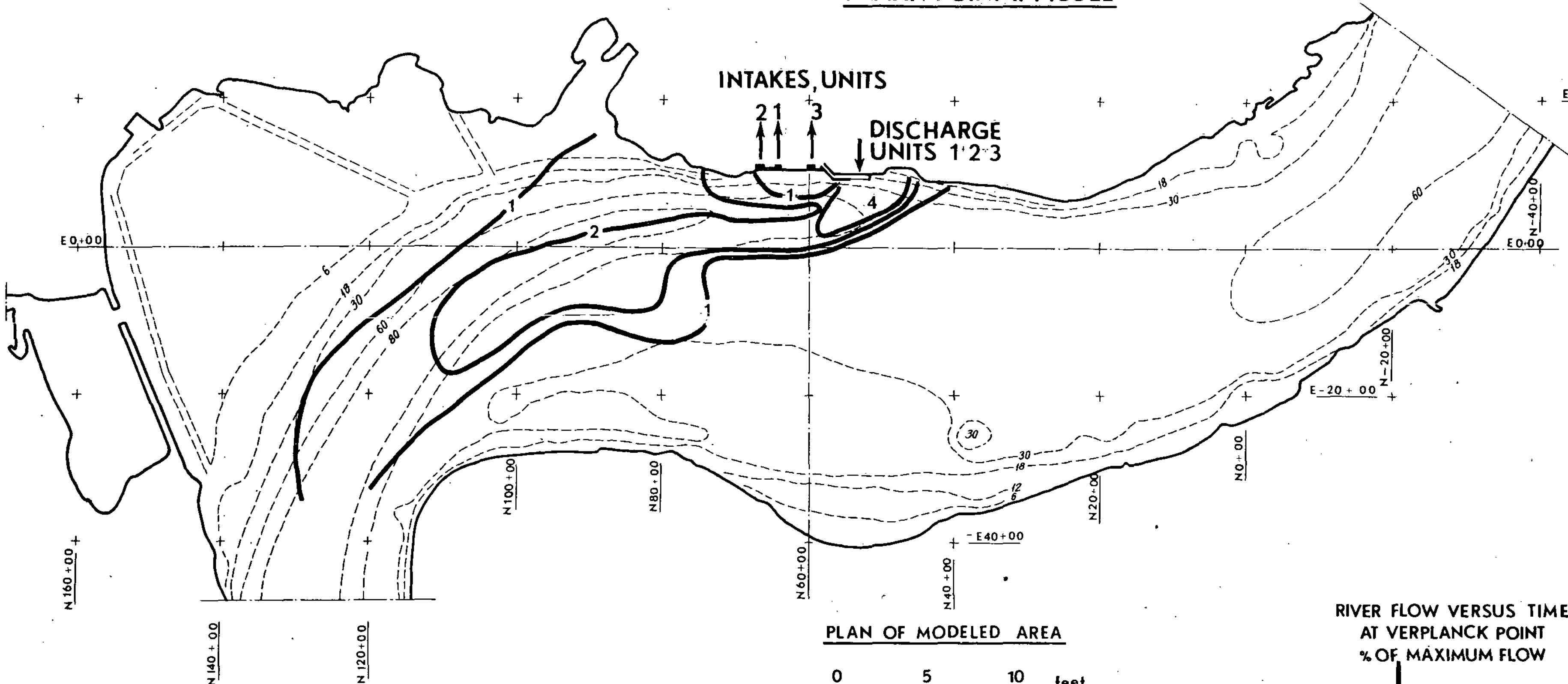
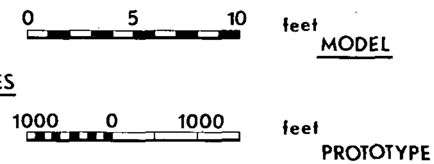
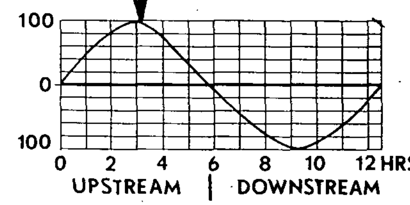
INDIAN POINT II MODEL



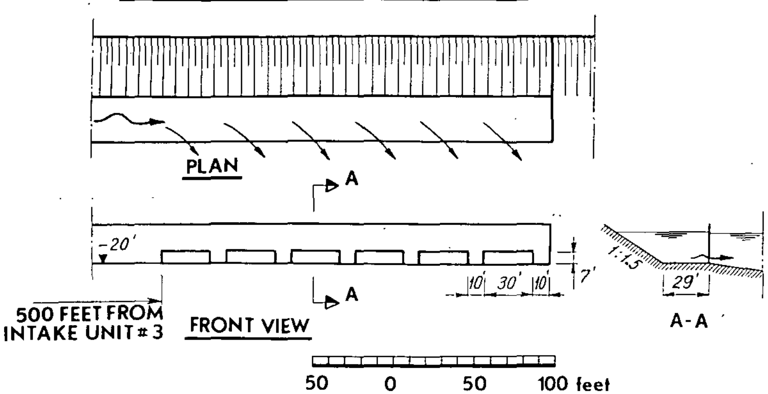
PLAN OF MODELED AREA



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

TEST NUMBER AND DATE 420 ; DEC 6,1968
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DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
RIVER AMBIENT TEMPERATURE 80 °F
AIR TEMPERATURE DRY BULB 77.7 °F
AIR TEMPERATURE WET BULB 71 °F
RELATIVE HUMIDITY 73 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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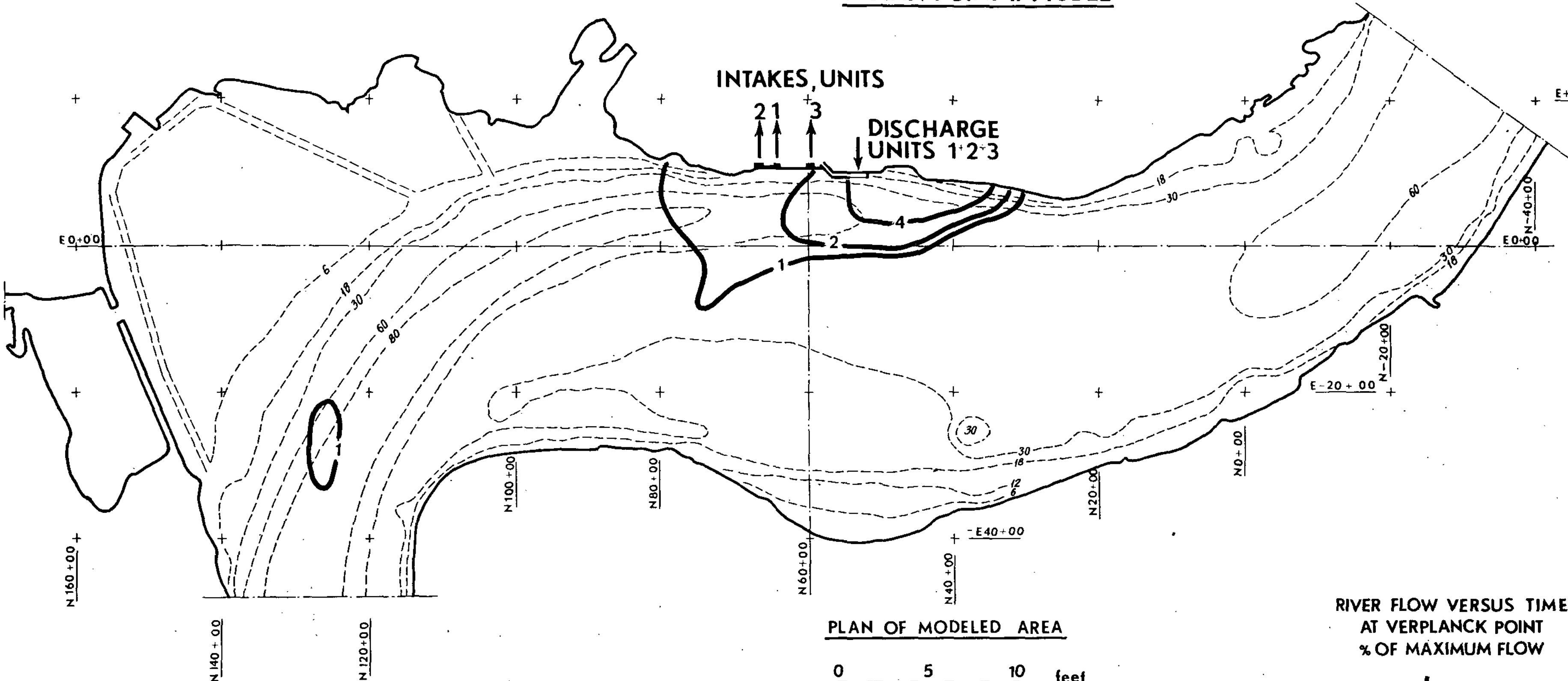
FIG. 96

FIG. 97

INDIAN POINT II MODEL



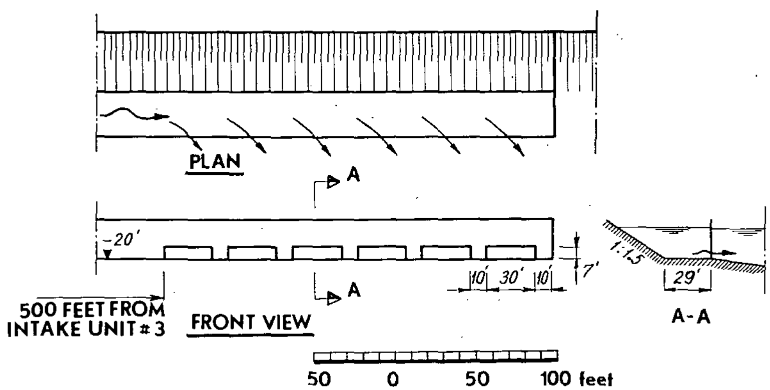
PLAN OF MODELED AREA

SCALES

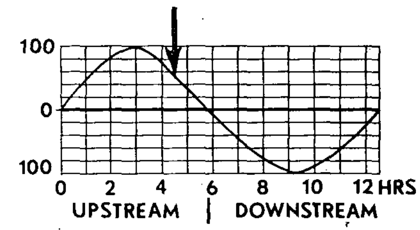
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



TEST CONDITIONS

TEST NUMBER AND DATE 420 ; DEC 6, 1968
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DISCHARGE TEMPERATURE ABOVE AMBIENT RIVER 14 °F
TIME IN TIDE CYCLE SEE DIAGRAM
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AIR TEMPERATURE DRY BULB 77.7 °F
AIR TEMPERATURE WET BULB 71 °F
RELATIVE HUMIDITY 73 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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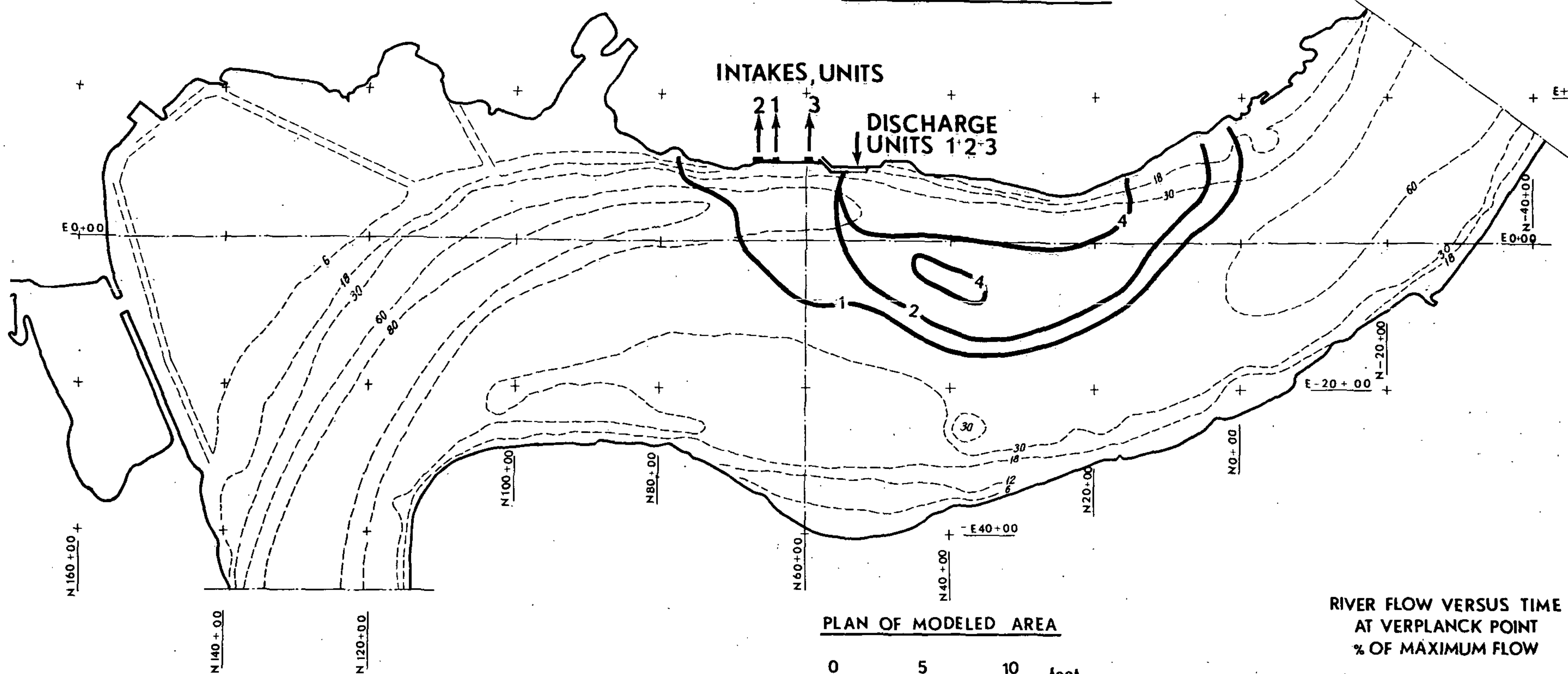
INDIAN POINT II MODEL



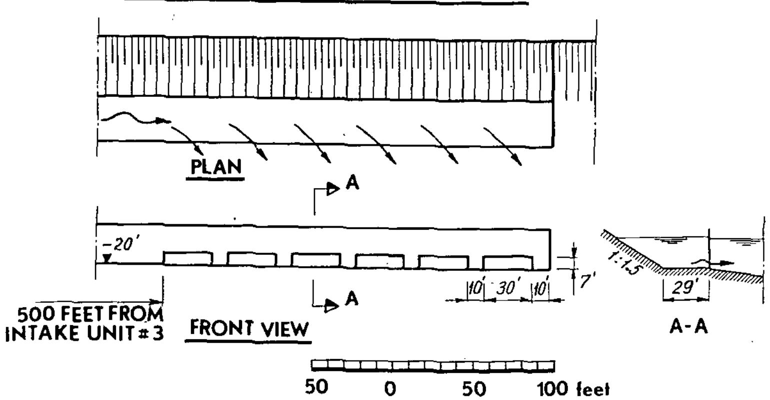
PLAN OF MODELED AREA

SCALES

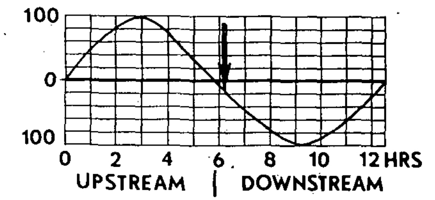
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



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DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

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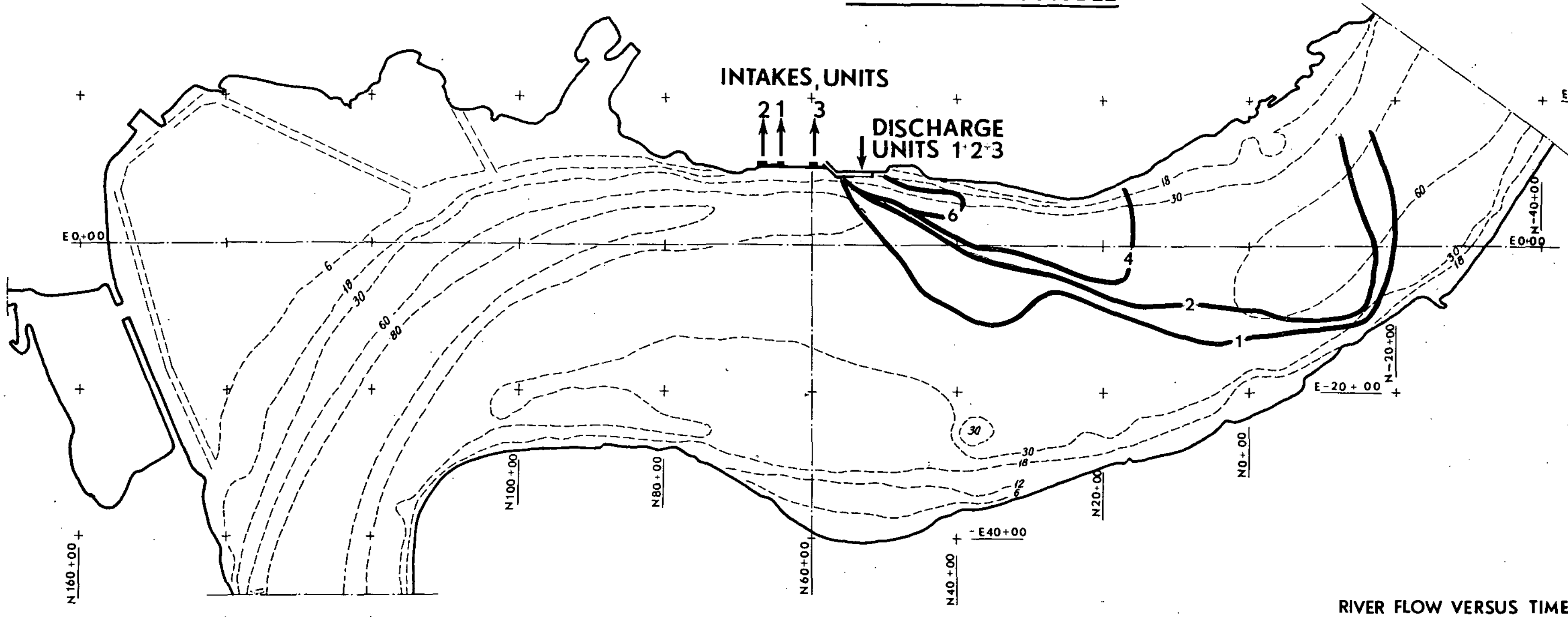
FIG. 98

FIG. 99

INDIAN POINT II MODEL



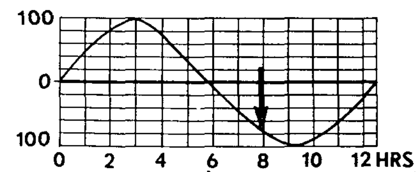
PLAN OF MODELED AREA

SCALES

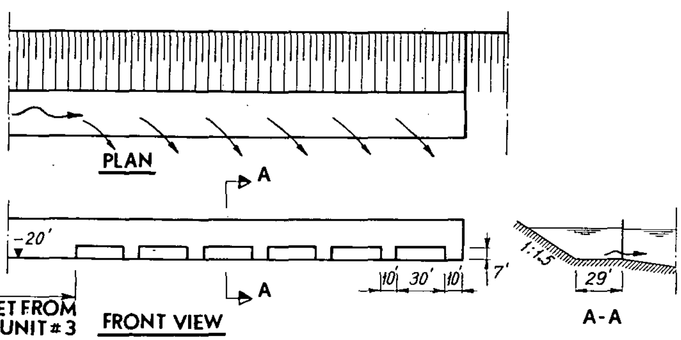
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME AT VERPLANCK POINT % OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



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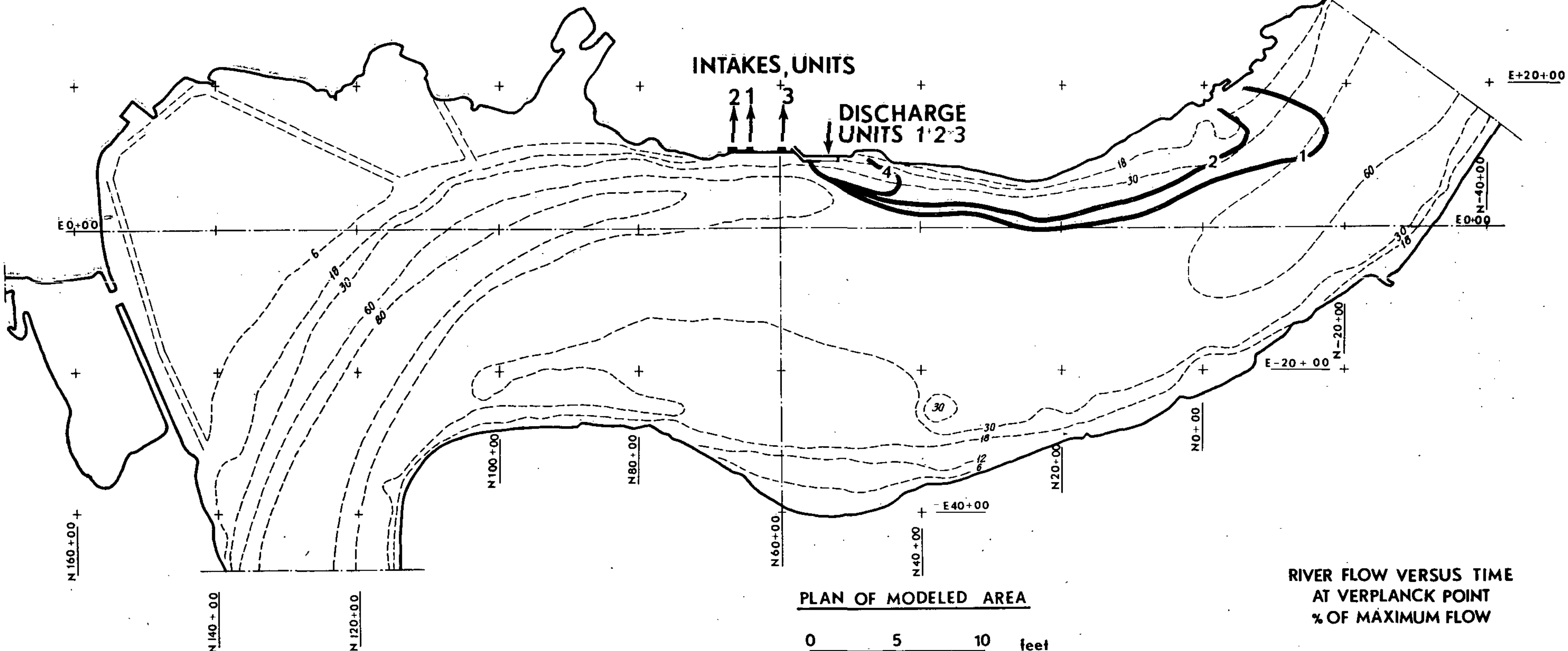
INDIAN POINT II MODEL



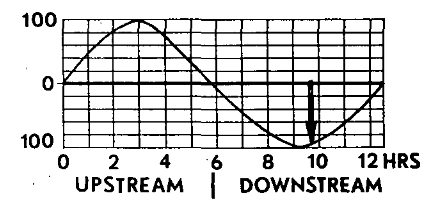
PLAN OF MODELED AREA

SCALES

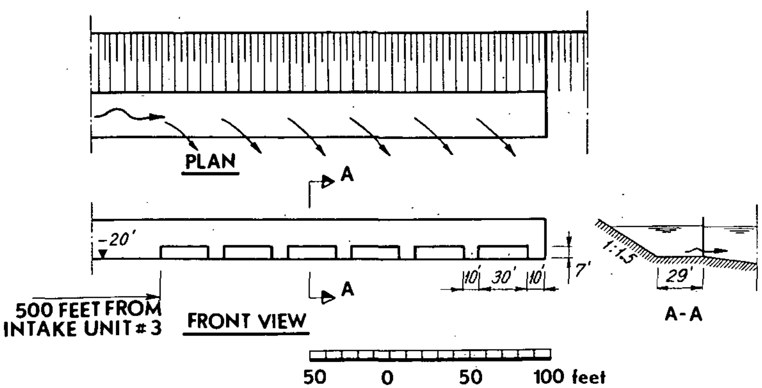
0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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RELATIVE HUMIDITY 73 %
DEPTH OF ISOTHERMS 0 feet
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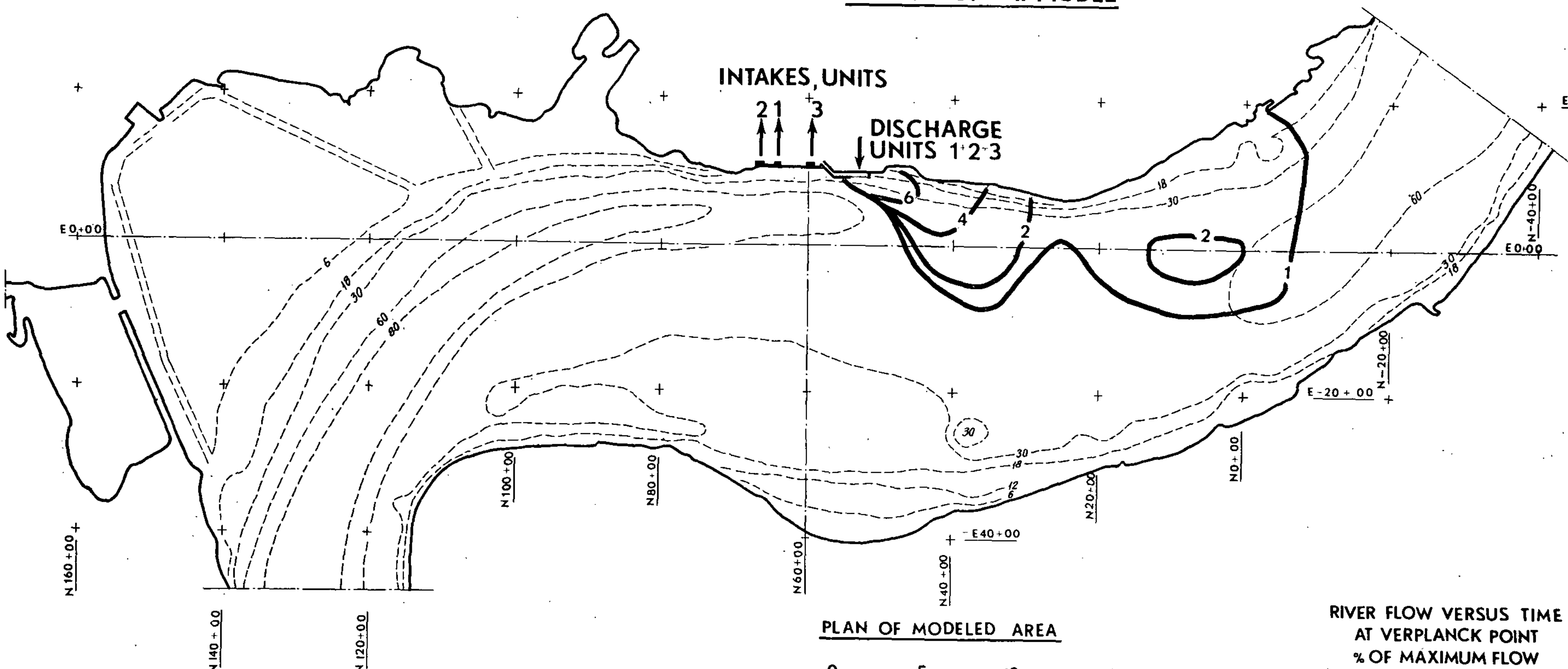
FIG. 100

FIG. 101

INDIAN POINT II MODEL



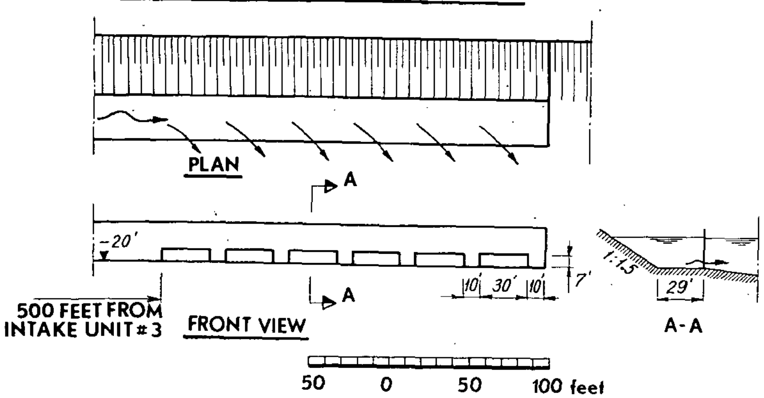
PLAN OF MODELED AREA

SCALES

0 5 10 feet MODEL

1000 0 1000 feet PROTOTYPE

ARRANGEMENT OF OUTFALL STRUCTURE



TEST CONDITIONS

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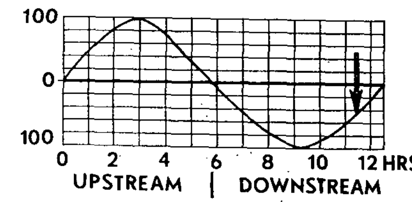
RELATIVE HUMIDITY 73 %
DEPTH OF ISOTHERMS 0 feet
ISOTHERMS ARE DEGREES ABOVE AMBIENT RIVER TEMPERATURE

RIVER FLOW VERSUS TIME
AT VERPLANCK POINT
% OF MAXIMUM FLOW



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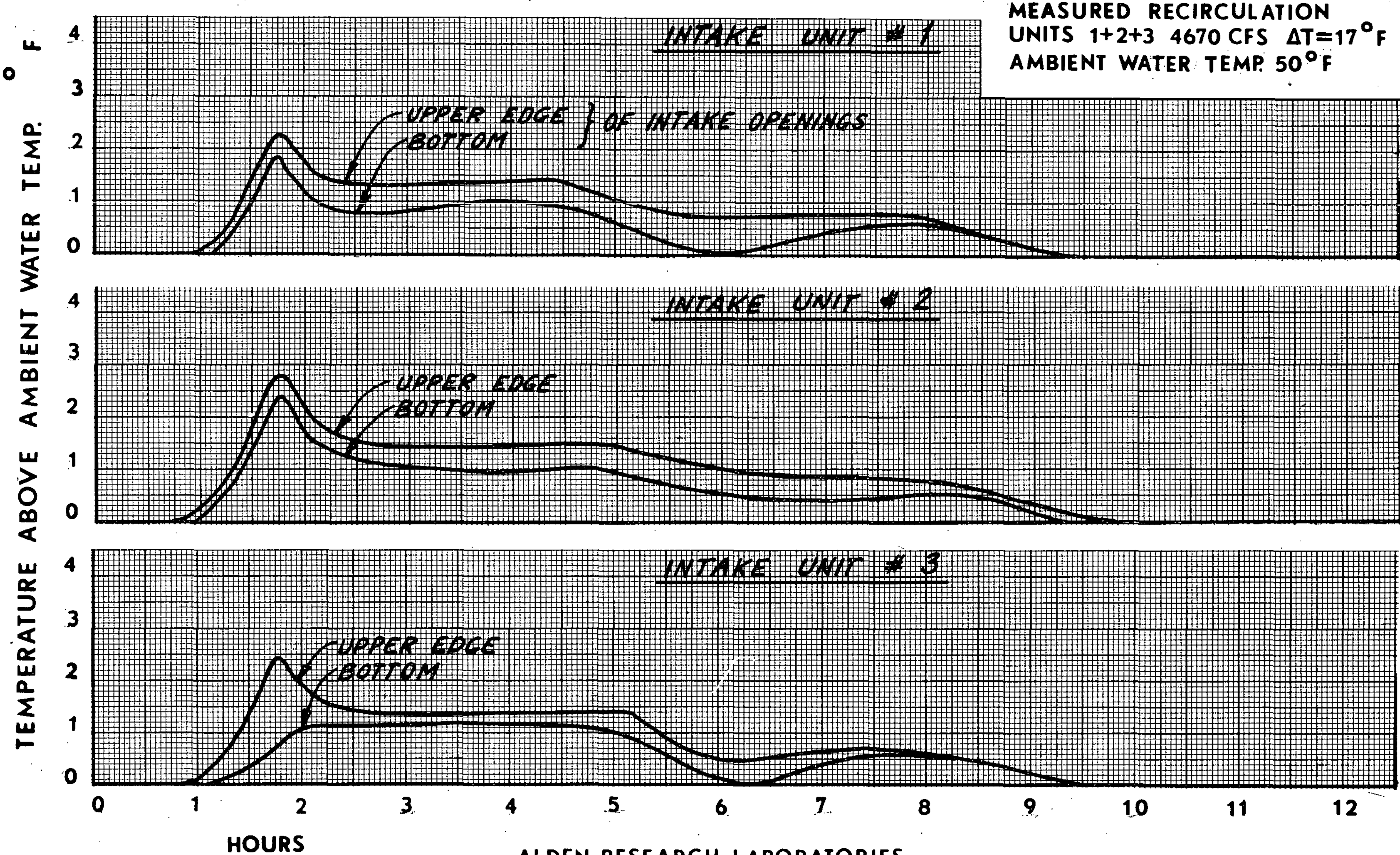
INDIAN POINT MODEL # 2

MEASURED RECIRCULATION
UNITS 1+2+3 4670 CFS ΔT=17°F
AMBIENT WATER TEMP. 50°F



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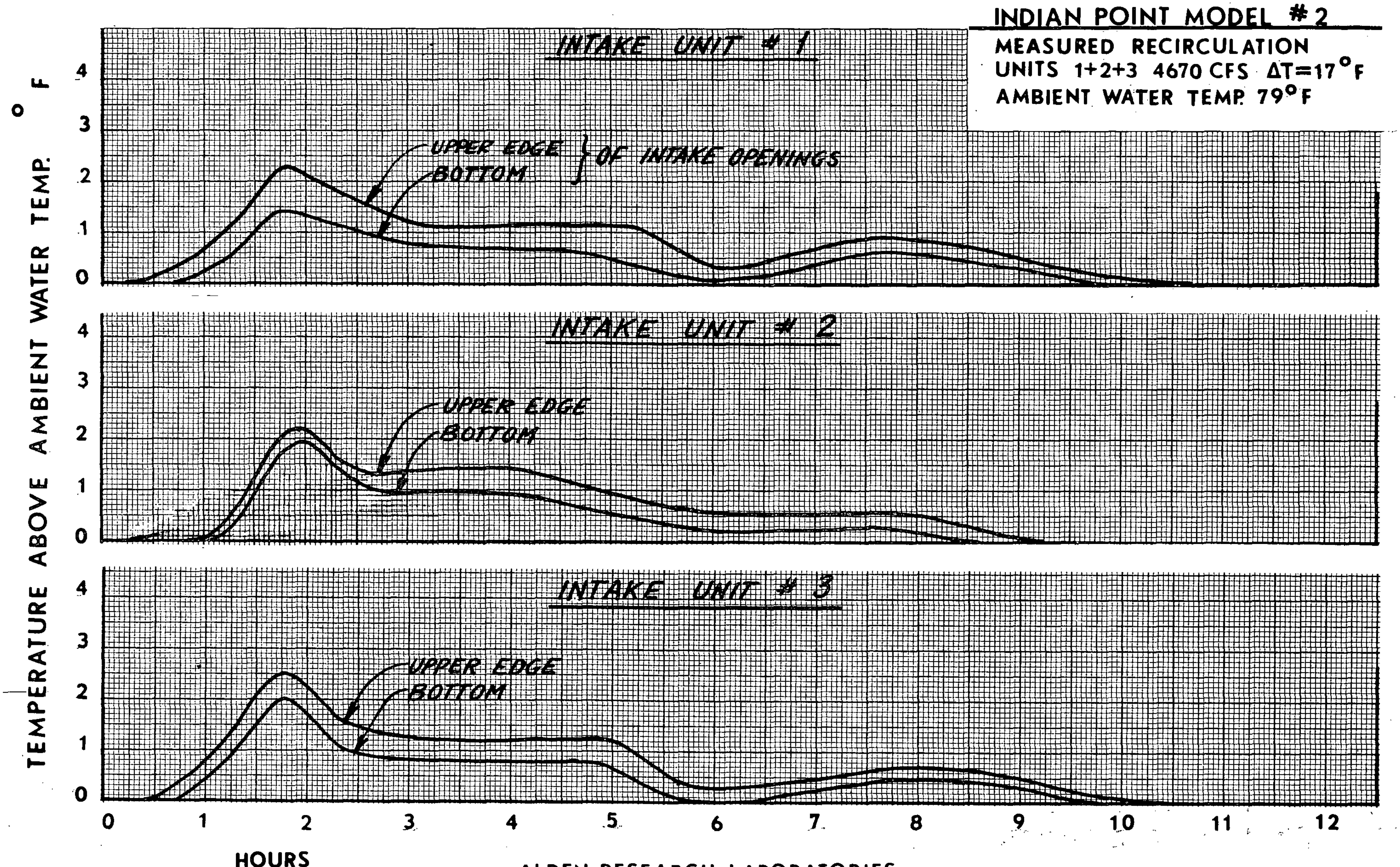
INDIAN POINT II MODEL

FIG. 102



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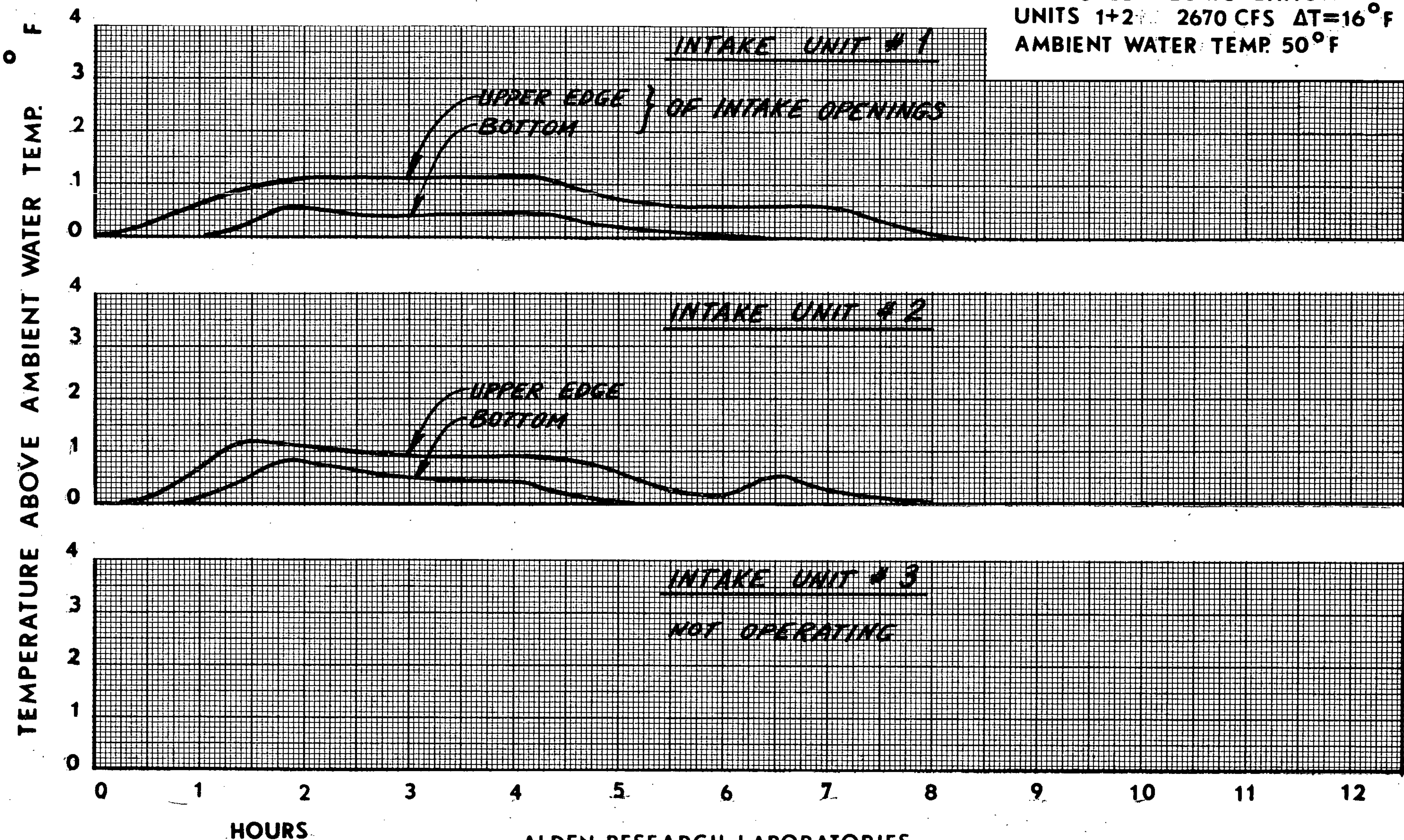
INDIAN POINT II MODEL

INDIAN POINT MODEL #2
MEASURED RECIRCULATION
UNITS 1+2 2670 CFS $\Delta T=16^\circ F$
AMBIENT WATER TEMP. 50°F



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INDIAN POINT II MODEL

FIG. 104

ARL