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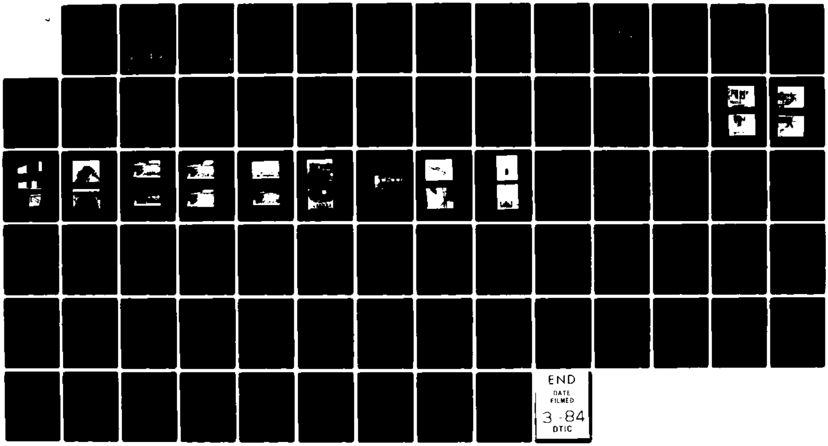

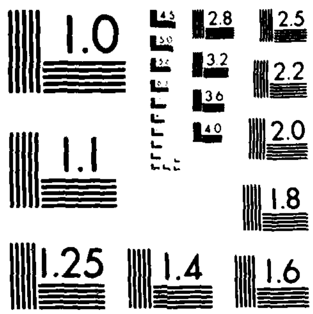

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TECHNICAL REPORT NO. 190-1

HYDRAULIC MODEL
INVESTIGATION

AD A137841

PowerHouse Intake Fingerling Collection at John Day and McNary Dams on the Columbia River, Oregon and Washington

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U. S. ARMY CORPS OF ENGINEERS
PORTLAND AND
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CONDUCTED BY
DIVISION HYDRAULIC LABORATORY
U. S. ARMY CORPS OF ENGINEERS
NORTH PACIFIC DIVISION
BONNEVILLE, OREGON

December, 1983

US Army Corps
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John Day Dam	Submerged Traveling Screens
Gate Wells	Vertical Barrier Screens

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

1:20- and 1:50-scale models were used to assist in testing and design of screen devices to more efficiently transport fingerlings into and through the gate wells of the powerhouse intakes at McNary and John Day Dams--both of which are located on the Columbia River. Flow conditions past submerged traveling screens located near the entrance to the gate well along the intake roofline were studied. Model studies of perforated plates attached to vertical barrier screens within the gate wells were accomplished to guide prototype

testing at the McNary project. The results of the prototype tests indicated that the design would efficiently move fingerlings through the gate well and into the bypass facility; the vertical barrier screen design was subsequently included in the John Day Dam fingerling bypass contract.

PREFACE

Model studies to improve fingerling collection capability in the powerhouse intakes at McNary and John Day Dams were conducted at the Division Hydraulic Laboratory, U.S. Army Engineer Division, North Pacific, during the period June 1980 to February 1982. Model study authorization was granted by the Office of Chief of Engineers, on 4 April 1977 at the request of the U.S. Army Engineer District, Walla Walla, for specific application at the Little Goose Lock and Dam project. Subsequently, the model studies became of general purpose nature to investigate fishery matters in coordination with ongoing research programs, and on 14 April 1981, responsibility for the model study was transferred to the U.S. Army Engineer District, Portland.

The studies were conducted by Mr. D. E. Fox under the supervision of Mr. P. M. Smith, Director of the Laboratory. This report was prepared by Mr. M. M. Kubo, U.S. Army Engineer District, Seattle, Hydrology and Hydraulics Branch.

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CONSERVATION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
miles	1.6093	kilometres
feet per second	0.3048	metres per second
cubic feet per second	0.0283	cubic metres per second
pounds (mass)	0.4536	kilograms

POWERHOUSE INTAKE FINGERLING COLLECTION
AT JOHN DAY AND MCNARY DAMS ON THE COLUMBIA RIVER,
WASHINGTON AND OREGON

Hydraulic Model Investigations

PART I: INTRODUCTION

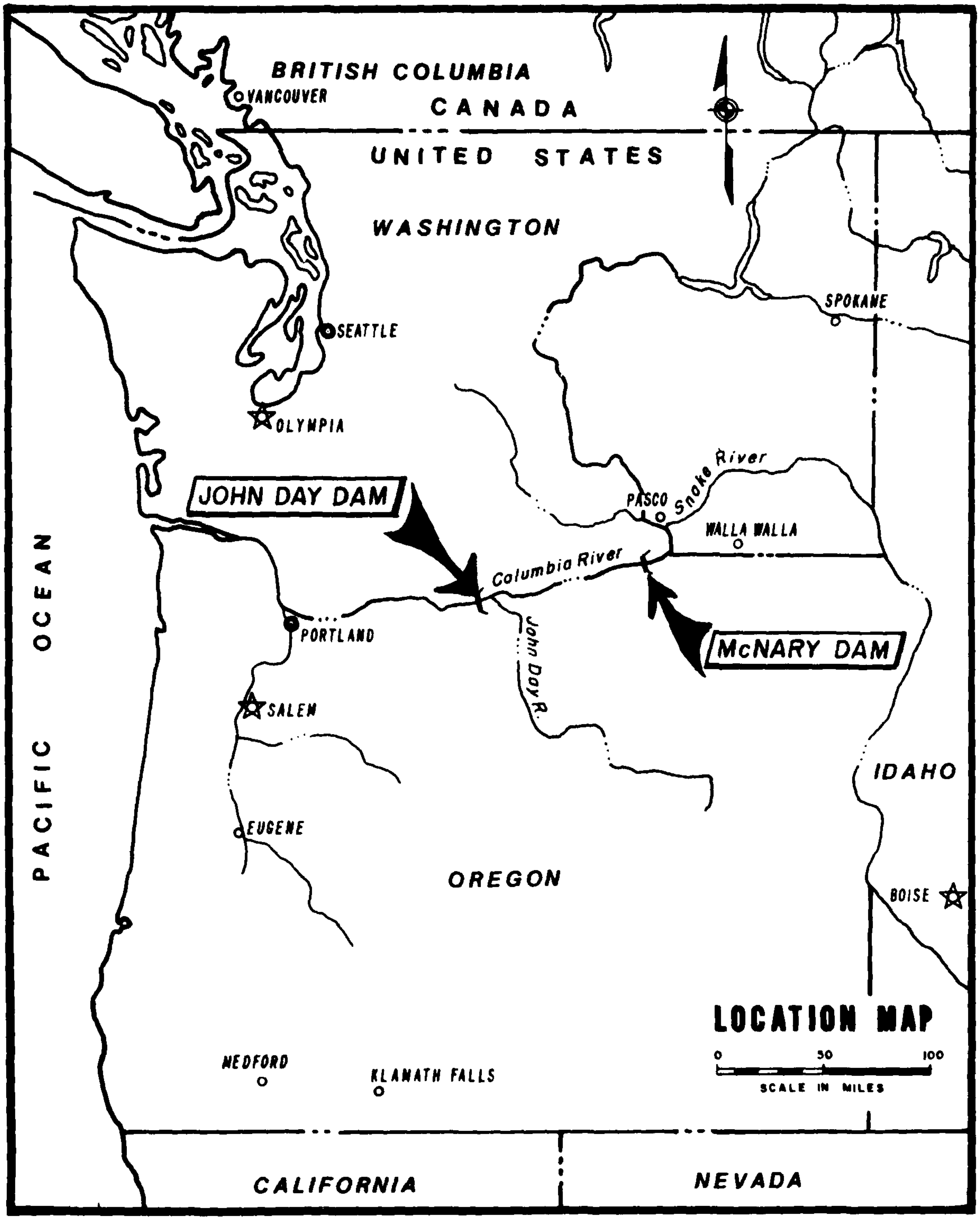
The Prototype

1. John Day and McNary Dams are located at River Miles 215.6 and 292.0, respectively, on that portion of the Columbia River forming the border between the states of Washington and Oregon. John Day and McNary Dams are located approximately 29 and 106 road miles, respectively, east from the city of The Dalles, Oregon (see figure 1).

2. The John Day Dam project includes a 20-bay, tainter-gate-controlled spillway and a 20-unit powerhouse. Overall length of the project along the dam axis is approximately 5,900 feet (see plate 1). The McNary Dam project has an overall length of approximately 6,600 feet and includes a 22-bay spillway and 14-unit powerhouse (see plate 2). Both projects have an 86-foot-wide by 675-foot-long single-lift navigation lock and two fish ladders, one on each bank of the river. Both projects either presently have or will have fingerling bypass facilities consisting of submerged traveling screens (STS) to deflect fish into power unit bulkhead/operating gate wells which contain orifices leading to open-channel flow systems which transport the fingerlings around the dam structure (see figure 2).

Need for Model Study

3. Model studies were required to assist in design of appurtenances to more efficiently transport fingerlings into and through the gate wells of the powerhouse intakes. Specific purposes of the model were to determine flow deflection under the STS, evaluate flow patterns in the gate well, determine and improve (as required) velocities through the vertical



BRITISH COLUMBIA
VANCOUVER
CANADA
UNITED STATES
WASHINGTON
SEATTLE
OLYMPIA
SPOKANE
Snake River
PASCO
WALLA WALLA
JOHN DAY DAM
Columbia River
McNARY DAM
John Day R.
PORTLAND
SALEM
EUGENE
PACIFIC OCEAN
OREGON
IDAHO
BOISE
LOCATION MAP
0 50 100
SCALE IN MILES
MEDFORD
KLAMATH FALLS
CALIFORNIA
NEVADA

Figure 1

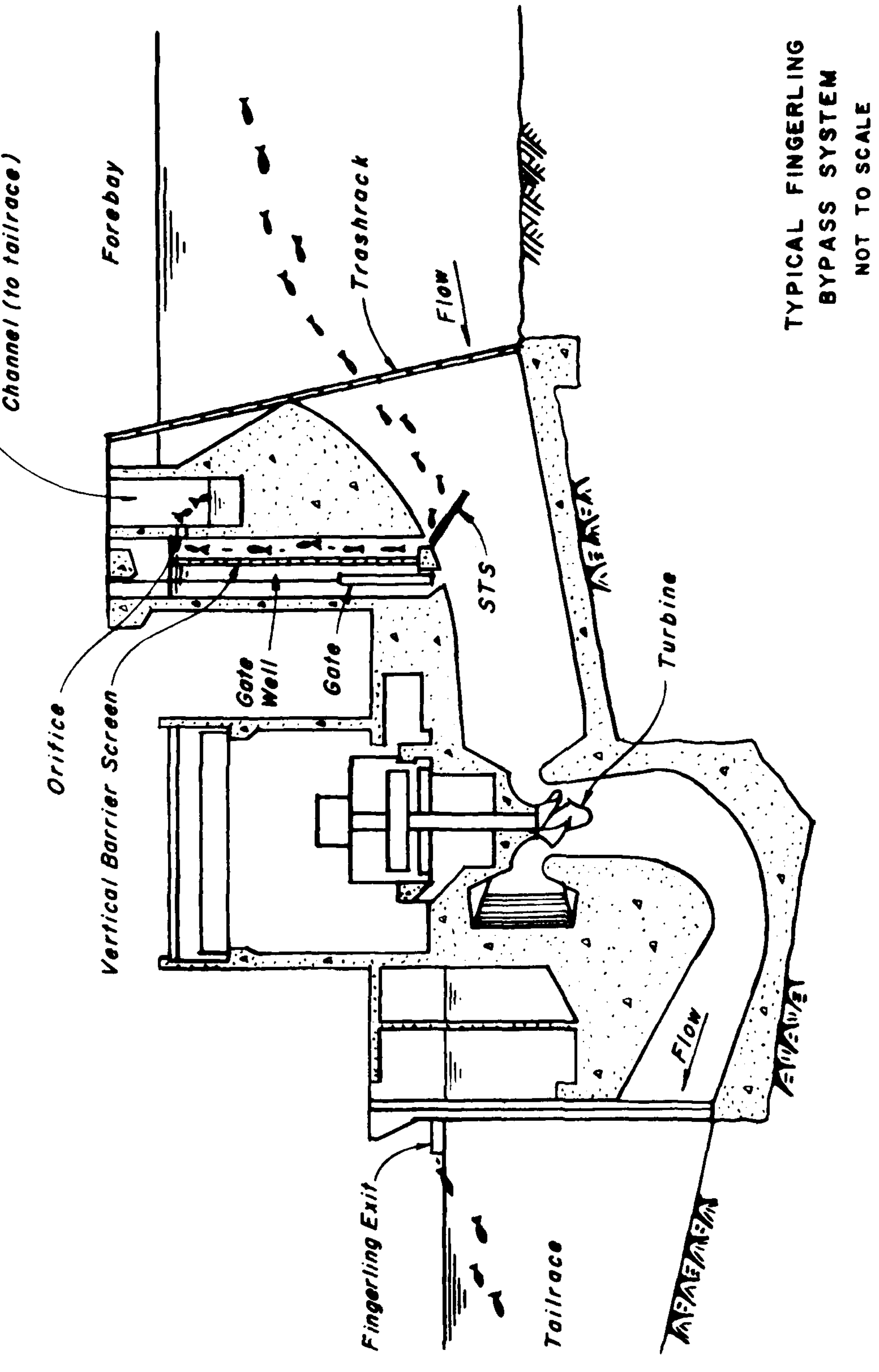

TYPICAL FINGERLING BYPASS SYSTEM
NOT TO SCALE
Forebay
Fingerling Conveyance Channel (to tailrace)
Trashrack
Flow
STS
Turbine
Gate
Gate Well
Orifice
Vertical Barrier Screen
Flow
Fingerling Exit
Tailrace

Figure 2

barrier screens, determine fingerling transportation velocities in vicinity of the exit orifices, evaluate methods of guiding and stabilizing flow to the orifices, and assist in guiding prototype research at the McNary project under simulated John Day conditions.

PART II: THE MODELS

Description

4. A 1:20-scale model of the McNary Dam intake was used to evaluate the existing flow conditions in the fingerling collection areas of the intake and to develop methods of improving flow conditions in these areas. The model reproduced one of three intake bays including the bulkhead and operating gate well, fingerling exit orifices, the operating gate, vertical barrier screens, and the submerged traveling screen (see plate 3 and photographs 1 through 5). The John Day Dam gate well was simulated in the model by raising the intake gate to allow flow to pass through the gate well without restriction. Subsequently, the model was used to study the effect of passive barriers on John Day Dam by modifying the McNary intake to simulate the John Day intake entrance opening (see plate 4). The passive barriers were intended to function as weirs to provide continuous movement of surface water and to attract fingerlings from areas near the surface having slack or very low velocity water.

5. The 1:20-scale model was installed in a narrow wooden flume and constructed of clear plastic to allow viewing from both sides. The wooden-flume approach channel was adequate to simulate forebay elevations for McNary Dam but was not deep enough to simulate maximum John Day forebay elevation. The model depth was sufficient to simulate the John Day conditions simulated in the McNary prototype research tests. Tailwater elevations were maintained in the downstream section of the wooden flume by means of a valve in the return line.

6. An existing 1:50-scale general model simulating intakes of five units of the John Day powerhouse (see plate 5 and photographs 6 and 7) was used to supplement the 1:20-scale flume model information and to evaluate general flow conditions, primarily along the reservoir surface, in the approach to the intakes both with and without passive barriers.

7. The 1:50-scale powerhouse intake was constructed of waterproof wood and plywood. The model forebay was part of a large tank used as a head bay for a general purpose model, and therefore the actual John Day project forebay topography was not simulated. A false floor was inserted in the model just upstream of the intakes to generally simulate the approach to a "typical" unit. However, the intended purpose of this model was to evaluate the effect of the passive barrier in drawing reservoir surface water into the intakes and exact modeling of the reservoir bed was not considered necessary for that purpose.

8. Water for the models was supplied by recirculating systems and measured with calibrated orifices. For the 1:20-scale model, forebay and tailwater elevations were measured by water manometers connected to piezometers in the flume. Water levels within the gate wells were measured to the nearest 0.02 feet prototype by electronic point gauges in stilling wells connected to piezometers in the model gate wells. Discharges through the fingerling bypass system collection orifices were measured with a V-notch weir. For the 1:50-scale general model, forebay elevations were measured by an electronic point gauge in a stilling well connected to a piezometer in the model. Velocities in both models were measured with Kent Miniflow current meters which had 1.2 cm diameter propellors and capability to measure velocities as low as 0.075 fps (0.33 fps prototype at 1:20-scale and 0.53 fps at 1:50-scale) with a specified accuracy of ± 5 percent. Meters with horizontal and vertical propeller shafts were used in the gate wells of the 1:20-scale model to permit alignment of the meter with the flow. Dye streaks and cork chips were used in both models to observe the flow patterns.

Scale Relationships

9. The required similitude of the models to the prototype were obtained with the following scale relationships based on the Froude model law:

Dimension	Ratio	1:20-Scale Relationship	1:50-Scale Relationship
Length	L_r	1:20	1:50
Area	$A_r = L_r^2$	1:400	1:2500
Velocity	$V_r = L_r^{1/2}$	1:4.47	1:7.07
Time	$T_r = L_r^{1/2}$	1:4.47	1:7.07
Discharge	$Q_r = L_r^{5/2}$	1:1788.85	1:17677.67

PART III: TESTS AND RESULTS

Existing Conditions

10. Tests were made to determine existing hydraulic characteristics of the fingerling collection systems for both the McNary and John Day Dams. These tests were primarily accomplished at an intake bay discharge of 5,914 cubic feet per second (cfs). This flow is estimated to be a normal powerload flow through a center intake bay at McNary Dam. Less extensive tests of the existing characteristics were made at a low powerload flow of 2,880 c.f.s. and at a maximum powerload flow of 6,243 cfs.

11. Flow conditions through the McNary bulkhead and operating gate well with a discharge of 5,914 cfs are shown on plate 6. The velocity into the gate well was 5 feet per second (fps), and the maximum velocity through the vertical barrier screens was 2 fps with return flow through the bottom two-fifths of the screens. Flow in the vicinity of the fingerling bypass orifices had an indefinite pattern and very low velocity. The influence of flow withdrawal through the orifices was not detectable more than 2 feet away from the orifice. Discharge through the well was 256 cfs and orifice discharge was 11 cfs (total). Flow conditions with a reduced flow discharge of 2,880 cfs through the center bay are shown on plate 7. At this reduced discharge, velocity into the well was 2 fps and velocities through the vertical barrier screens were less than 0.5 fps.

12. At John Day Dam the operating gate is not stored in the gate slot. This condition was initially simulated in the model by raising the stored gate 30 feet. Flow conditions observed in the model with the simulated John Day conditions are shown on plate 8. Maximum velocity into the gate well was 9.5 fps, and maximum velocity through the vertical barrier screens was 2 fps. Discharge through the well increased to 407 cfs. Flow conditions with the gate completely removed from the slot are shown on plate 9 and were similar to those occurring with the gate raised 30 feet.

Vertical Barrier Screen Tests

13. The vertical barrier consisted of eight 8.44-feet-high by 19-feet-wide panels. The upper three panels were solid while the lower five consisted of mesh having a porosity of 71 percent. A maximum velocity criteria of 0.5 fps through the vertical barrier screens was set to prevent impingement of fingerlings on the screens. Existing-condition tests of both the McNary and simulated John Day intakes indicated that the velocity criteria was not met at either project. Screen designs having various porosities were tested to determine if the velocity criteria could be achieved. The porosity was varied by attaching perforated plate to the backs of the structural frame members of the vertical screens.

14. The 0.5-fps maximum velocity criteria was met with the McNary intake by using perforated plate having a porosity of 30 percent. Flow conditions with a discharge of 5,914 cfs are shown on plate 10. With the perforated plate, discharge through the well remained at 256 cfs (same as that which occurred with the 71-percent porosity screens and no perforated plate), but flow through the screens was signficantly more uniform. Flow conditions in the well with the upper three solid-barrier panels replaced with screens and 30-percent porosity perforated plate were generally unchanged (see plate 11) except that flow to the orifices was slightly improved due to stronger upward flow at the orifices. With the intake discharge increased to 6,243 cfs, return flow passed through a somewhat smaller portion of the vertical screens. Maximum velocity criteria through the screens was still met; however, upward flow at the orifices was weak. Flow conditions are shown on plate 12.

15. In an attempt to reduce the discharge through the simulated John Day gate well to that known to be effective at McNary Dam for egress of fingerling, perforated plates with porosities of 0 to 4.3 percent were tested. The plates with a lower percent of porosity caused the greatest

reduction in discharge but also increased the head drop across the vertical barrier screens. A head drop of 1.0 foot (screen structural design head) was produced with a 4.3-percent porosity plate with corresponding gate well discharge of 281 cfs. Gate well discharges and corresponding head drops across the vertical screens for the various plate porosities are shown in table A. Complete blockage of the screens caused water surface fluctuations of 0.1 to 0.2 foot upstream of the screen and almost 2 feet downstream of the screen. Subsequently, higher discharges into the well were deemed acceptable and it was concluded that plate porosity should be set to produce a uniform velocity of 0.5 fps through the screens.

16. With the simulated John Day intake, the velocities through the vertical screens were up to 1 fps with the perforated plate having 30-percent porosity. In order to meet the maximum velocity criteria, perforated plate having a 15-percent porosity was required. Flow conditions with the 15-percent porosity perforated plate and an intake discharge of 5,914 cfs are shown on plate 13. Discharge through the gate well was 342 cfs, and return flow through the vertical screen was essentially eliminated. Plate 14 shows flow conditions in the well with the upper three solid vertical panels replaced with screens and with perforated plates of 15 percent porosity. Again, this design slightly improved flow to the orifices.

Submerged Traveling Screen (STS) Tests

17. Flow past and through the STS was observed with dye traces that showed the flow lines. The normal flow pattern in the intake without flow interception by the STS is shown in photograph 8 by nine equally spaced flow lines that were initially 4 feet apart vertically. The pattern with the McNary STS in place is shown in photograph 9. The third and fourth flow lines from the bottom of the group which normally would pass through the area occupied by the bottom of the screen deflected beneath it. About 22 percent of the flow to the area intersected by the

screen deflected under it. The majority of the upper 50 percent of the flow to the screen was deflected to the top of the screen and to the bulkhead slot. When the perforated plate within the STS was changed from 46- to 30-percent porosity, deflection under the screen was the same but more flow was deflected to the top of the screen and the slot (photograph 10). When the perforated plate was changed to 50-percent porosity, deflection under the screen was essentially the same but slightly more flow passed through the screen (photograph 11). Replacement of the 18-inch-long solid plate at the bottom of the STS (photograph 5) with 46-percent porosity plate permitted flow that had previously deflected under the screen to pass through (photograph 12) and about 16 percent of the flow approaching the screen deflected under the screen. Removal of the solid plate and without replacement with perforated plate caused the same deflection around the screen (photograph 13, compare with photograph 12).

Passive Barriers on John Day Dam Intakes

18. The effect of passive barriers (plate 15) on the John Day Dam powerhouse intake was evaluated in the 1:50-scale general model of five intakes and in the 1:20-scale McNary Dam intake modified to simulate John Day Dam conditions. The passive barriers were box-like structures attached to the upstream face of the powerhouse and open to flow only at the top and bottom. The barriers were submerged and intended to function as weirs to draw water from near the surface into the intakes through wells formed by the panels and their solid sides (photographs 14 and 15). The barriers were intended to continually draw surface water from the area just upstream of the powerhouse. The surface water is generally slack or has a very low velocity and fingerlings are thought to mill in the area instead of sounding into the deep intake. It was anticipated that the continuous movement of the surface water would keep the fingerlings moving and minimize delay and subsequent predation of fingerlings which would occur immediately upstream of the powerhouse.

19. The 1:50-scale John Day general model was used to evaluate flow conditions in the approach to the intakes with passive barriers installed and with all five adjacent power units operating with a discharge of 21,000 cfs per unit and a pool elevation of 265. Observations were made with passive barriers installed as follows:

a. At all three bays of the three center units.

b. At all three bays of the center unit.

c. At only the center bay of the center unit.

20. The 1:20-scale McNary intake was modified with a false headwall (plate 4) to simulate the vertical opening of the John Day intakes in order to evaluate detailed flow conditions in the immediate area of the intake both with and without passive barriers. However, the model was limited to providing only a 30-foot submergence on the simulated intake roof in lieu of the 63.5-foot submergence which exists at John Day with forebay elevation 265. These flow conditions were evaluated with a discharge of 7,560 cfs—the estimated discharge of the center bay of a three-bay intake passing 21,000 cfs.

21. Flow conditions in the approach to the John Day intakes with existing conditions (without passive barriers) are shown in photograph 16 and on plates 16 through 18. Velocities in the upper 25 feet of the reservoir 150 feet upstream from the powerhouse were 2 fps. At 100 feet from the powerhouse, flow began to draw down toward the intakes. At the face of the powerhouse, flow above the intakes consisted of a low-velocity vertical eddy with a drift toward one end of the powerhouse for a short time and then toward the other end. The predominate drift was toward the spillway or center of the dam. Velocities upstream of and in the immediate vicinity of the simulated John Day intake ranged from 2 fps near the intake roof to 5 fps near the floor (see plate 18).

22. Observations were initially made in the 1:50-scale model with barriers having vertical faces located 3, 7, and 10 feet upstream from the face of the powerhouse. These tests indicated best flow conditions were obtained with the bottom of the barrier at or below the top of the intake opening and the top of the barrier at a submergence of either 15 or 20 feet. The spacings of 3 and 7 feet from the powerhouse were determined to be too close to permit raking of the trashracks. Subsequent tests were therefore accomplished with the barriers located to provide 10-foot minimum clearance from the powerhouse.

23. More-detailed evaluation of vertical-faced barriers indicated that the best conditions were obtained when the barrier extended across all three bays of each unit intake and flow was allowed to occur over the sidewalls; however, eddies which form between the barrier and the powerhouse face were potential milling places for fingerlings. Therefore, the vertical faced barriers were considered to be undesirable.

24. More-desirable flow conditions in the well resulted when the upstream face of the barrier was sloped parallel to the face of the powerhouse. As with the vertical faced barrier, the best conditions were produced with a barrier which extended across all three intake bays of each unit and flow was allowed over the sides of the barriers. Plates 19 and 20 show the velocities existing in the approach to the intakes with the sloping face barrier. The withdrawal effect extended about 85 feet upstream from the powerhouse and across the entire width of the powerhouse. A withdrawal extending 125 to 150 feet upstream was desired for effective fingerling movement. The barriers caused a head loss of approximately 0.04 foot in the intake.

25. Subsequent to the above tests, it was determined that a minimum clearance of 12.5 feet would be preferable between the powerhouse face and the upstream face of the passive barrier to provide clearance for passage of the existing trash rake. Locating the passive barrier at the

12.5-foot clearance produced flow conditions similar to those existing with the barrier having a 10-foot clearance. Plate 21 shows the flow characteristics for this condition.

Miscellaneous Tests

26. Guide Vanes. Under existing conditions, flow circulation in the gate well varies with time and powerhouse operations. One of the objectives of the model tests was to develop a method of insuring a stable flow condition which would guide the fingerlings to one specific orifice location independent of powerhouse operation. A deflector located on the sidewall of the upstream (bulkhead) slot was ineffective in developing such a stable condition. A screen across the upstream slot inclined upward at 40 degrees from the top of the vertical barrier screens did isolate one orifice but did little to improve guidance to that orifice.

27. A strong, stable flow condition within the gate well that would lead fingerlings to an orifice at one end of the well was created when guide vanes were placed in the bottom of one-half of the well. The vanes were tilted 30 degrees from the vertical in a frame that rested on top of the outer frame of the traveling screen and was easily removed from the slot. The frame was reversible which permitted the flow to be set to lead fingerlings to either end of the well. Details of the vanes are shown in photographs 17 and 18 and on plate 22. Tests indicated that three vanes were optimum for creating the desirable flow pattern. The pattern with McNary conditions and 30-percent porosity perforated plate on the vertical barrier screens (see paragraph 13) is shown on plate 23. Flow was upward in just over one-half of the upstream slot with velocities of 0.5 to 1 fps, crossed from one side to the other in the upper 8 feet of depth with a velocity of 0.5 fps, and was downward on the other side for most of the depth of the well. The flow would lead fingerlings to the orifice on the downward flow side. Flow through the area between the vanes and the vertical barrier screen was upward the full width of the well in the lower half while circulation similar

to that occurring in the upstream slot existed in the upper half of the well. With simulated John Day conditions and 15-percent porosity plate on the screen, the flow pattern was the same (see plate 24). With the top three solid panels replaced by screens in the simulated John Day condition (see plate 25), the flow pattern and velocities were essentially the same as those which existed with solid panels above the screens, however, the crossover velocity near the screens was 2 fps instead of 1 fps.

28. Airlift Pump. Fingerling collection utilizing an airlift pump with a screened cone collector was being considered for use at John Day Dam. The apparatus consists of a vertical pipe (10-12 inches in diameter) extending the full depth of the gate well and connected to a screened cone collector which sets in the gate well near the roofline of the intake. The cone collector is shaped like an inverted funnel to guide fingerlings into the pipe. Air introduced into the pipe reduces the water density in the pipe, thus causing the column of water (with fingerlings) in the pipe to rise above the water surface in the gate well where the confined water and fingerlings are spilled into a bypass facility. A model of the cone collector (photographs 19 and 20) was tested to determine the lowest position that would meet the velocity criteria of 0.5 fps through the cone screens. To avoid interrupting flow within the cone, measurements of velocities through the screens were made in the flow emitted from the back side (top) of the screens. These tests indicated that the bottom of the cone could be no lower than elevation 299 and 312 for McNary Dam and simulated John Day conditions at McNary Dam, respectively.

PART IV: SUMMARY

29. Model studies were accomplished in an attempt to define flow conditions in the fingerling collection areas of the powerhouse intakes at McNary and John Day Dams and to develop measures to improve the flow conditions where needed. Guide vanes in the gate well were developed which would enhance efficiency of a single fingerling exit orifice. Perforated plates were developed for attachment to the vertical barrier screens located in the intake gate wells to limit velocities through the screens to 0.5 fps, maximum, in order to prevent fingerling impingement on the screens. The STS with various modifications was studied to evaluate effects on flow deflection caused by the STS. Minimum acceptable operating elevations of a vertical airlift cone were identified.

30. Prototype testing of the vertical barrier screens with the perforated plates developed in the model was accomplished at McNary Dam in simulating John Day Dam conditions. The results of the prototype tests indicated that the design would efficiently move fingerlings through the gate well and out the orifices into the bypass facility. The vertical barrier screen is included in the present John Day Dam fingerling bypass facility contract.

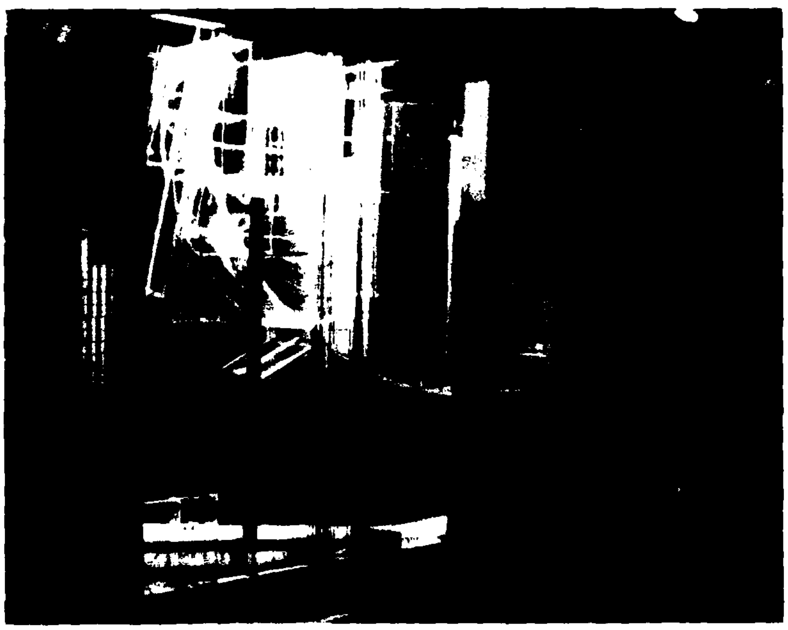
31. Passive barriers consisting of sloping faced wells attached to the upstream face of the powerhouse were developed for John Day Dam. The barriers improved flow conditions in the powerhouse approach by drawing slack water located near the reservoir surface adjacent to the powerhouse into the intakes. The areas of slack water were thought to contribute to fingerling milling with subsequent predation. Although the barriers did improve surface flow conditions near the intake, the improvement was not considered substantial enough to justify incorporation in the prototype.

TABLE A

GATE WELL DISCHARGES AND HEAD DROPS

Operating Conditions	Discharge Through Gate Well (cfs)	Head Drop Across Vertical Barrier Screens (Feet)
Normal McNary	256	
McNary with 30-percent porosity plate on vertical barrier screens (velocity through screens 0.5 fps or less)	256	
McNary with 15-percent porosity plate on vertical barrier screens	250	
Simulated John Day (operating gate raised 30 ft in slot)	407	
Simulated John Day with 15-percent porosity plate on vertical barrier screens (velocities through screens 0.5 fps or less)	342	
Simulated John Day with 1-percent porosity plate on vertical barrier screens	230	1.8
Simulated John Day with 3-percent porosity plate on vertical barrier screens	256	1.3
Simulated John Day with 4.3-percent porosity plate on vertical barrier screens	281	1.0
Complete blockage of vertical barrier screens	0	2.2

Photograph 1

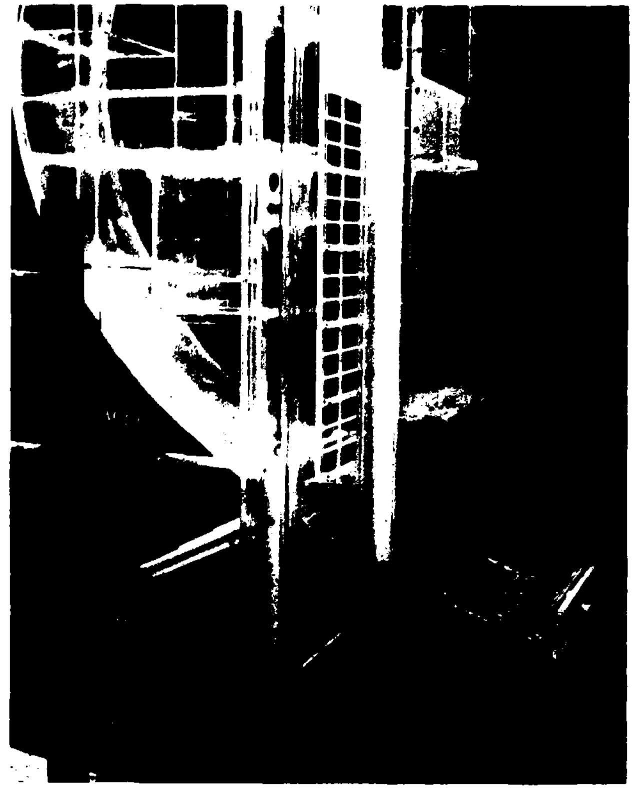


Photograph 2

Model of center bay of McNary powerhouse intake
with traveling screen and gate well vertical barrier screens

Photograph 3

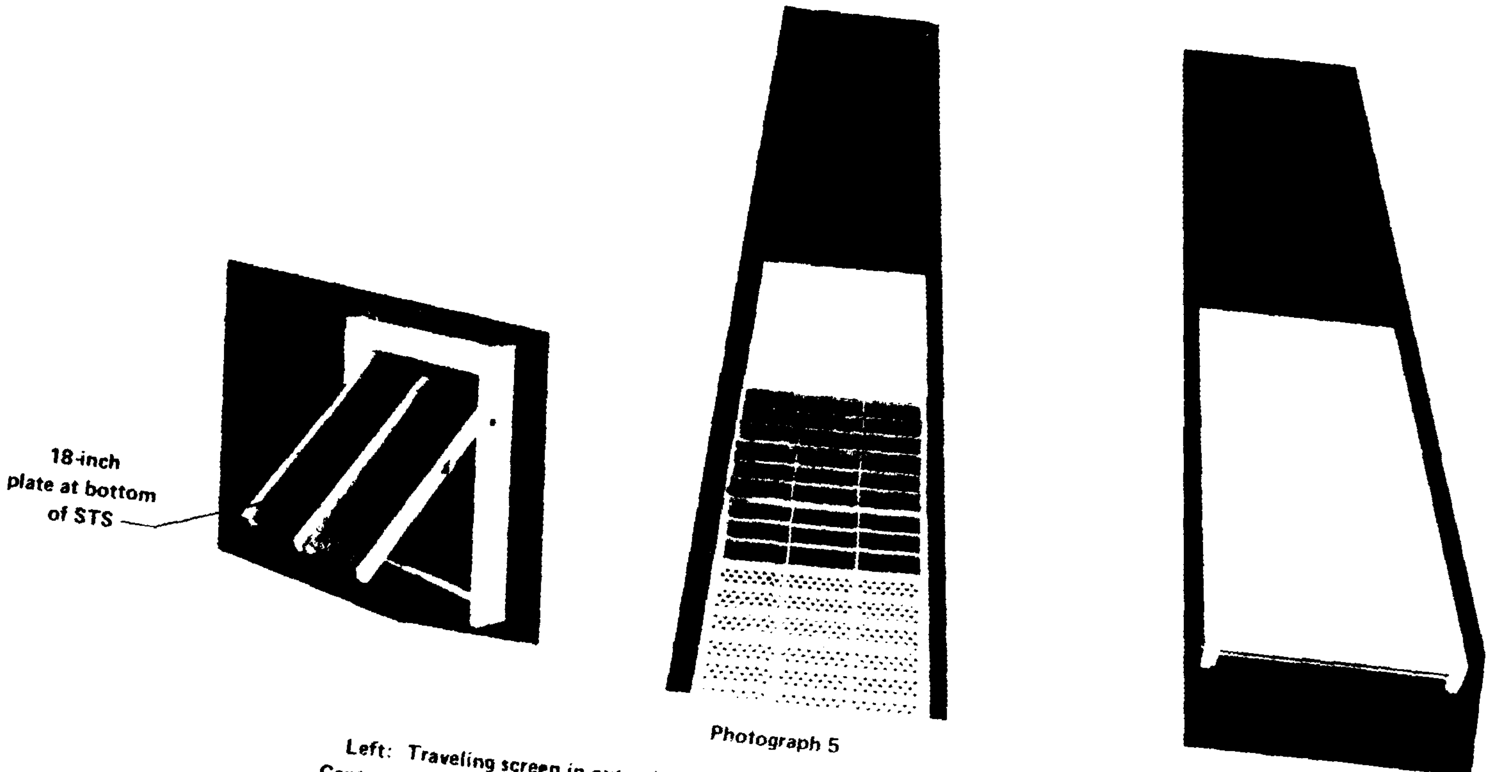
Traveling screen in place



Photograph 4

Traveling screen, vertical barrier screens, and operating gate in place

McNary powerhouse intake model

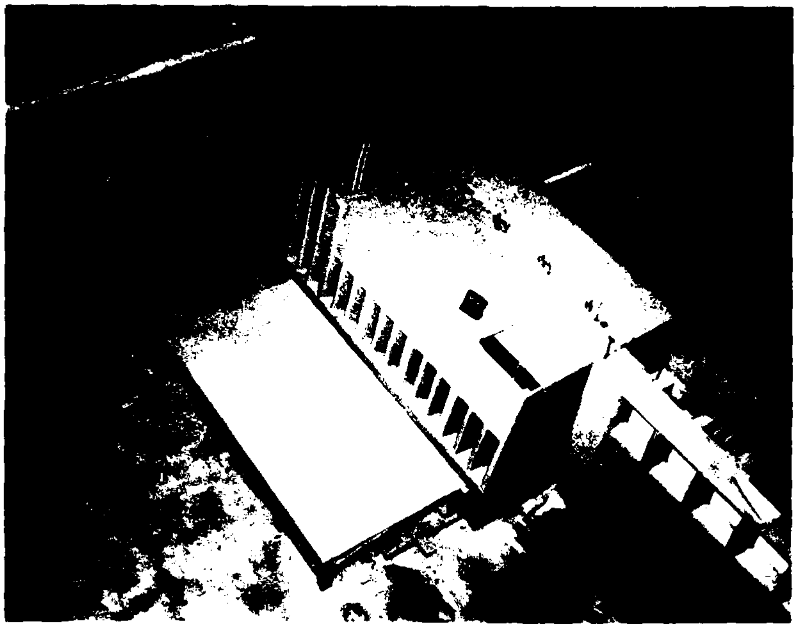


Photograph 5

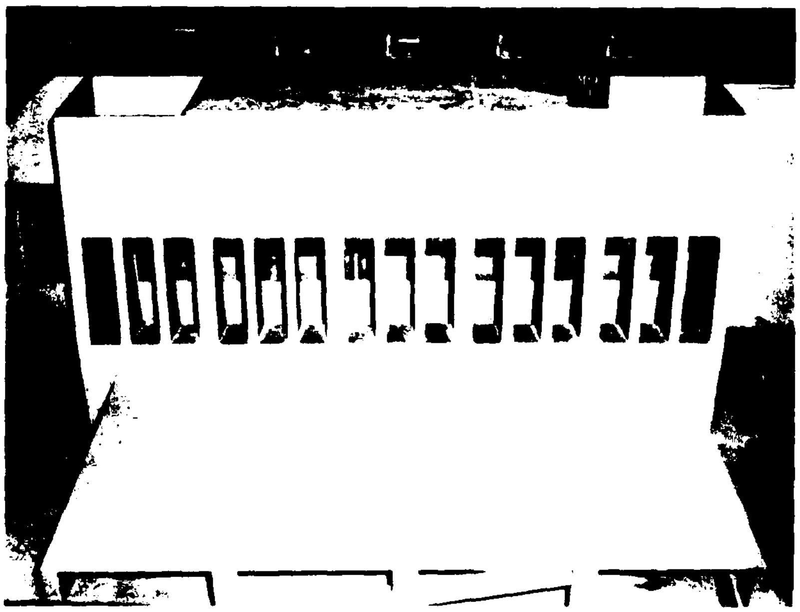
Left: Traveling screen in extended position with perforated plate showing through screen

Center: Vertical barrier screens with solid panels at top, original screens in center, and screens with 30-percent-porosity plates at bottom

Right: Operating gate



Photograph 6



Photograph 7

Five-intake, 1:50-scale model of John Day powerhouse intakes

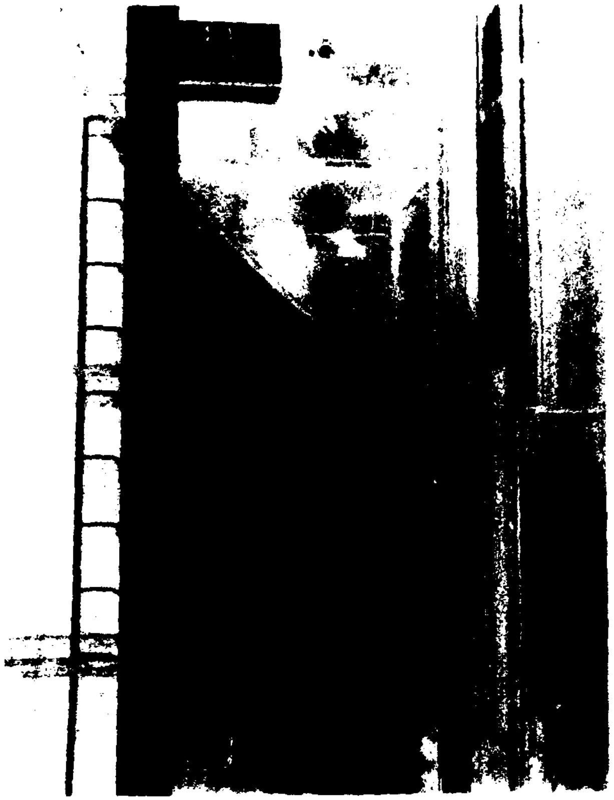
Photograph 8

Without traveling screen
(Dashed line shows location of screen when in place)

Photograph 9

With traveling screen
(Solid plate across lower section and
46-percent-porosity perforated plate)

Flow lines in upper portion of intake with McNary operating conditions



Photograph 10

With traveling screen with lower solid plate
and 30-percent-porosity perforated plate

Photograph 11

With traveling screen with lower solid plate
and 50-percent-porosity *perforated plate*

Flow lines in upper portion of intake with McNary operating conditions

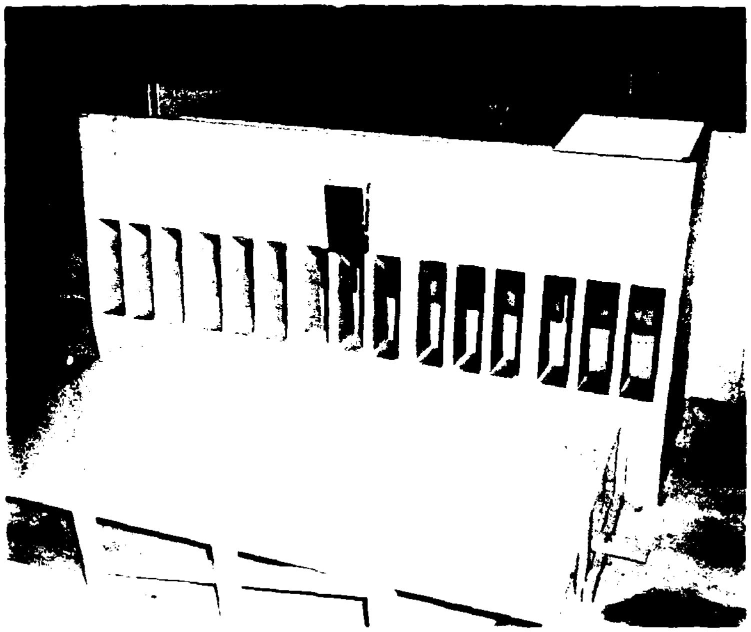
Photograph 12

With traveling screen with lower solid plate replaced with 46-percent-porosity perforated plate

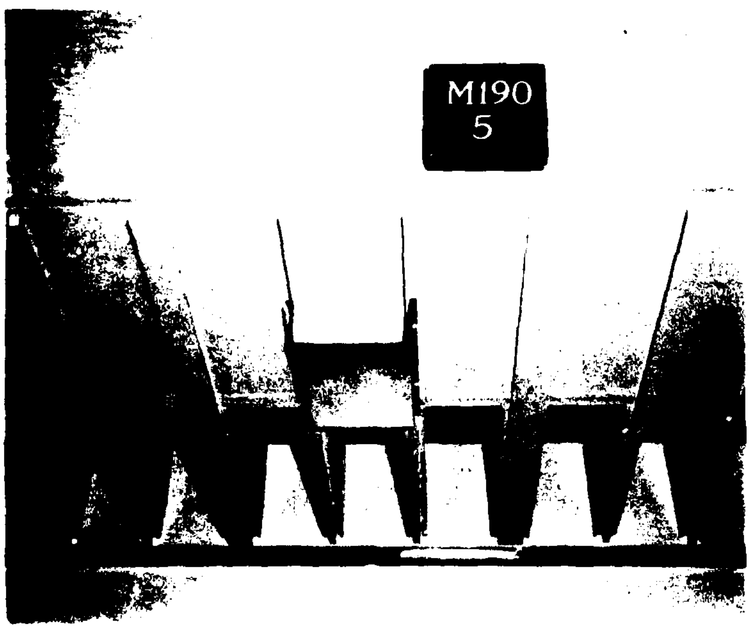
Photograph 13

With traveling screen with lower solid plate removed and no replacement

Flow lines in upper portion of intake with McNary operating conditions



Photograph 14



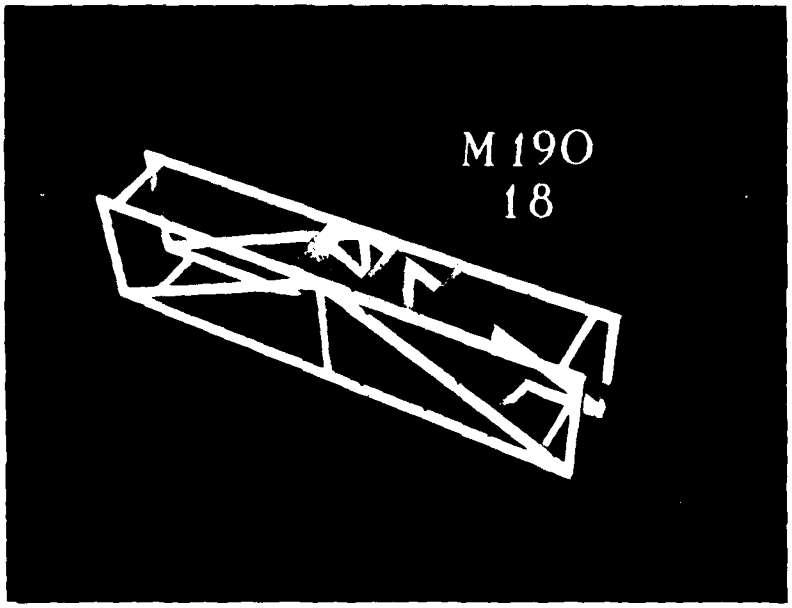
Photograph 15

Vertical passive barrier on center bay of intake

Photograph 16

Flow at intake

(Note deep dye streaks entering intake in bottom of photograph and shallow dye streaks with little movement or movement into well of the passive barrier in the upper part of photographs)

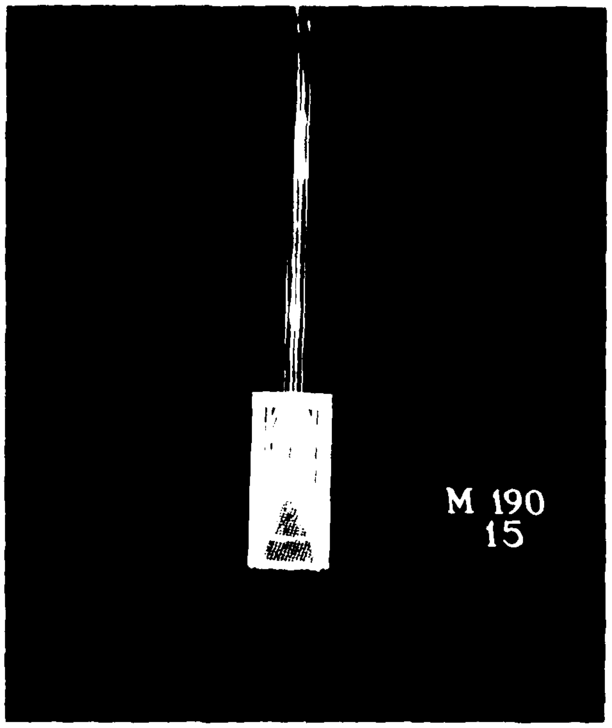


Photograph 17

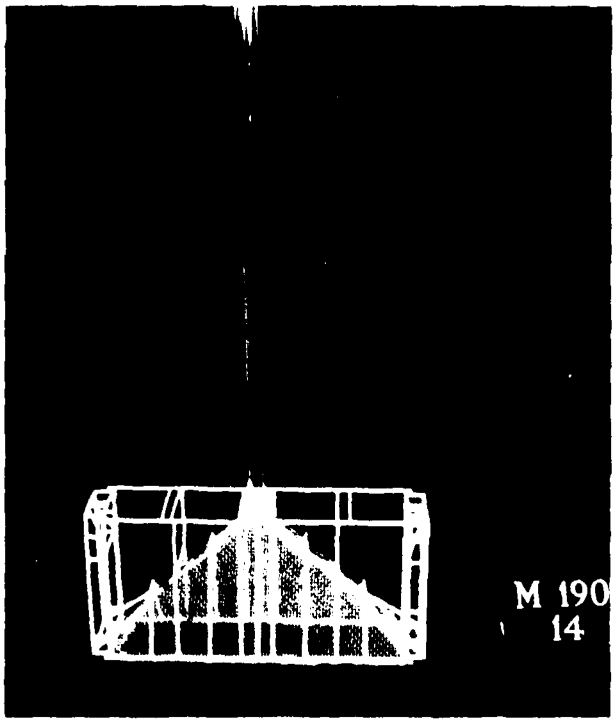
Guide vanes and frame

Photograph 18

Guide vanes in place on top of
outer frame of traveling screen

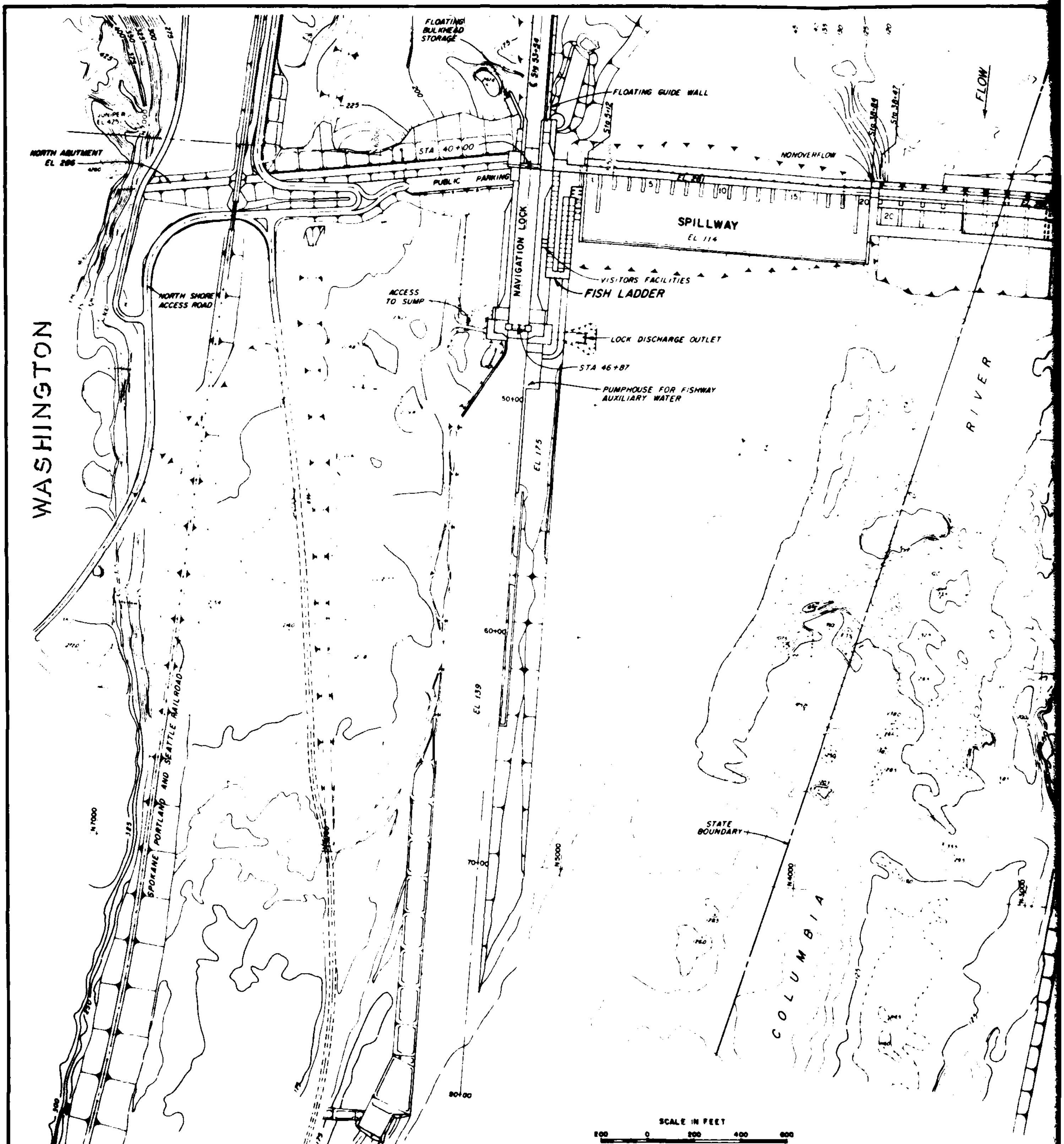


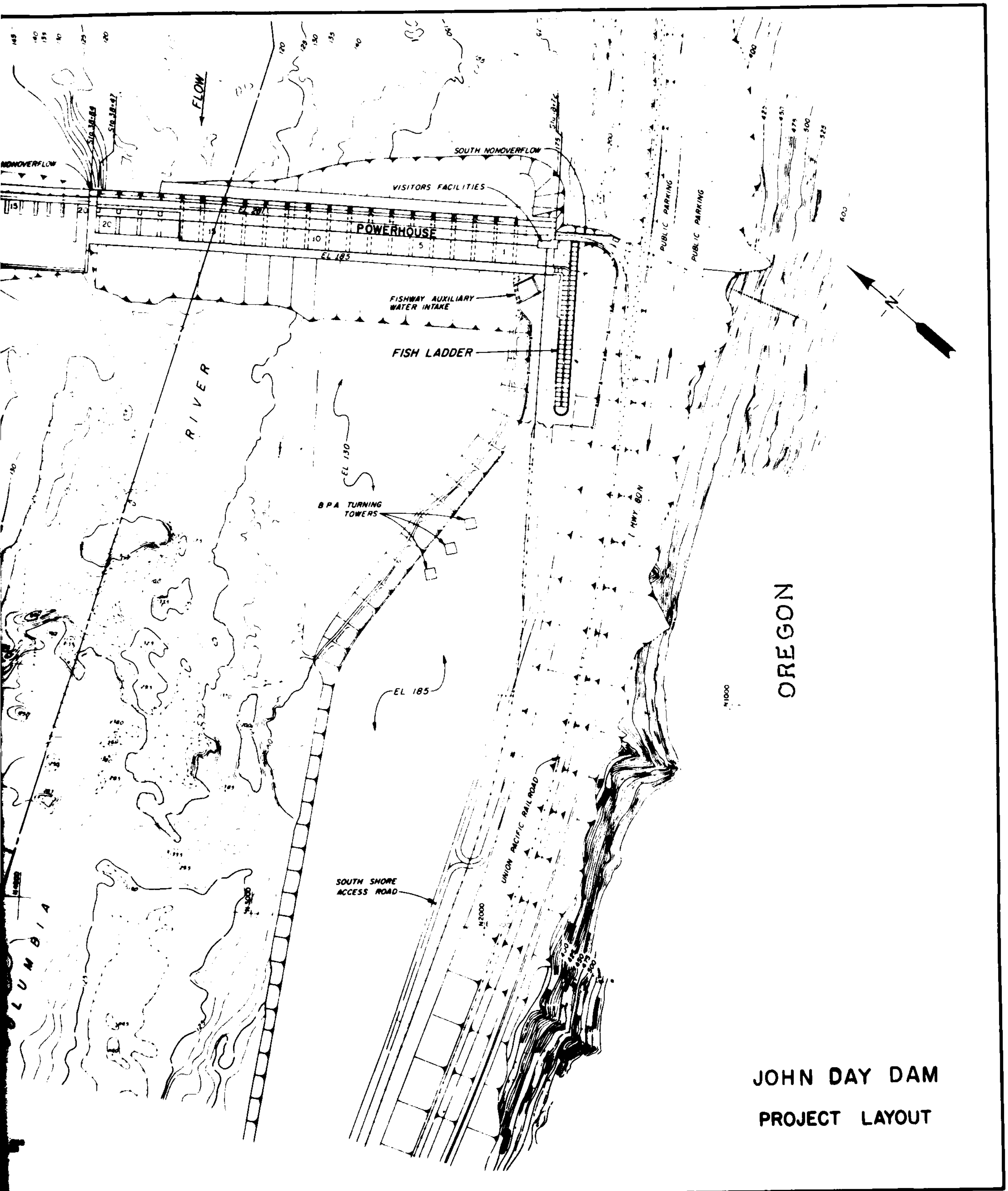
Photograph 19



Photograph 20

Collector cone of air-lift pump

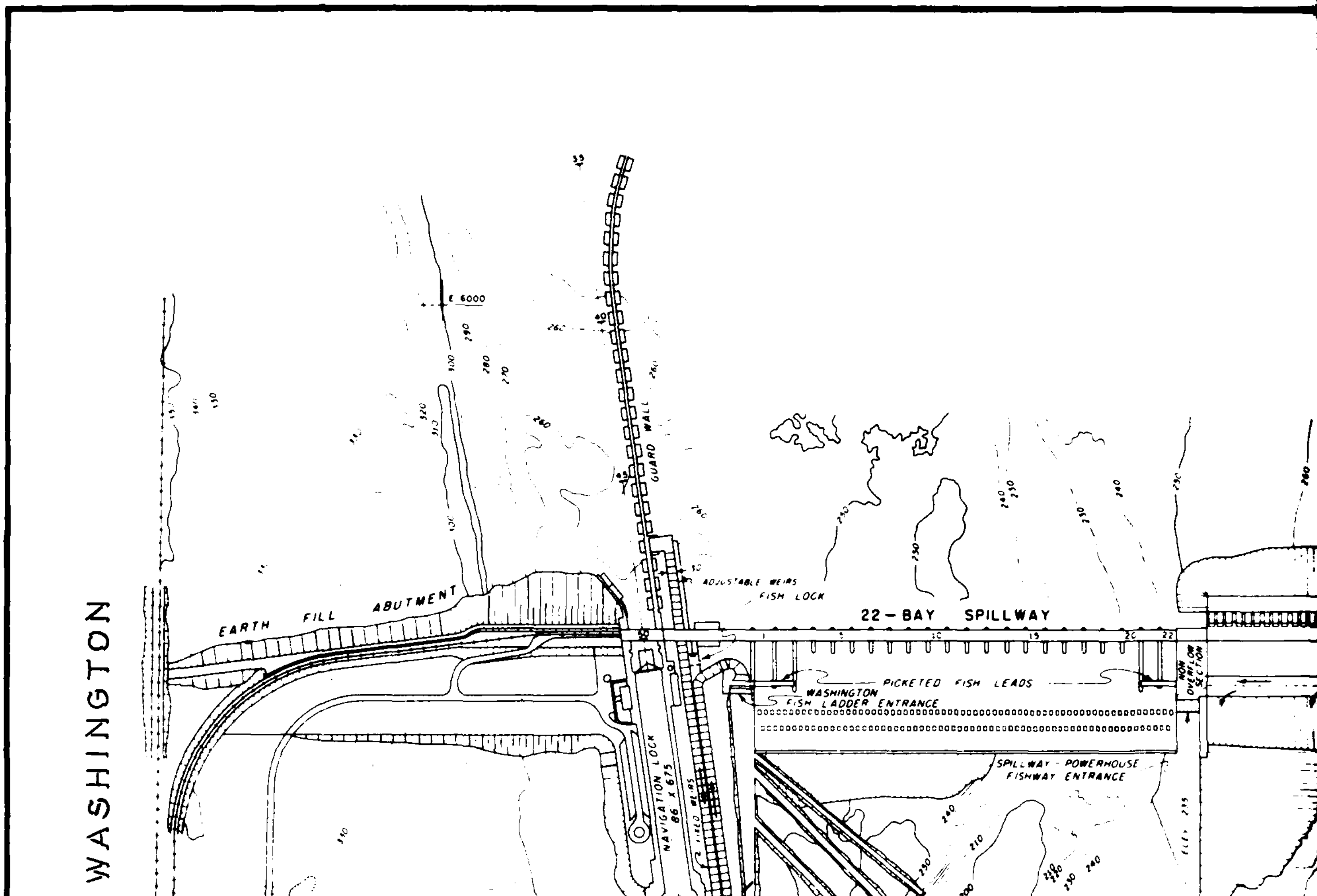

WASHINGTON
NORTH ABUTMENT
EL 286
JUNIPER
EL 425
FLOATING BULKHEAD STORAGE
FLOATING GUIDE WALL
STA 40+00
PUBLIC PARKING
NAVIGATION LOCK
NONOVERFLOW
FLOW
SPILLWAY
EL 114
VISITORS FACILITIES
FISH LADDER
NORTH SHORE ACCESS ROAD
ACCESS TO SUMP
LOCK DISCHARGE OUTLET
STA 46+87
PUMPHOUSE FOR FISHWAY AUXILIARY WATER
50+00
EL 175
60+00
EL 139
70+00
80+00
N5000
N4000
N7000
SPOKANE PORTLAND AND SEATTLE RAILROAD
STATE BOUNDARY
COLUMBIA
RIVER
SCALE IN FEET
200 0 200 400 600



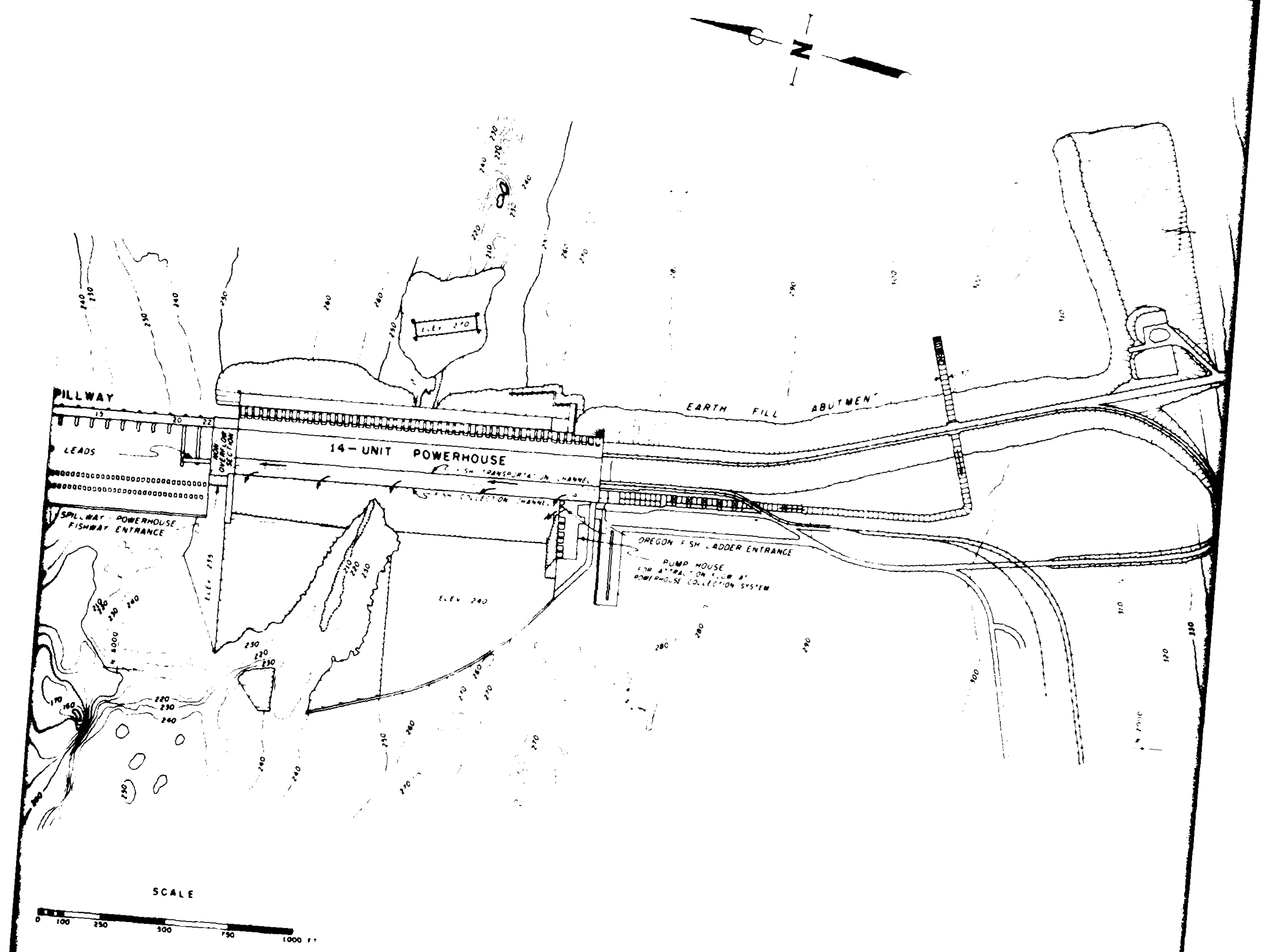
JOHN DAY DAM

PROJECT LAYOUT

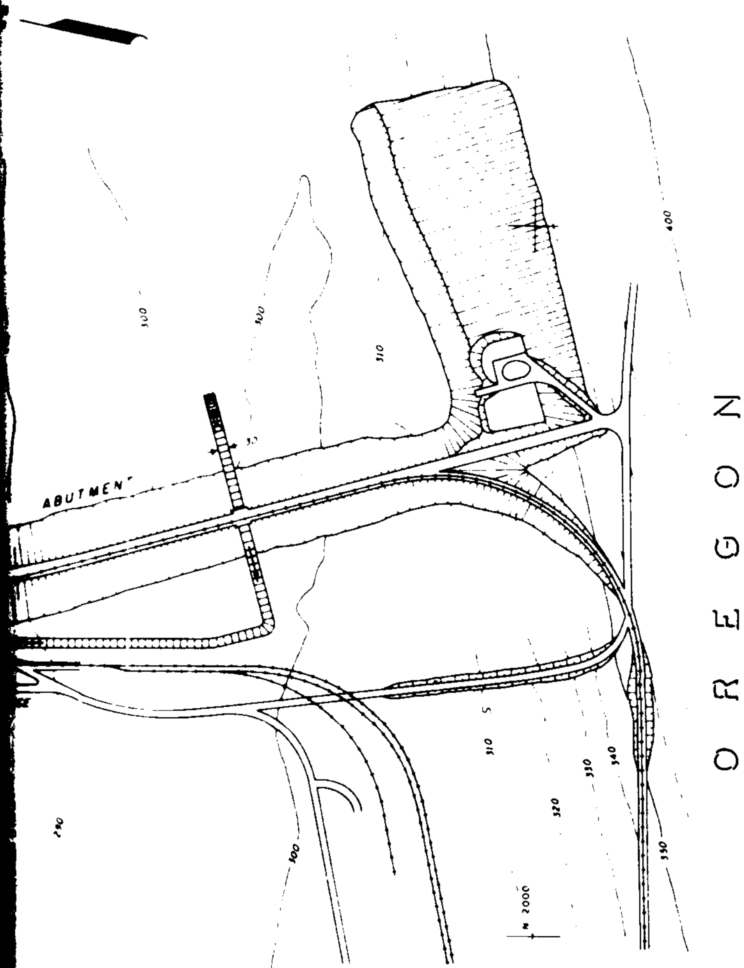
PLATE 1



WASHINGTON
EARTH FILL ABUTMENT
22 - BAY SPILLWAY
GUARD WALL
ADJUSTABLE WEIRS
FISH LOCK
PICKETED FISH LEADS
WASHINGTON FISH LADDER ENTRANCE
NON OVERFLOW SECTION
SPILLWAY - POWERHOUSE FISHWAY ENTRANCE
NAVIGATION LOCK 86 X 675
FISH CHANNELS EXCAVATED IN WASHINGTON REEF
ELEV 285
ELEV 234
GUARD WALL
E 6000
E 4000
SCALE
0 100 250 500 750

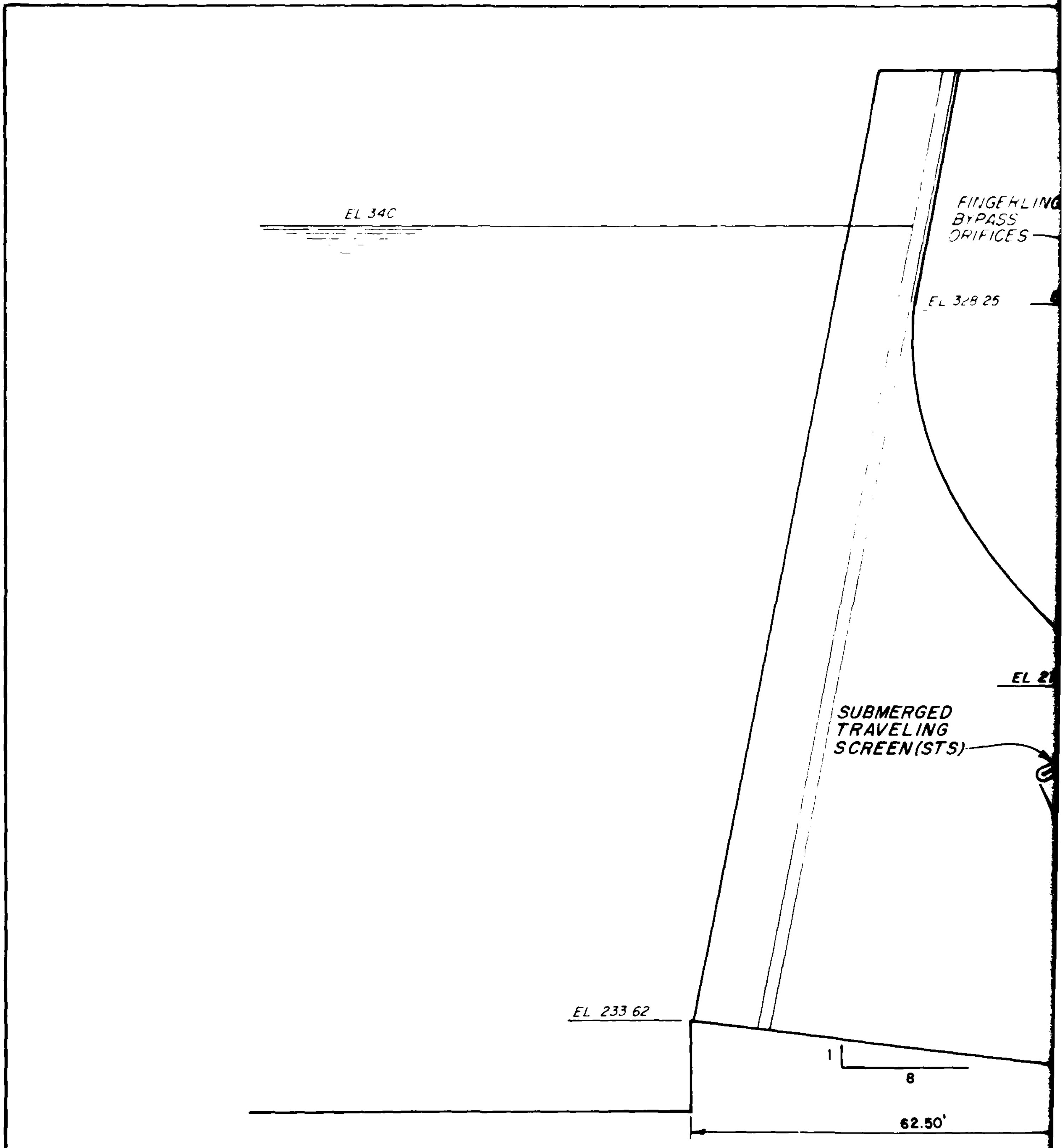


N
PILLWAY
LEADS
14-UNIT POWERHOUSE
EARTH FILL ABUTMENT
SPILLWAY - POWERHOUSE FISHWAY ENTRANCE
OREGON FISH LADDER ENTRANCE
PUMP HOUSE
ELEV 240
SCALE
0 100 250 500 750 1000 FT
Mc N
PROJ



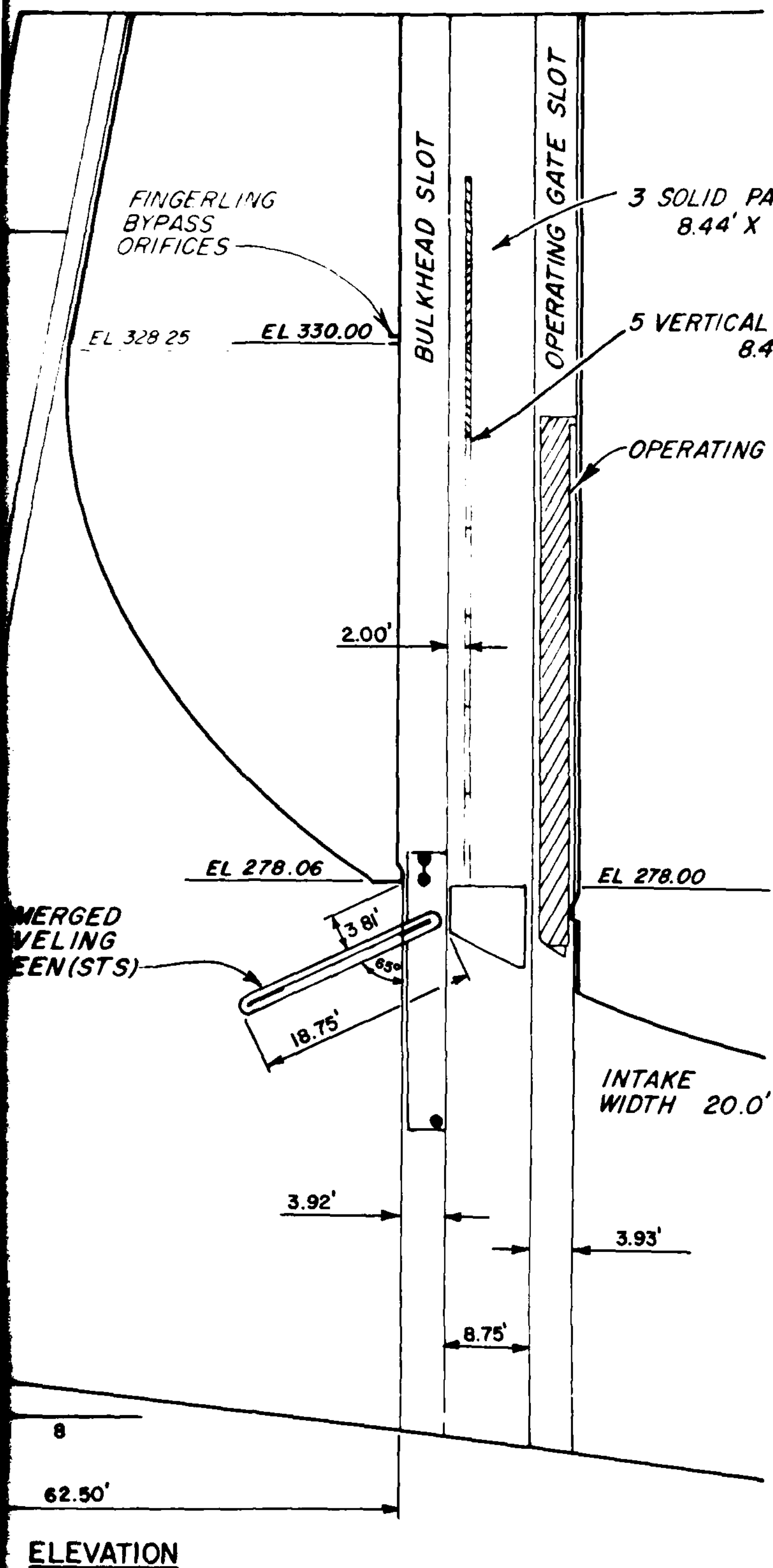
Mc NARY DAM

PROJECT LAYOUT

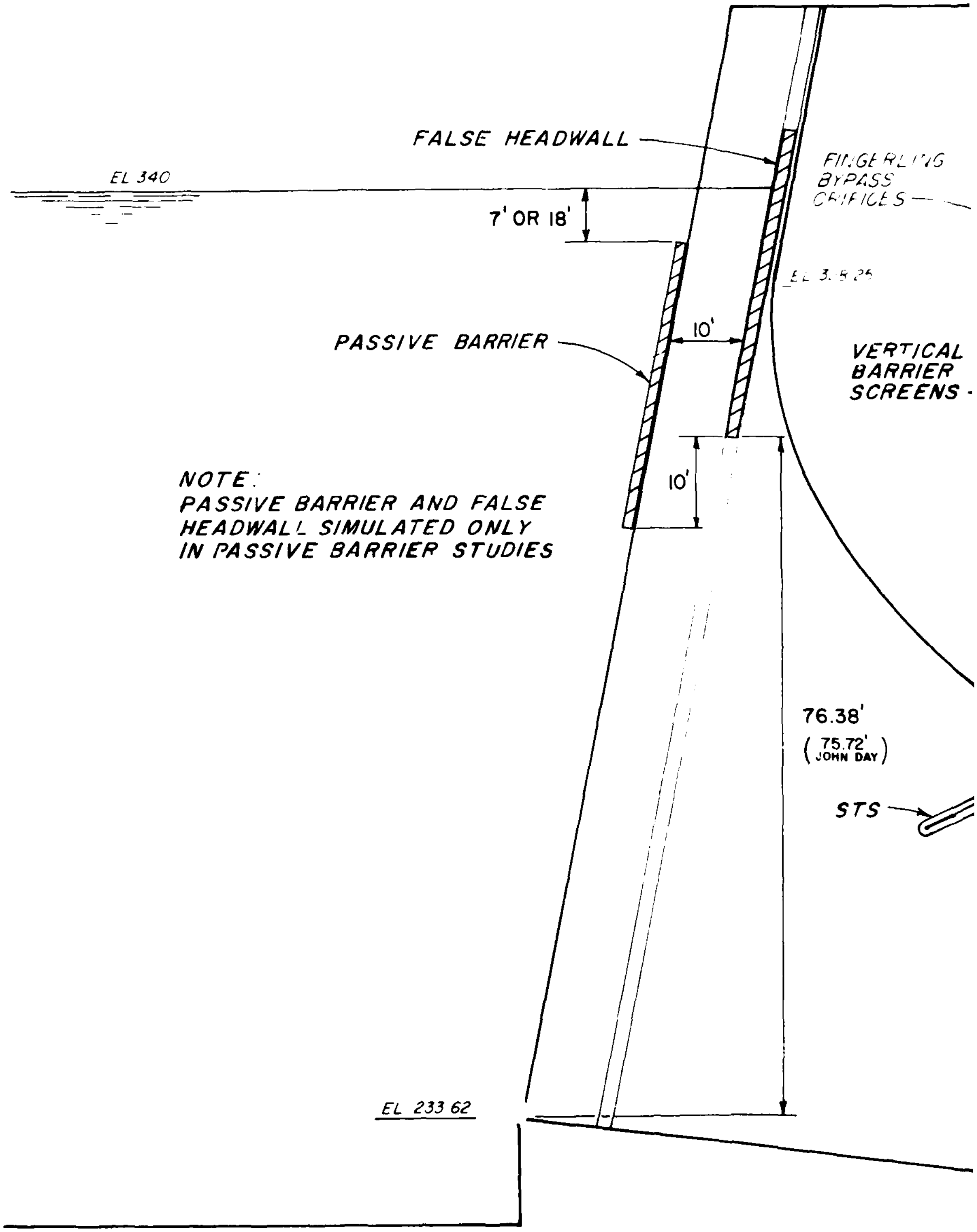


EL 34C
FINGERLING
BYPASS
ORIFICES
EL 328 25
EL 2
SUBMERGED
TRAVELING
SCREEN (STS)
EL 233 62
1
8
62.50'

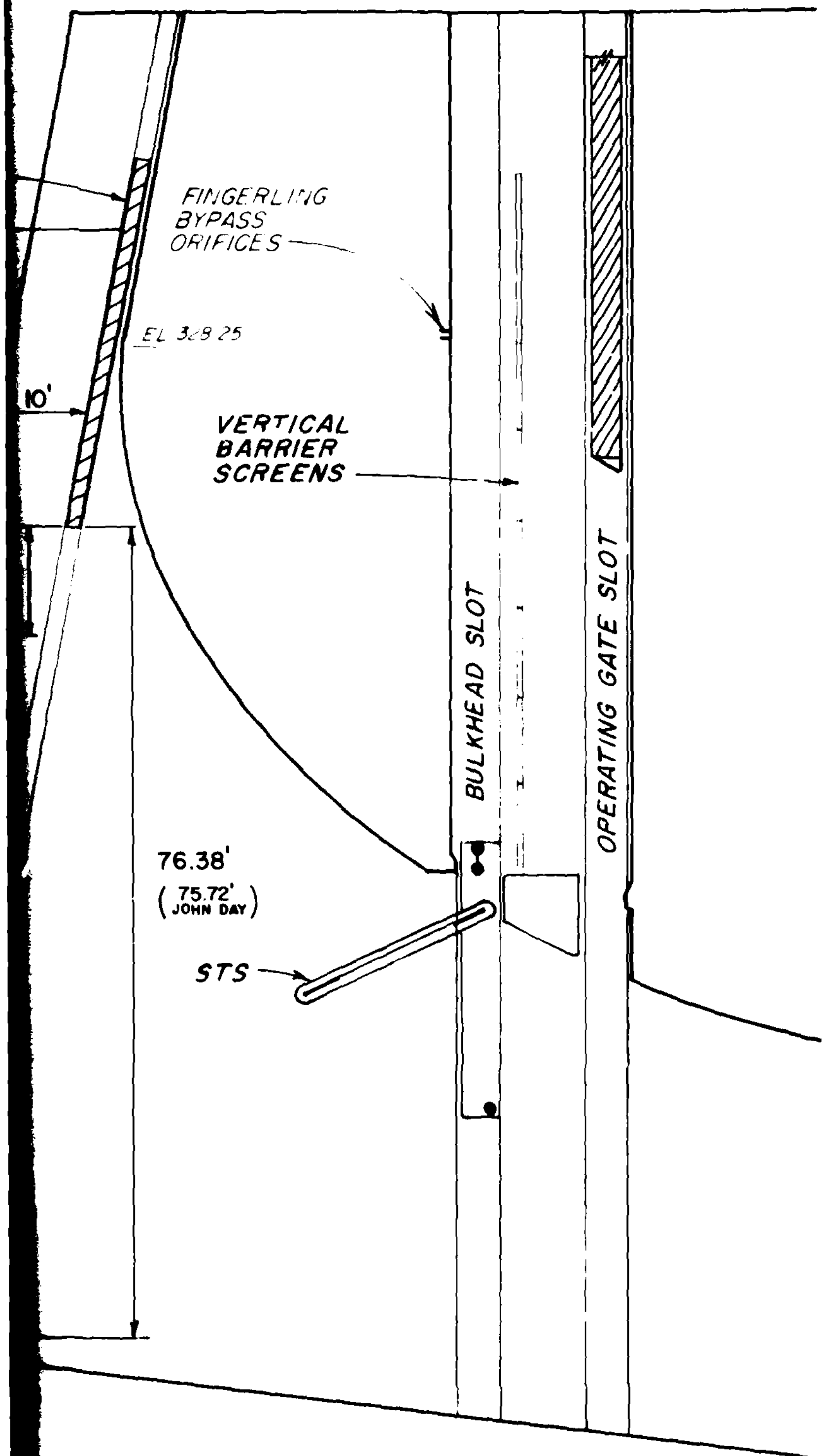
ELEVATION



CENTER BAY OF
McNARY INTAKE
WITH COLLECTION SCREENS

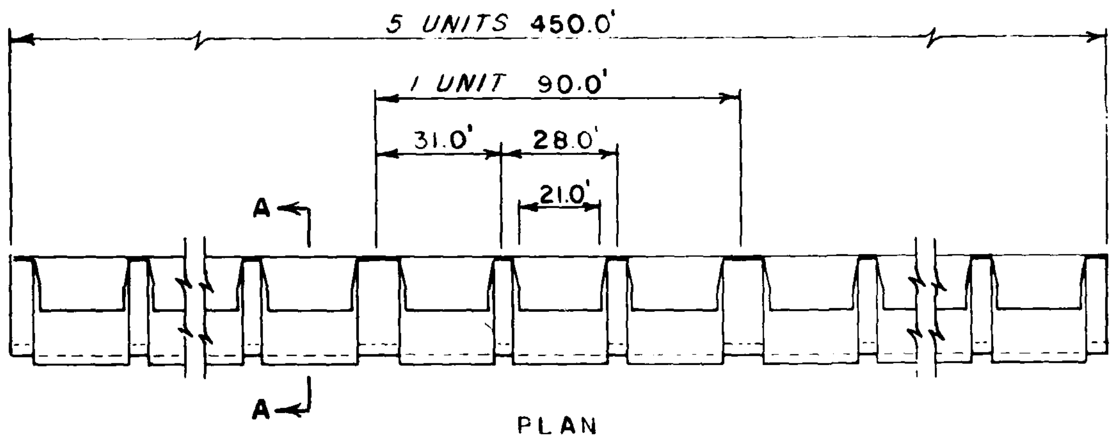


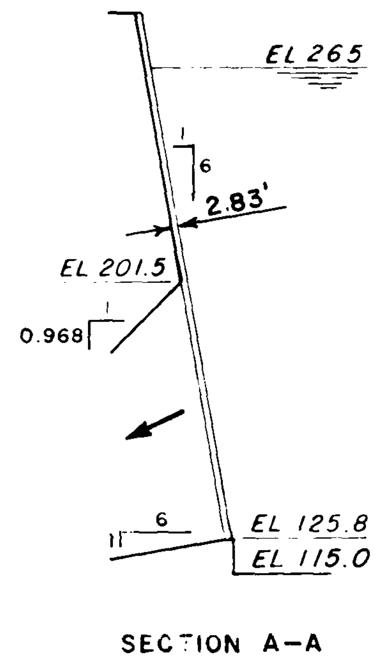
FALSE HEADWALL
FINGERLING BYPASS ORIFICES
EL 340
7' OR 18'
PASSIVE BARRIER
10'
VERTICAL BARRIER SCREENS
10'
NOTE:
PASSIVE BARRIER AND FALSE HEADWALL SIMULATED ONLY IN PASSIVE BARRIER STUDIES
76.38'
(75.72' JOHN DAY)
STS
EL 233 62



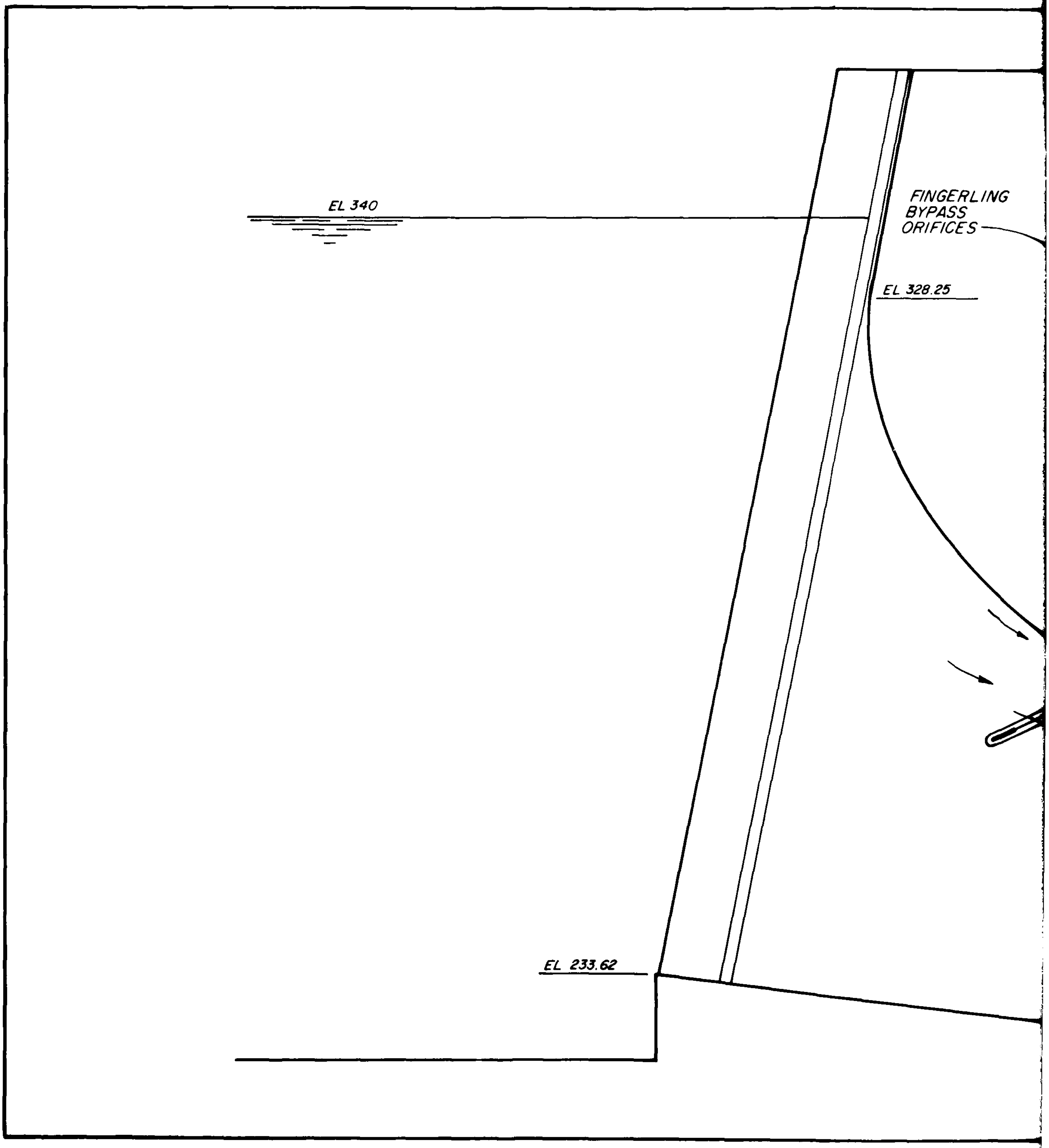
SIMULATED
JOHN DAY INTAKE

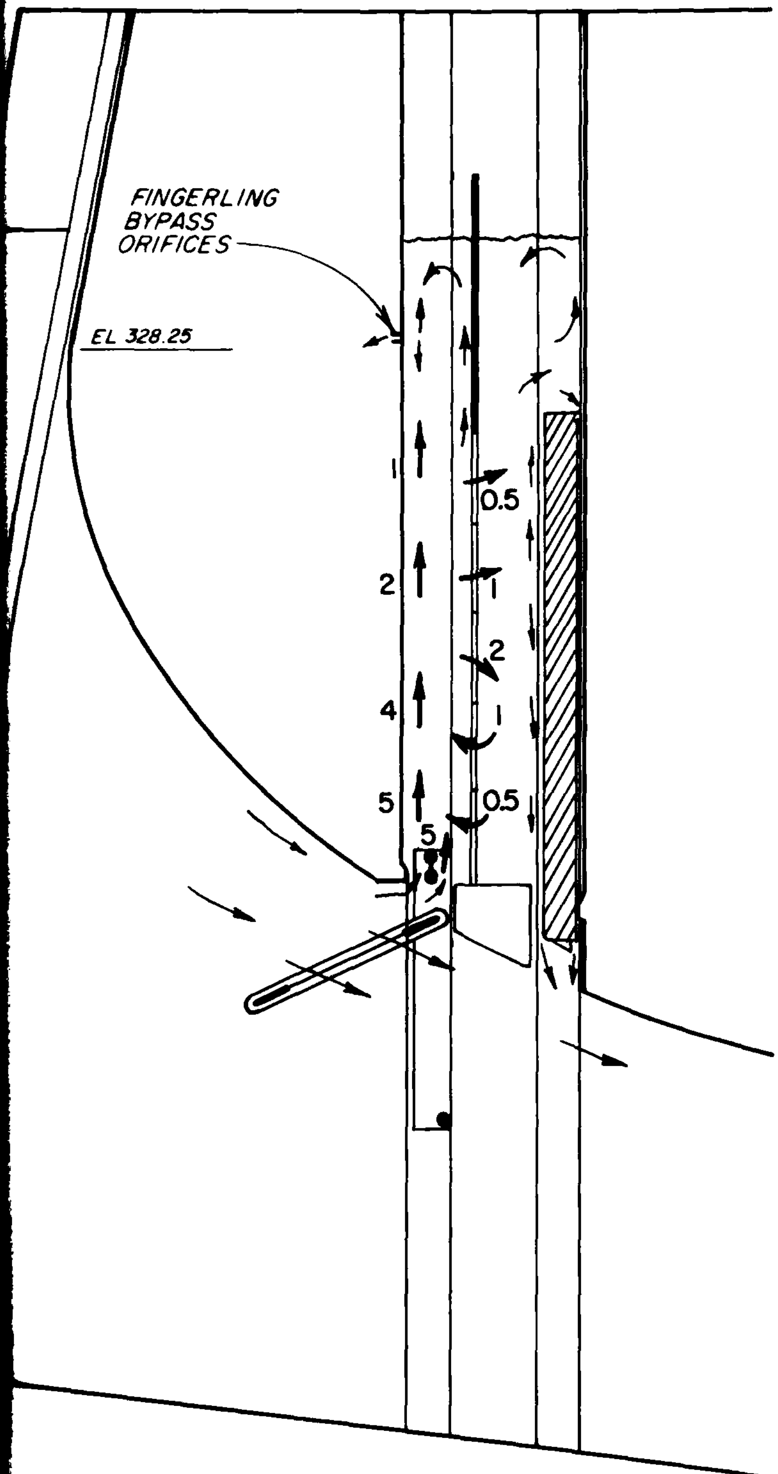
PLATE 4





MODEL DETAILS
JOHN DAY POWERHOUSE INTAKES


EL 340
FINGERLING
BYPASS
ORIFICES
EL 328.25
EL 233.62



LEGEND

4 → VELOCITY IN FPS

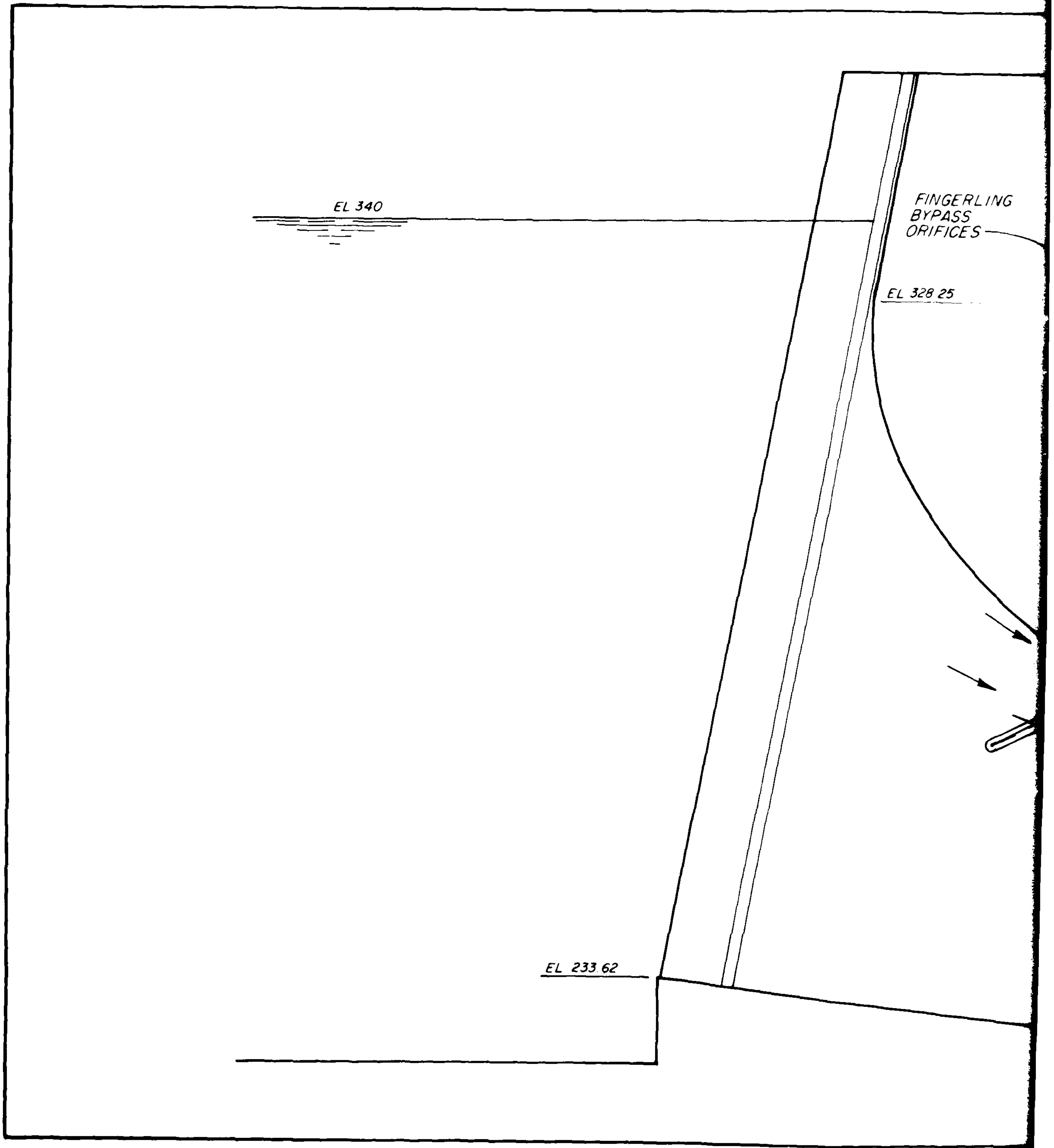
DISCHARGE

PER BAY	5,914 CFS
THROUGH WELL	256 CFS

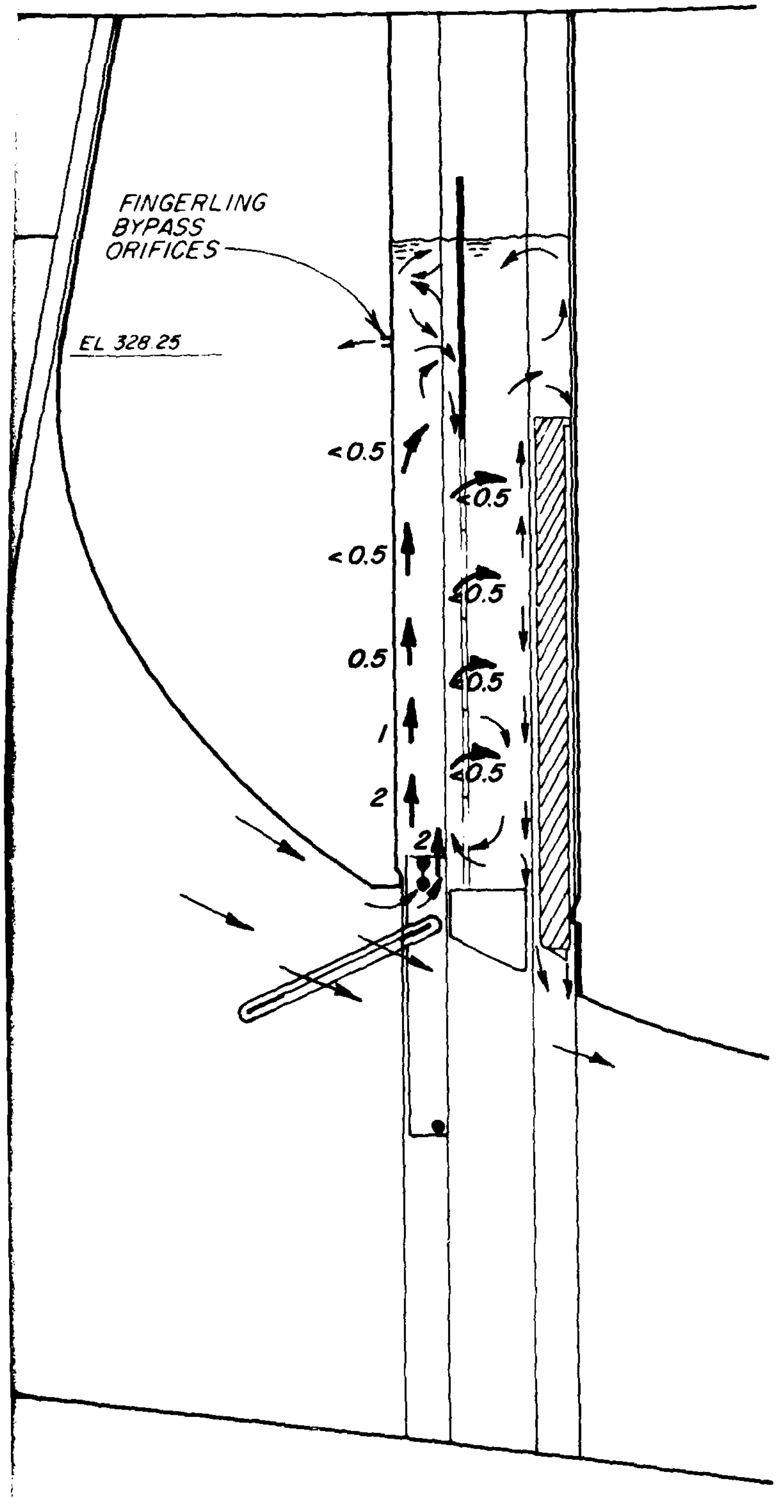
FLOW CONDITIONS

IN GATE WELL

McNARY INTAKE



EL 340
FINGERLING
BYPASS
ORIFICES
EL 328.25
EL 233.62



LEGEND

2 VELOCITY IN FPS

DISCHARGE

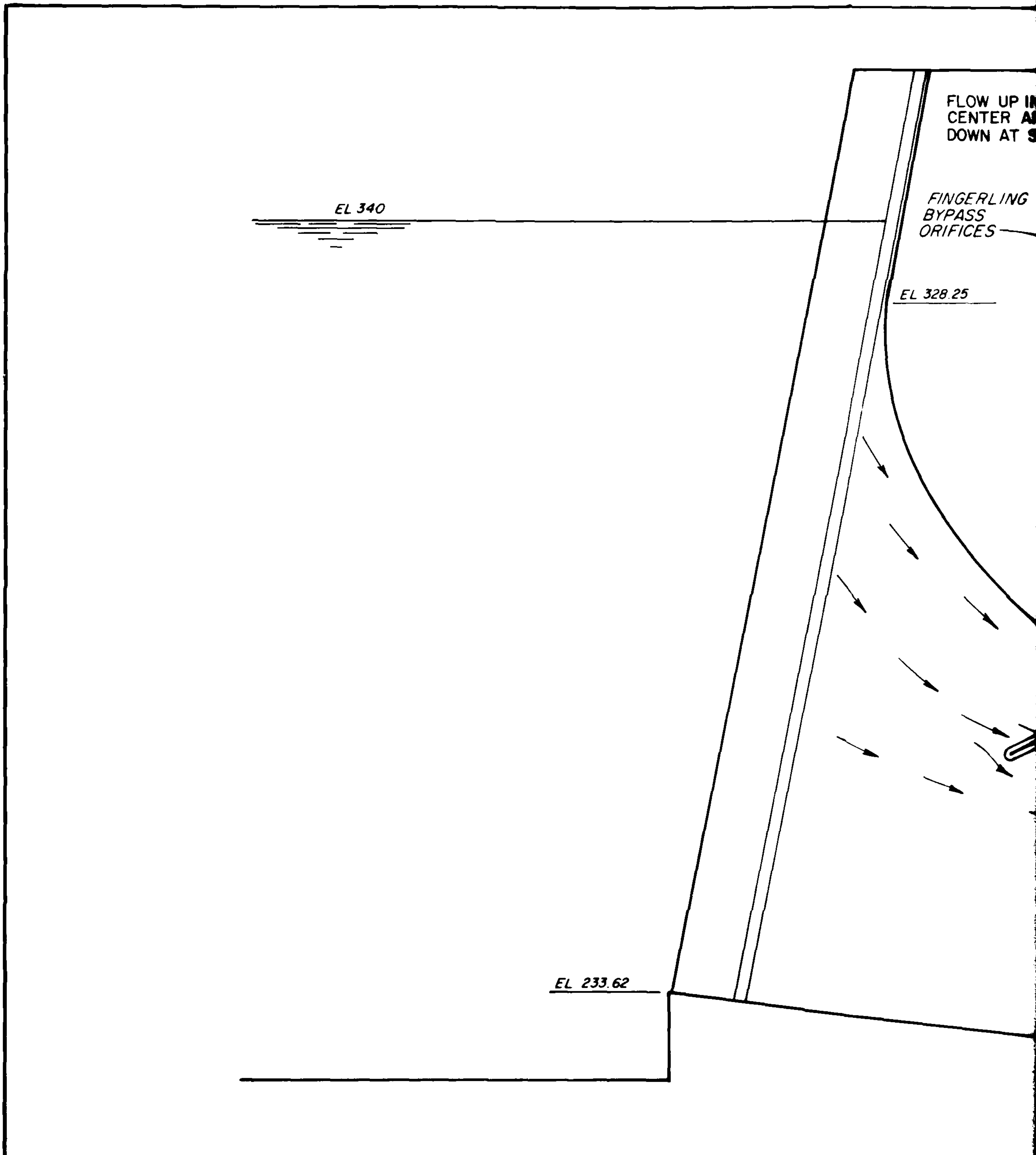
PER BAY 2 880 CFS

FLOW CONDITIONS IN GATE WELL

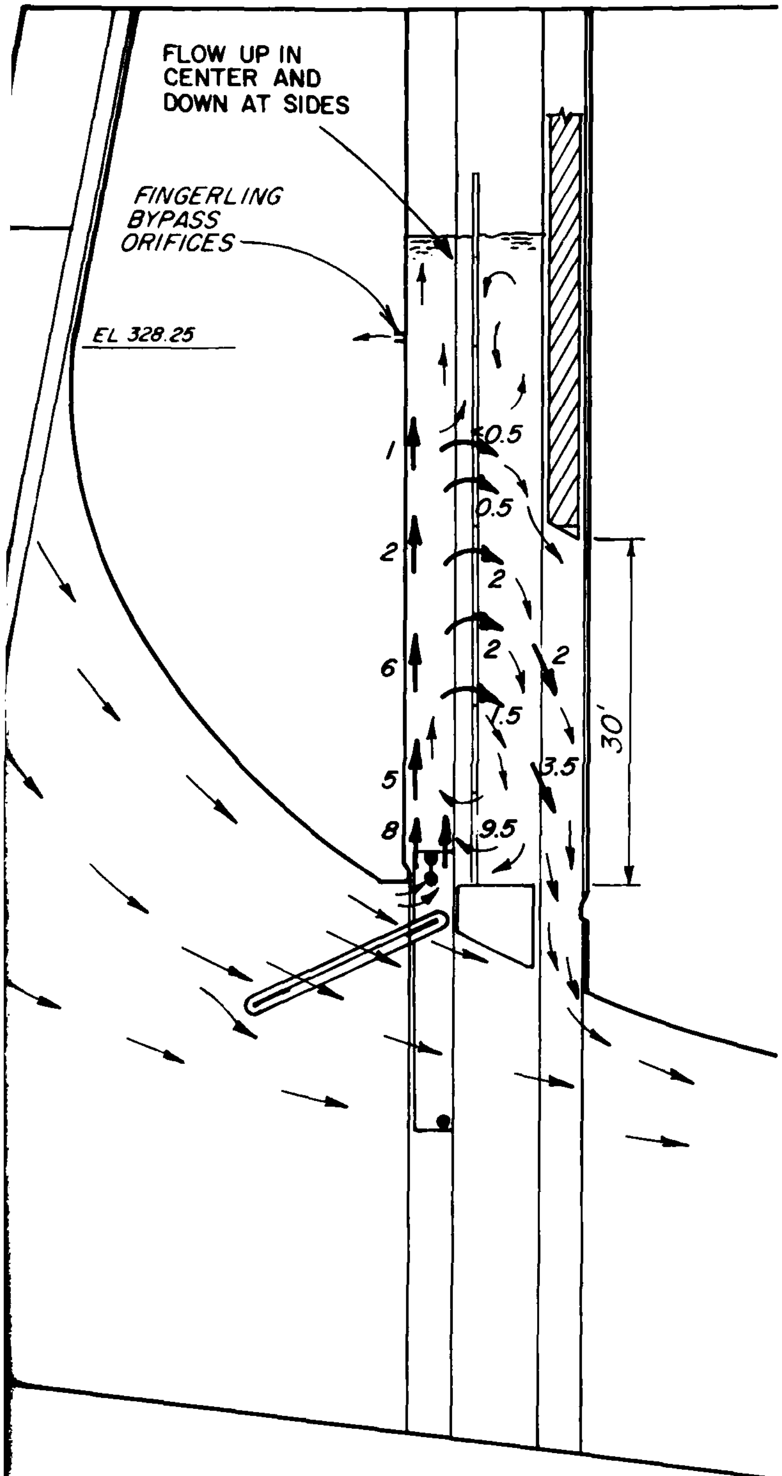
McNARY INTAKE

REDUCED LOAD DISCHARGE

7



FLOW UP IN
CENTER A
DOWN AT S
FINGERLING
BYPASS
ORIFICES
EL 340
EL 328.25
EL 233.62



LEGEND

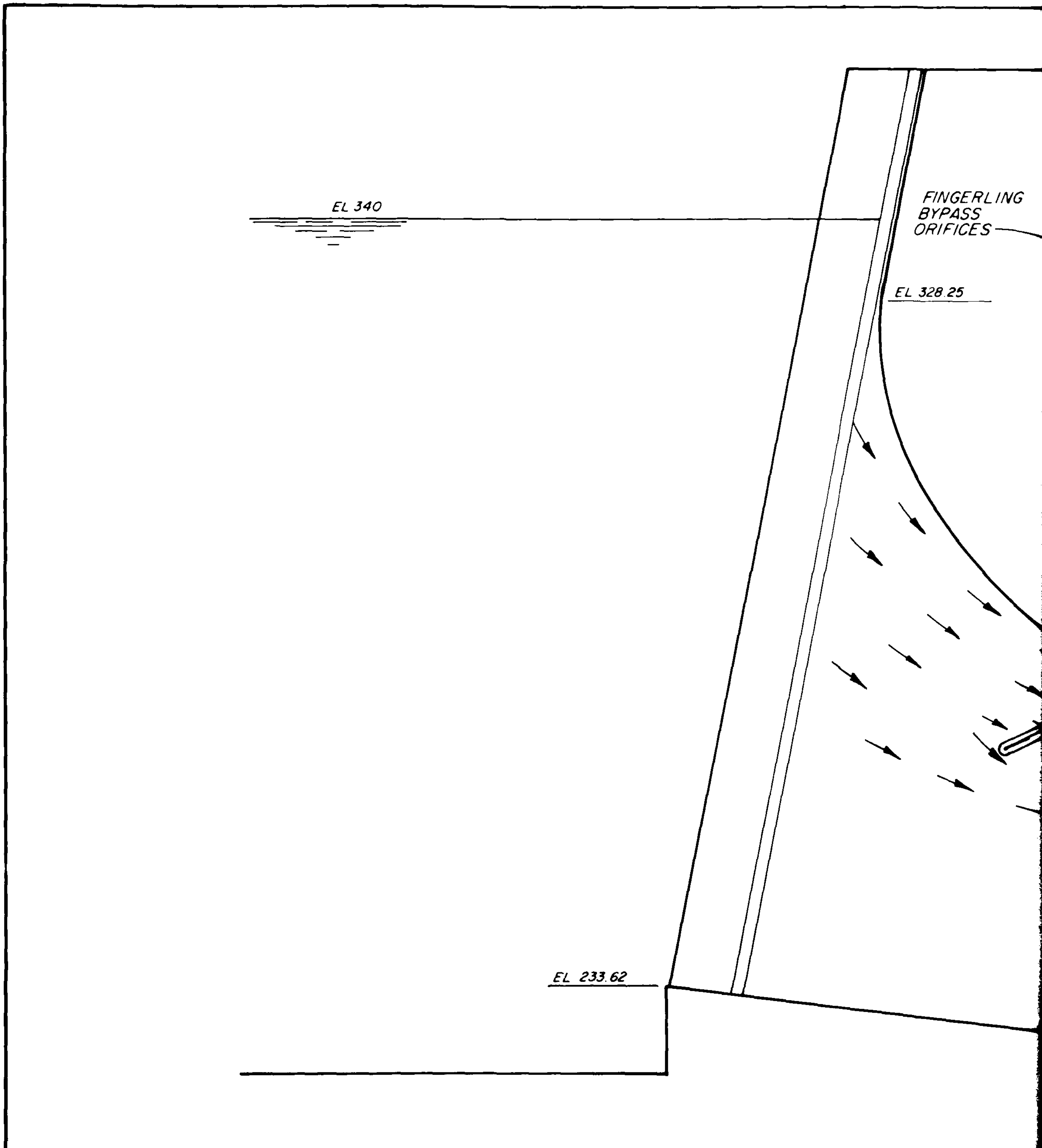
5 → VELOCITY IN FPS

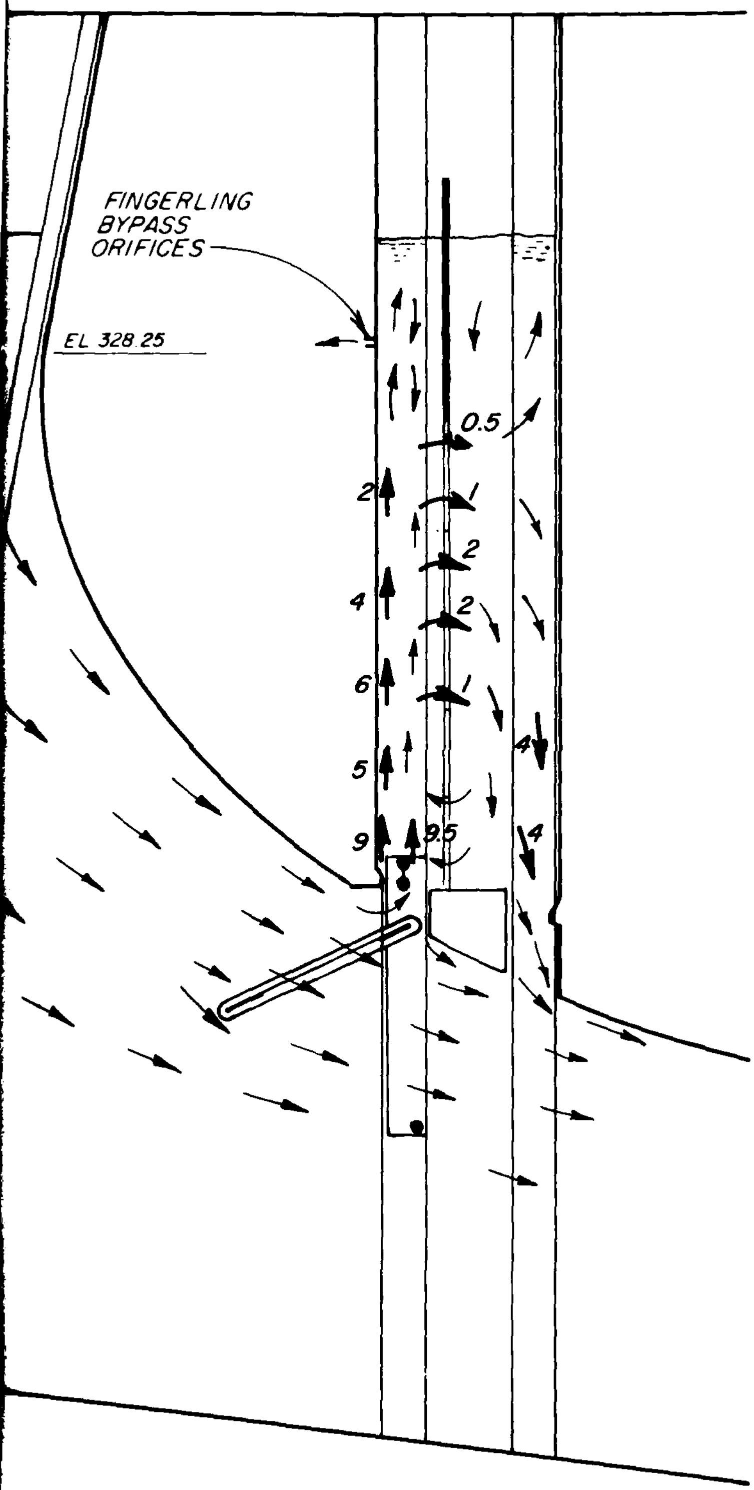
DISCHARGE

PER BAY	5914 CFS
THROUGH WELL	407 CFS

FLOW CONDITIONS
IN GATE WELL

McNARY INTAKE
SIMULATED JOHN DAY CONDITIONS


EL 340
FINGERLING BYPASS ORIFICES
EL 328.25
EL 233.62



LEGEND

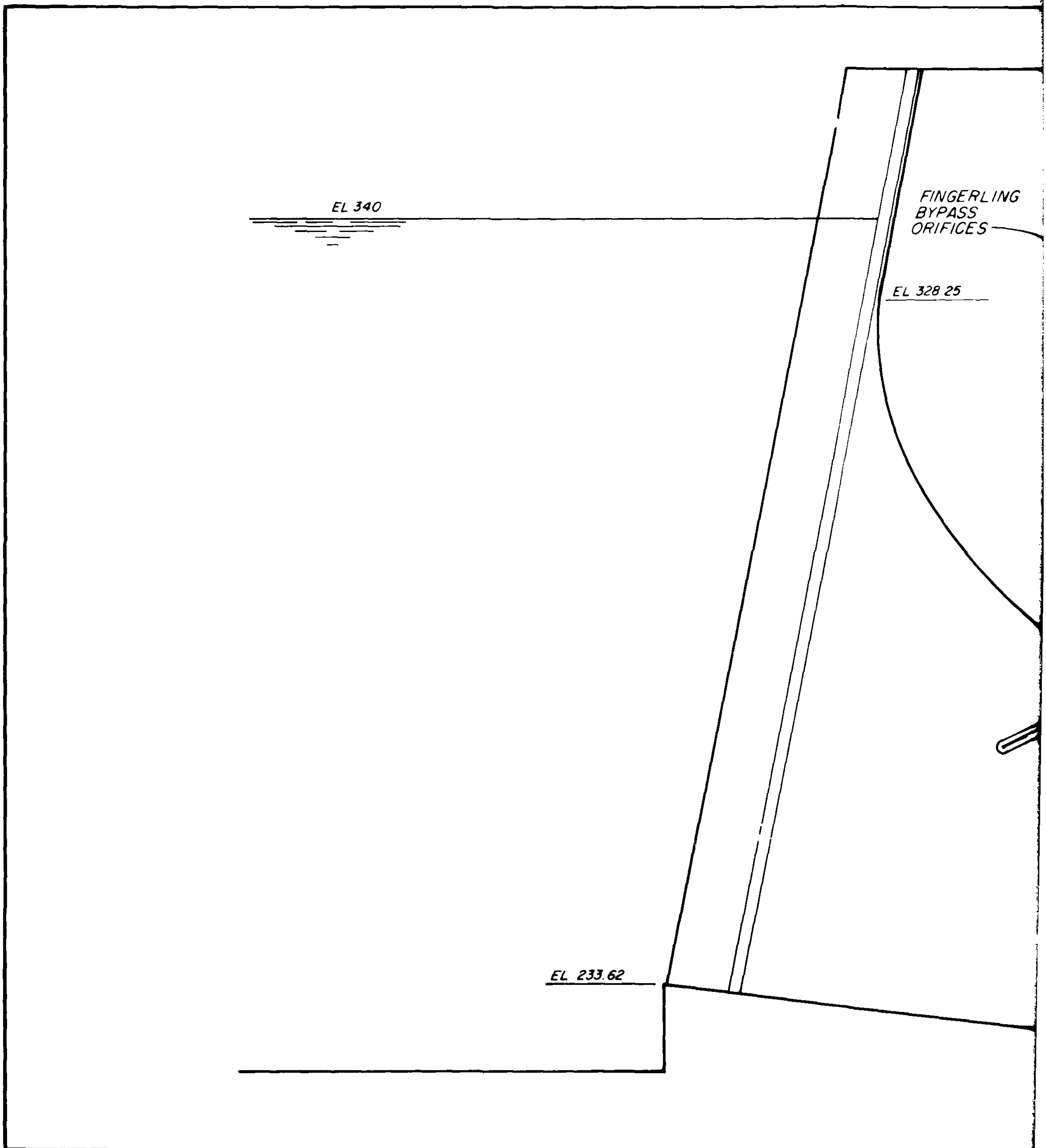
9 → VELOCITY IN FPS

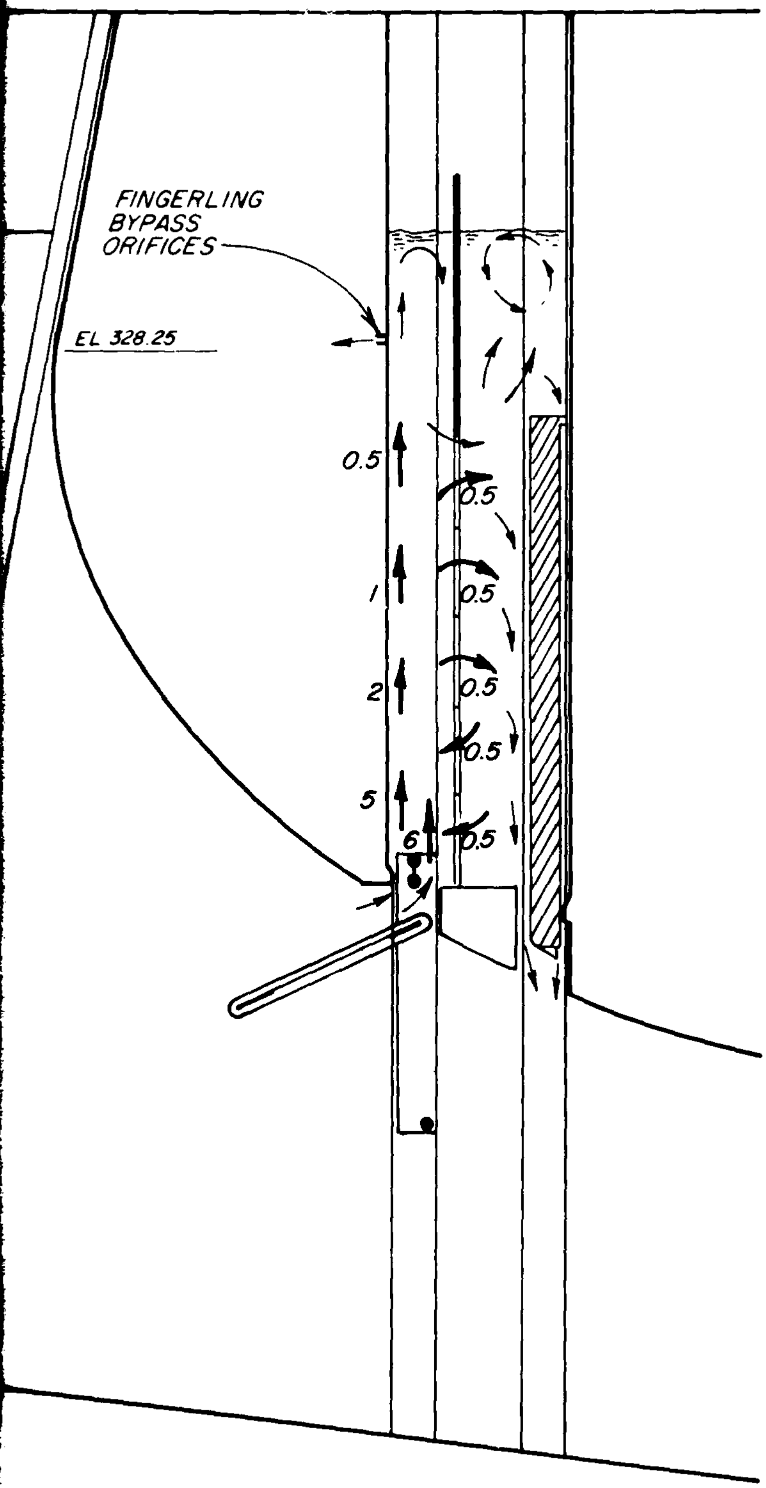
DISCHARGE

PER BAY 5 914 CFS

FLOW CONDITIONS IN GATE WELL

McNARY INTAKE
WITH GATE REMOVED


EL 340
FINGERLING
BYPASS
ORIFICES
EL 328.25
EL 233.62



LEGEND

5 → VELOCITY IN FPS

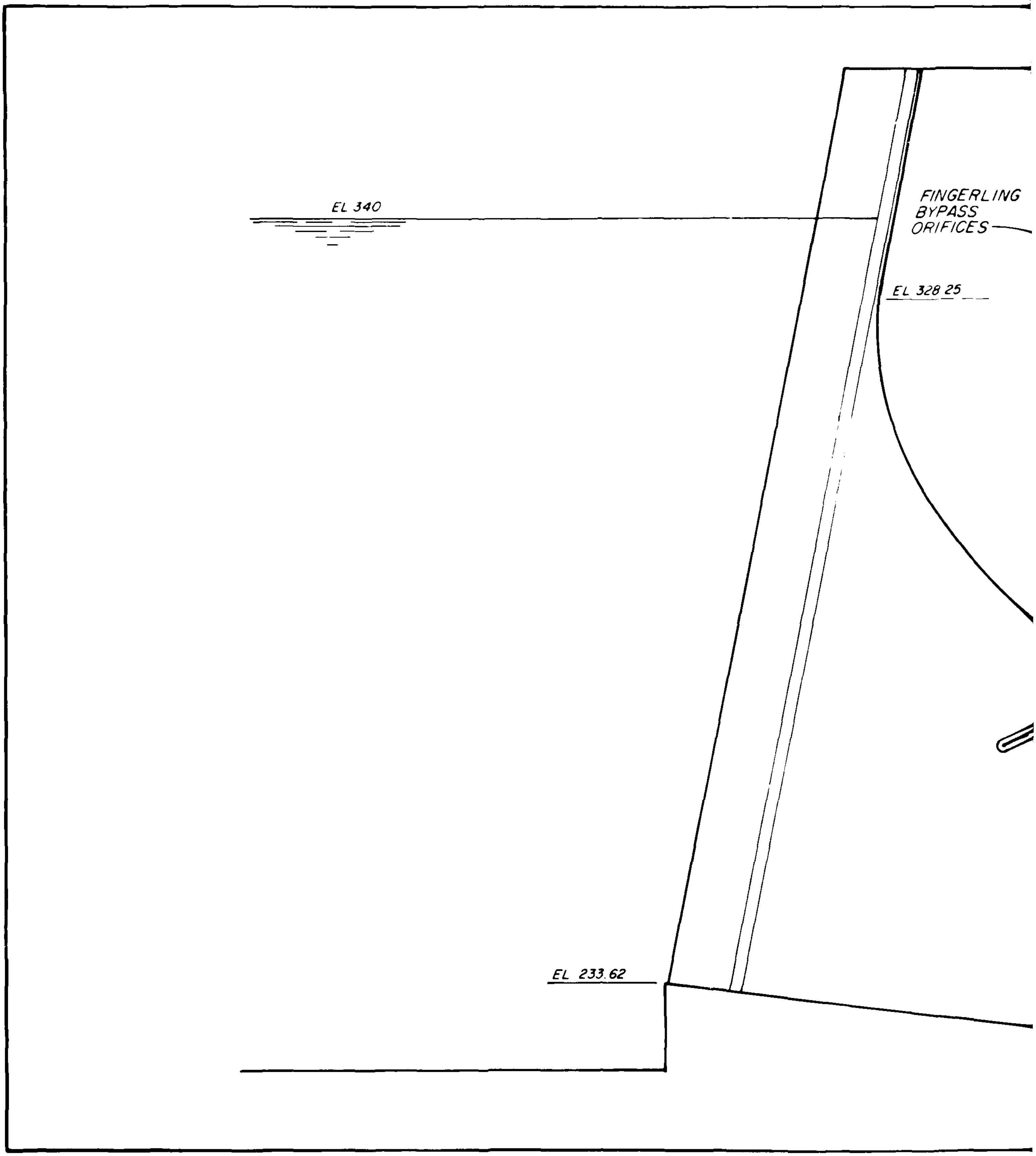
DISCHARGES

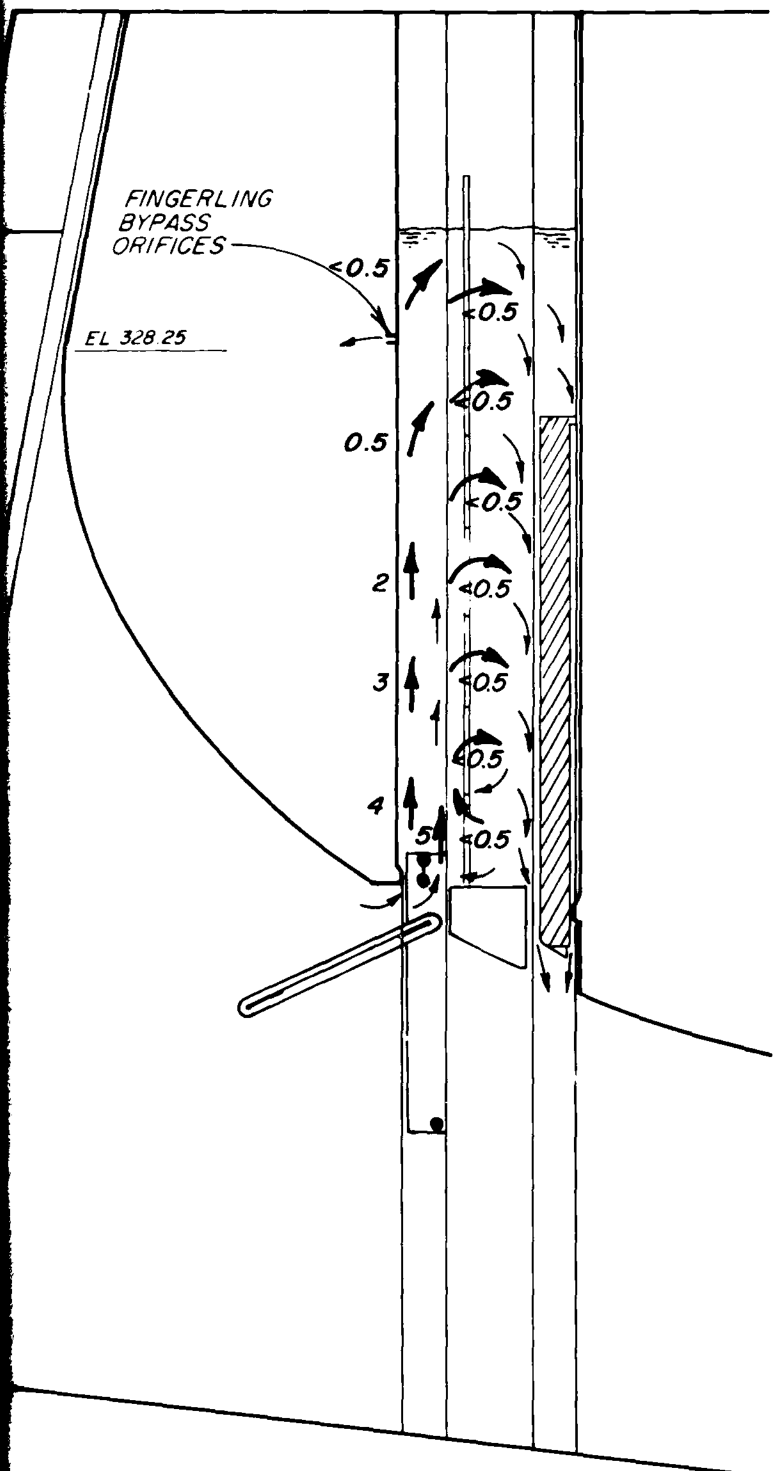
PER BAY	5 914 CFS
THROUGH WELL	256 CFS

FLOW CONDITIONS
IN GATE WELL

McNARY INTAKE

WITH 30 PERCENT POROSITY
PERFORATED PLATE ON
VERTICAL BARRIER SCREENS


EL 340
FINGERLING BYPASS ORIFICES
EL 328 25
EL 233.62



LEGEND

4 → VELOCITY IN FPS

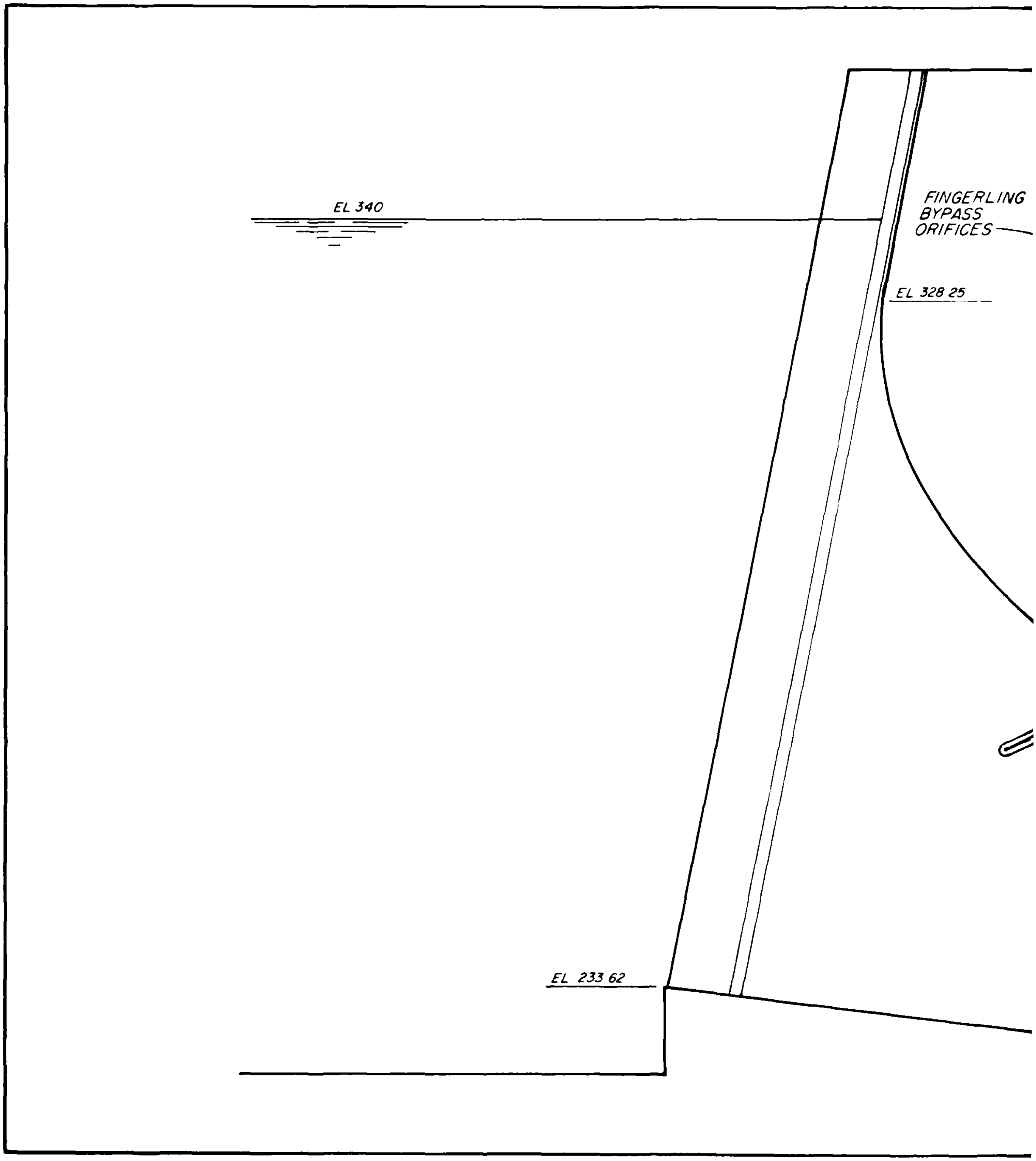
DISCHARGE

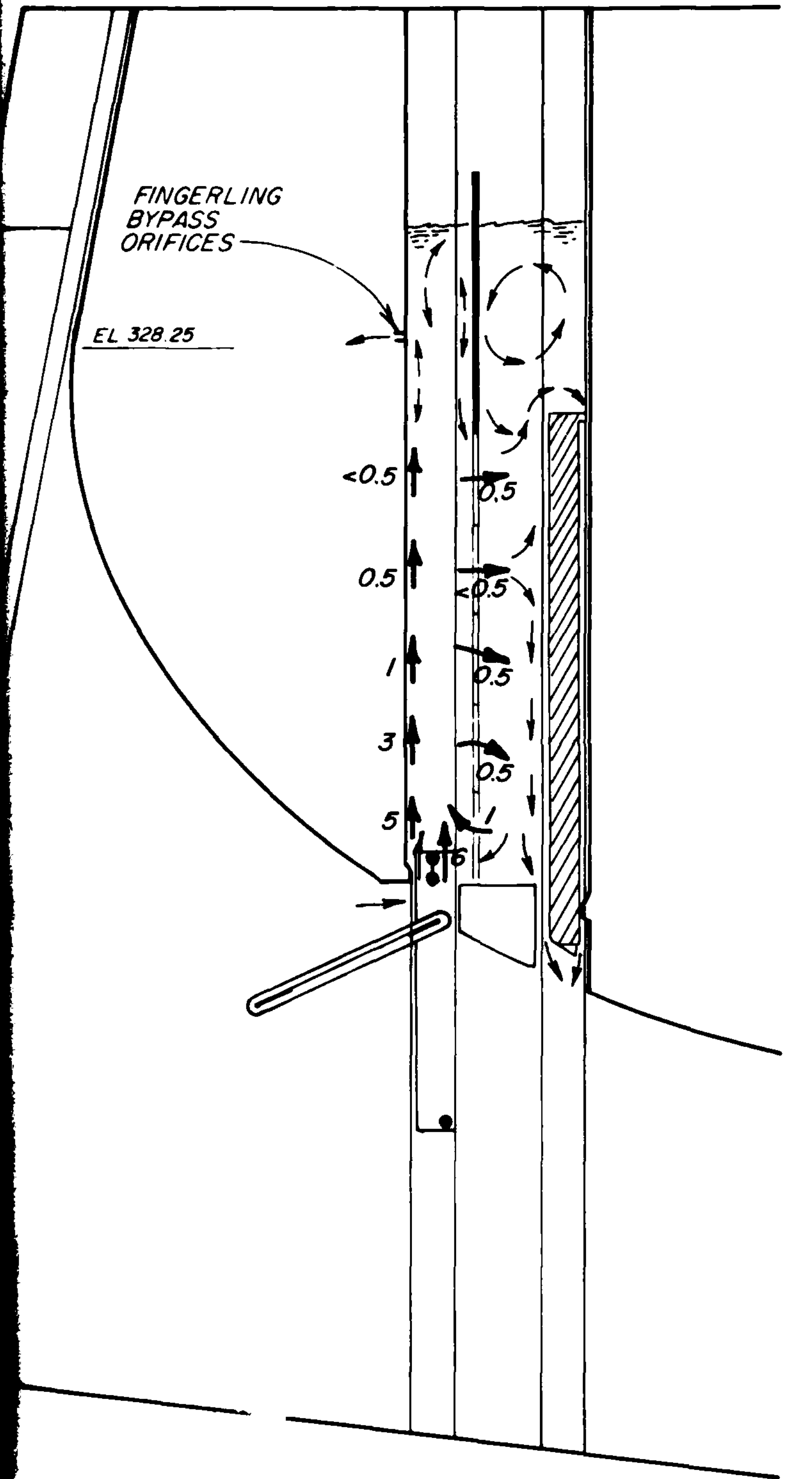
PER BAY 5 914 CFS

FLOW CONDITIONS
IN GATE WELL

McNARY INTAKE

WITH 30 PERCENT POROSITY
PERFORATED PLATE ON
VERTICAL BARRIER SCREENS
AND SCREENS IN TOP
THREE POSITIONS


FINGERLING
BYPASS
ORIFICES
EL 340
EL 328.25
EL 233.62



LEGEND

3 → VELOCITY IN FPS

DISCHARGES

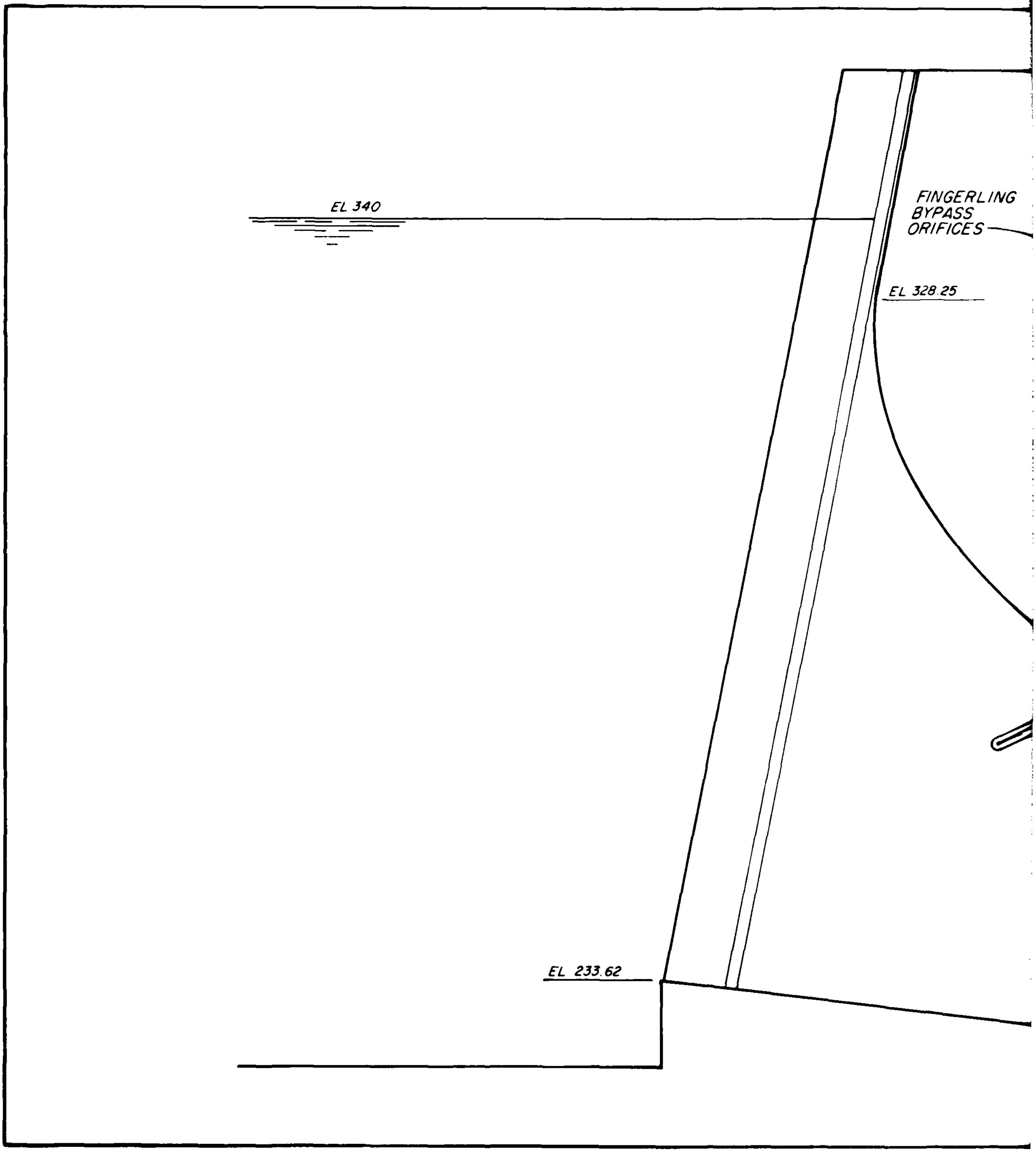
PER BAY 6 243 CFS

FLOW CONDITIONS
IN GATE WELL

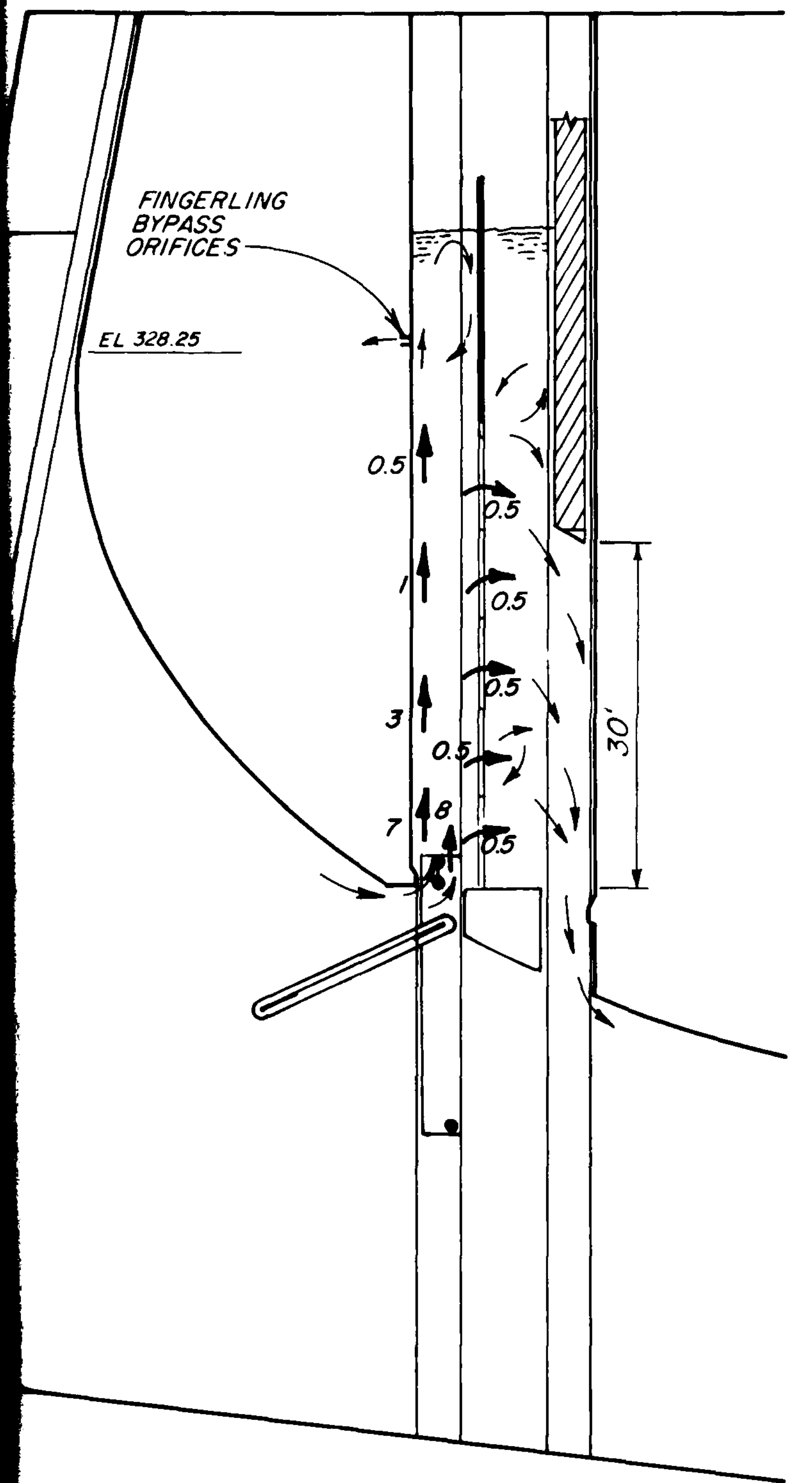
McNARY INTAKE

WITH 30 PERCENT POROSITY
PERFORATED PLATE ON
VERTICAL BARRIER SCREENS
AND MAXIMUM DISCHARGE

2



EL 340
FINGERLING
BYPASS
ORIFICES
EL 328.25
EL 233.62



LEGEND

7 → VELOCITY IN FPS

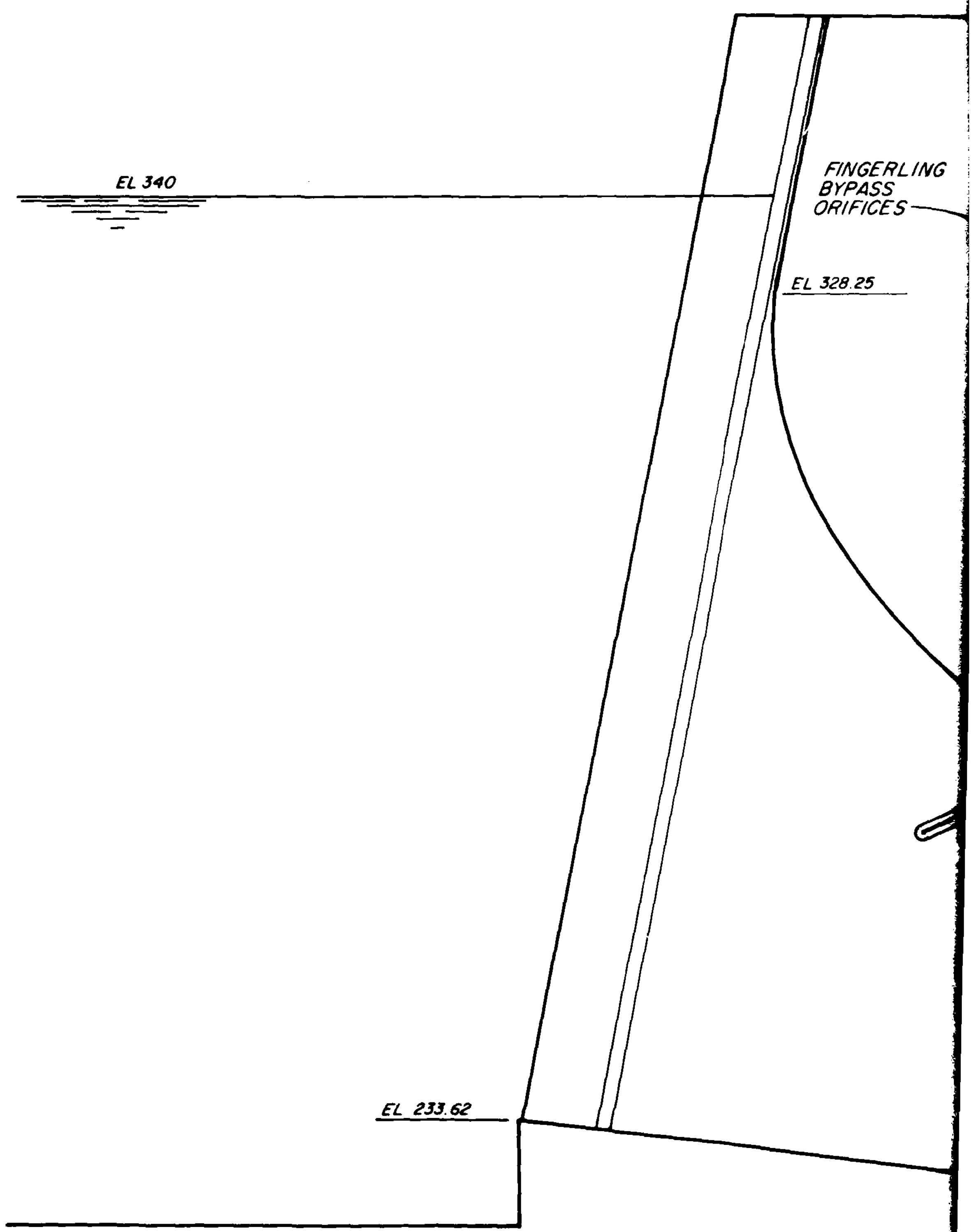
DISCHARGE

PER BAY	5 914 CFS
THROUGH WELL	342 CFS

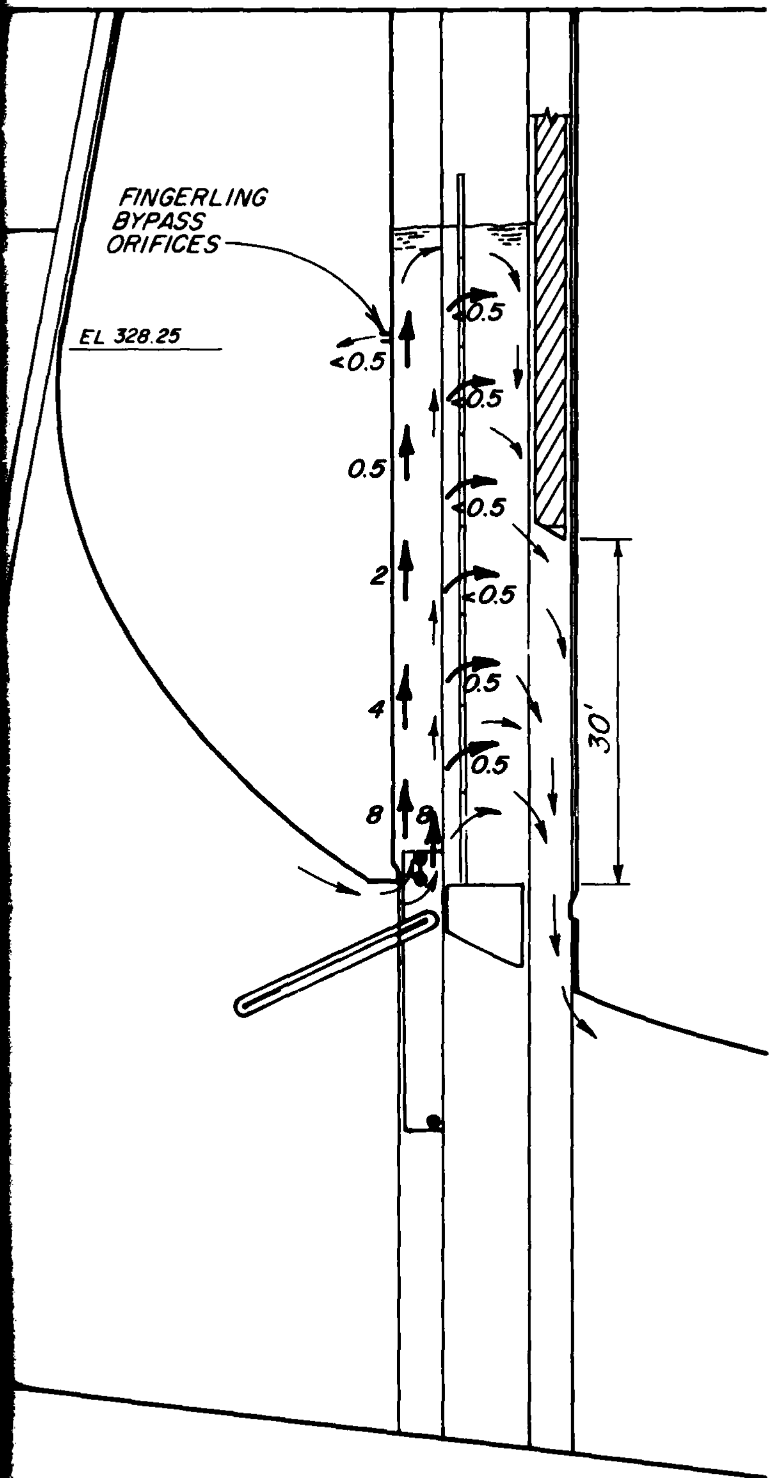
FLOW CONDITIONS
IN GATE WELL

McNARY INTAKE
SIMULATED JOHN DAY CONDITIONS

WITH 15 PERCENT POROSITY
PERFORATED PLATE ON
VERTICAL BARRIER SCREENS



EL 340
FINGERLING BYPASS ORIFICES
EL 328.25
EL 233.62



LEGEND

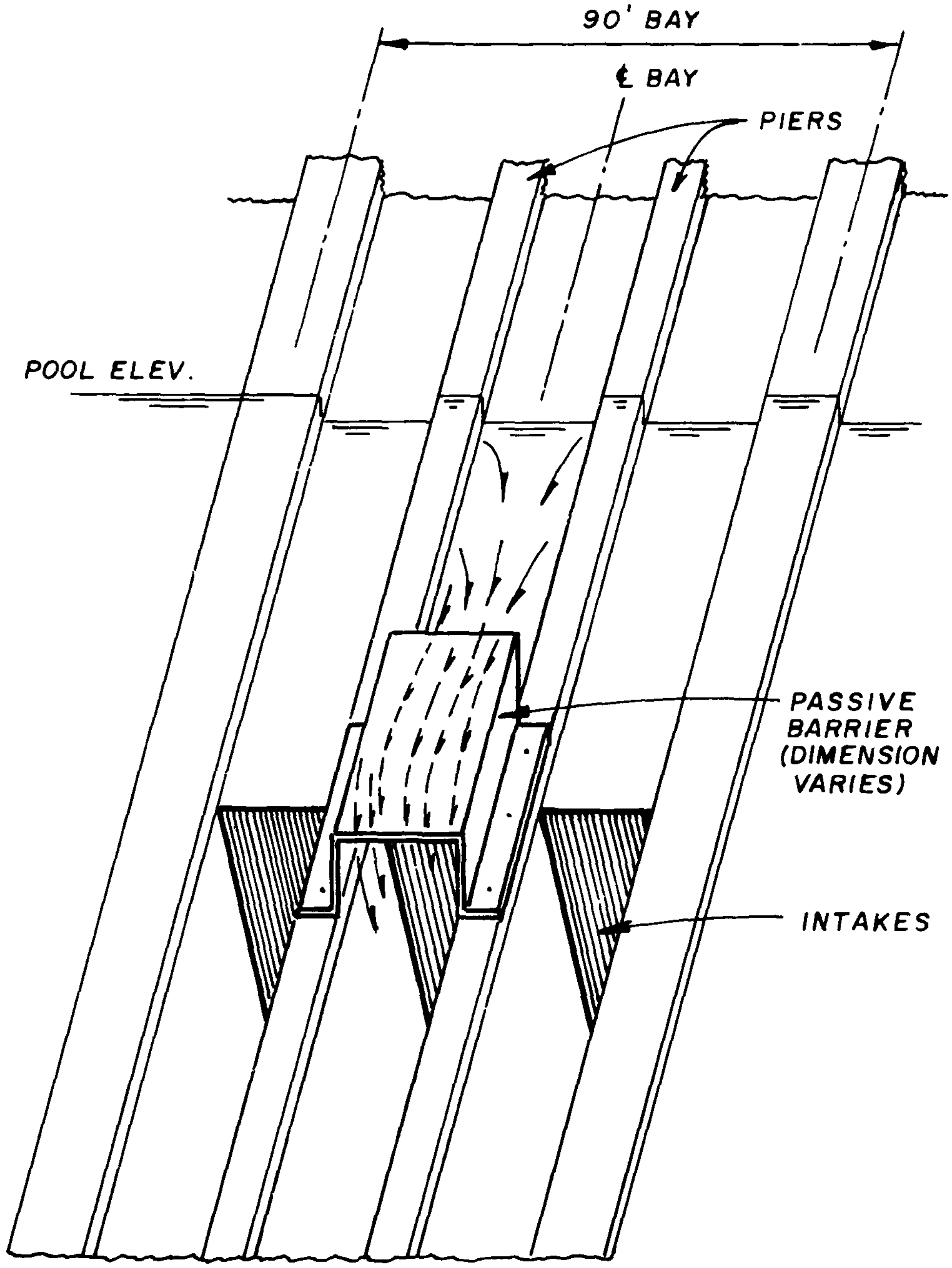
8 → VELOCITY IN FPS

DISCHARGE

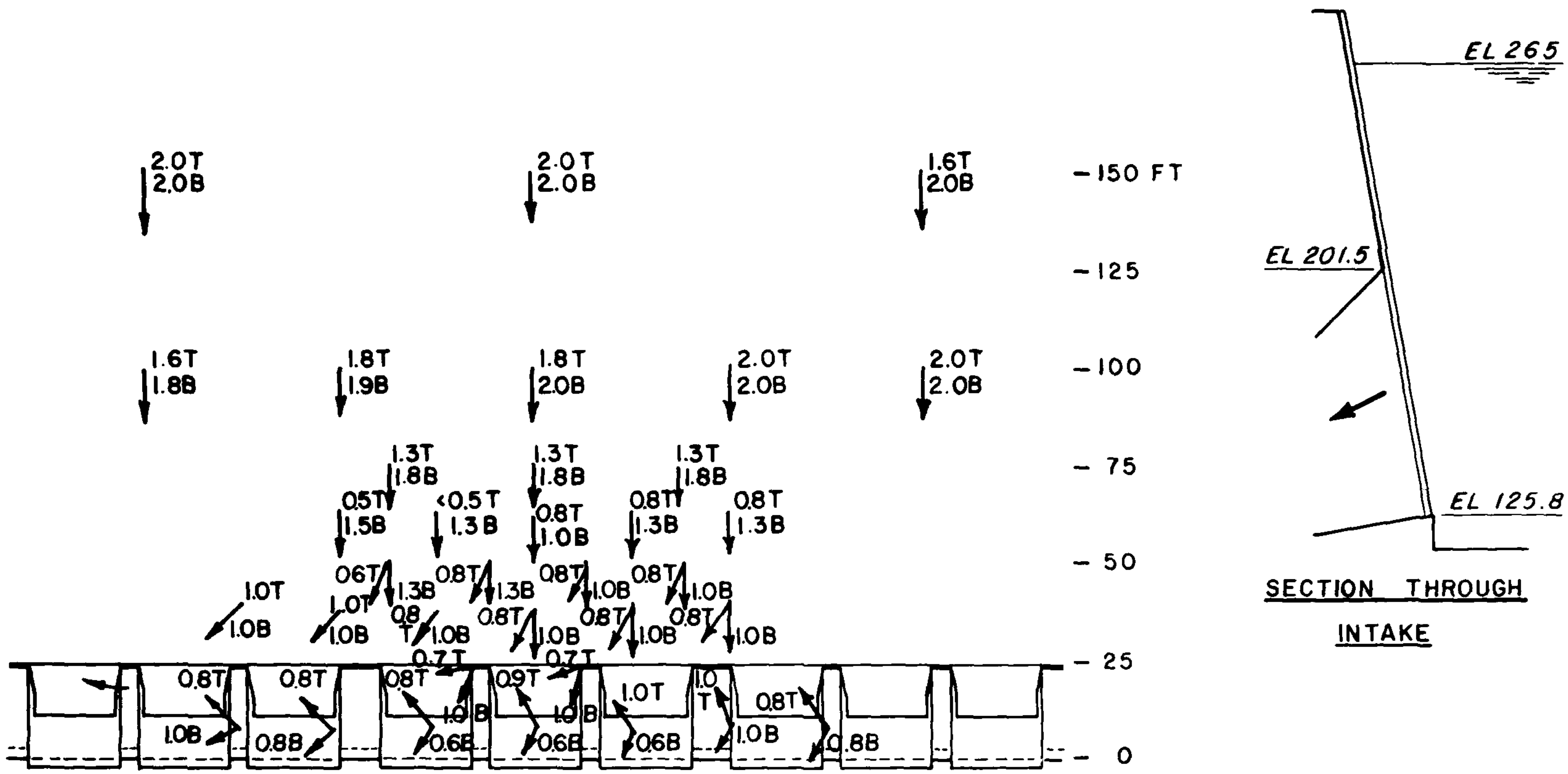
PER BAY 5914 CFS

FLOW CONDITIONS
IN GATE WELL

McNARY INTAKE
SIMULATED JOHN DAY CONDITIONS
WITH 15 PERCENT POROSITY
PERFORATED PLATE ON
VERTICAL BARRIER SCREENS
AND SCREENS IN TOP
THREE POSITIONS



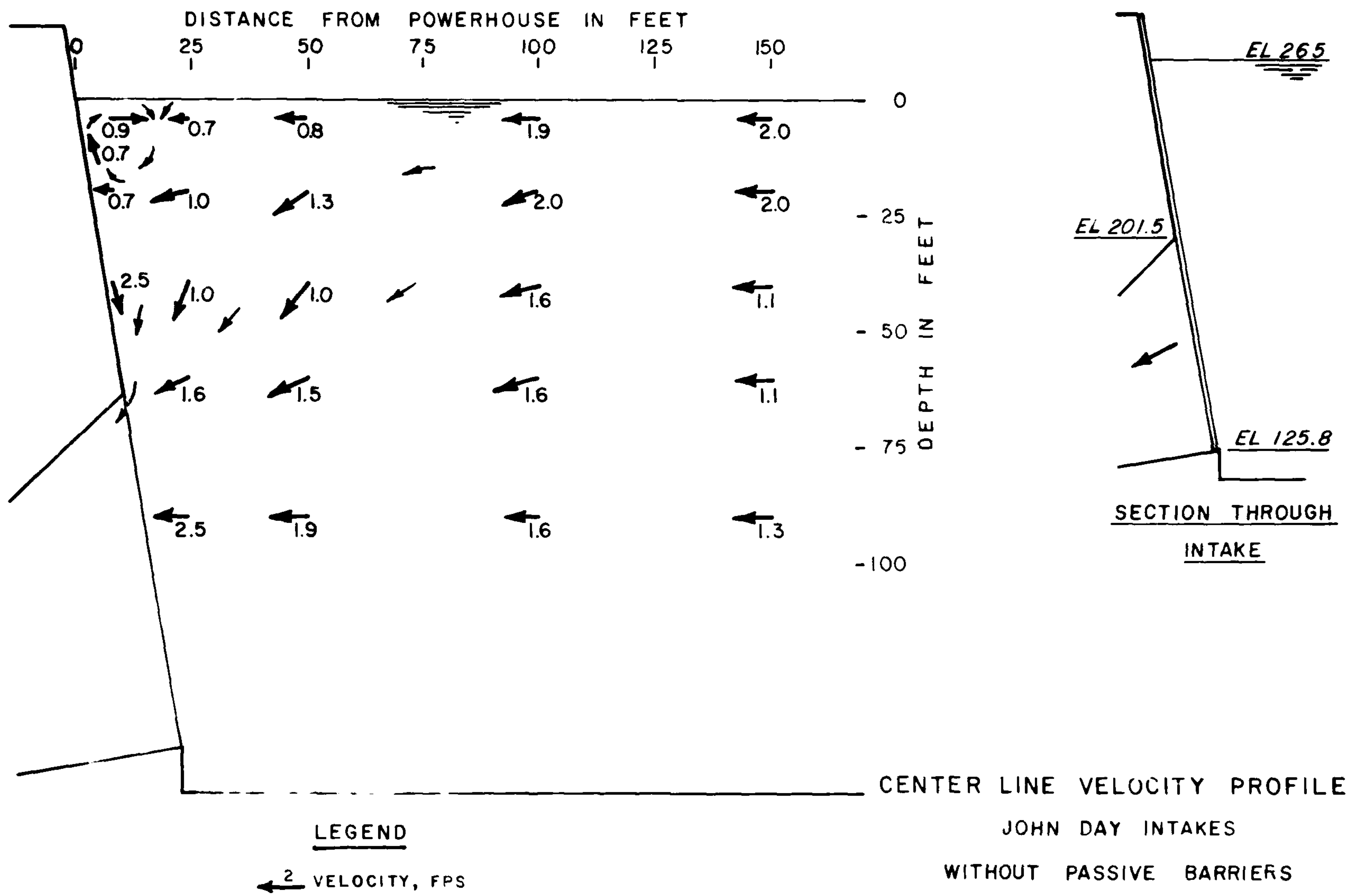
PASSIVE BARRIER
JOHN DAY DAM



LEGEND

2 VELOCITY, FPS
T 5-FT DEPTH
B 15-FT DEPTH

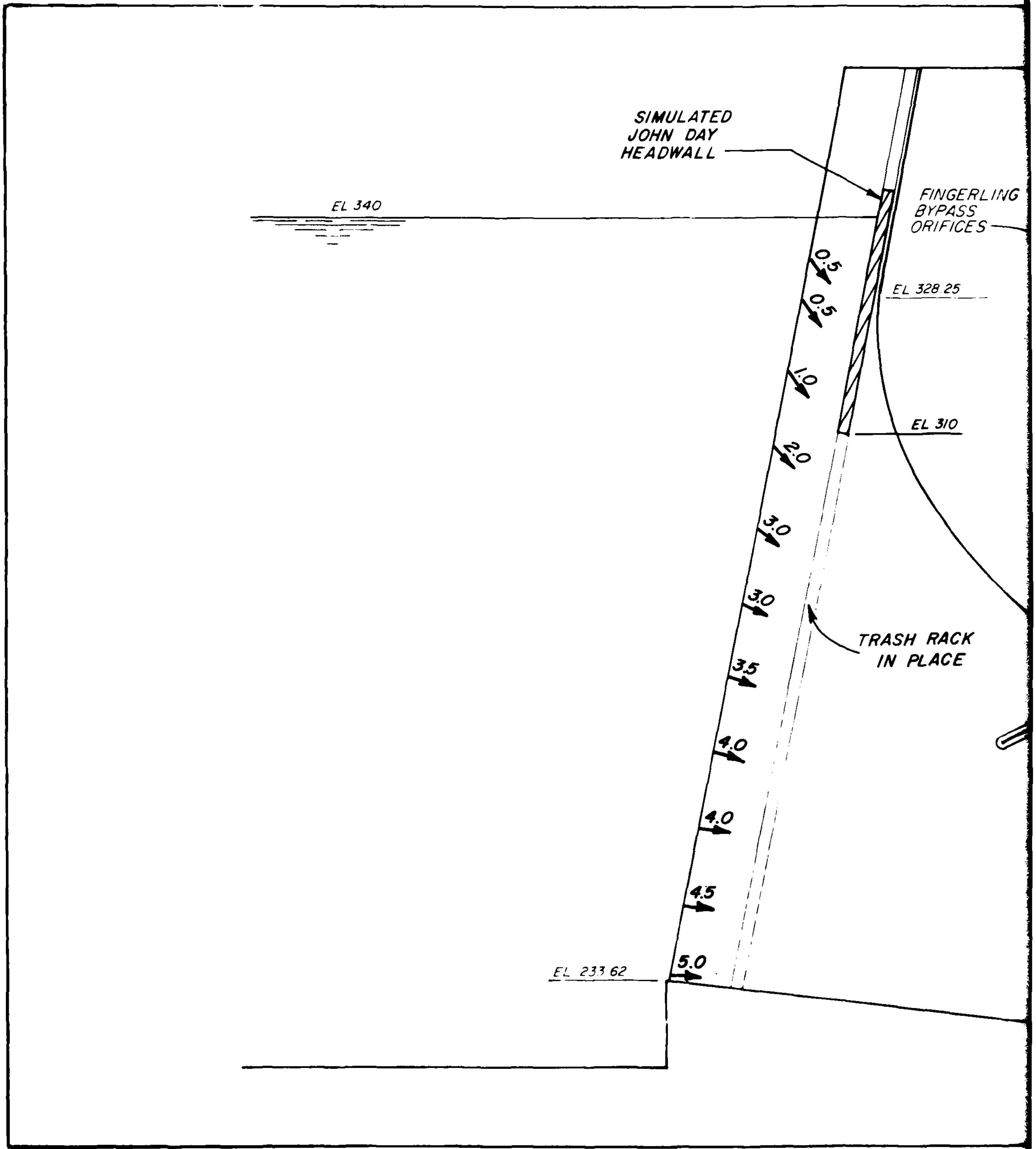
VELOCITIES
JOHN DAY INTAKES
WITHOUT PASSIVE BARRIERS



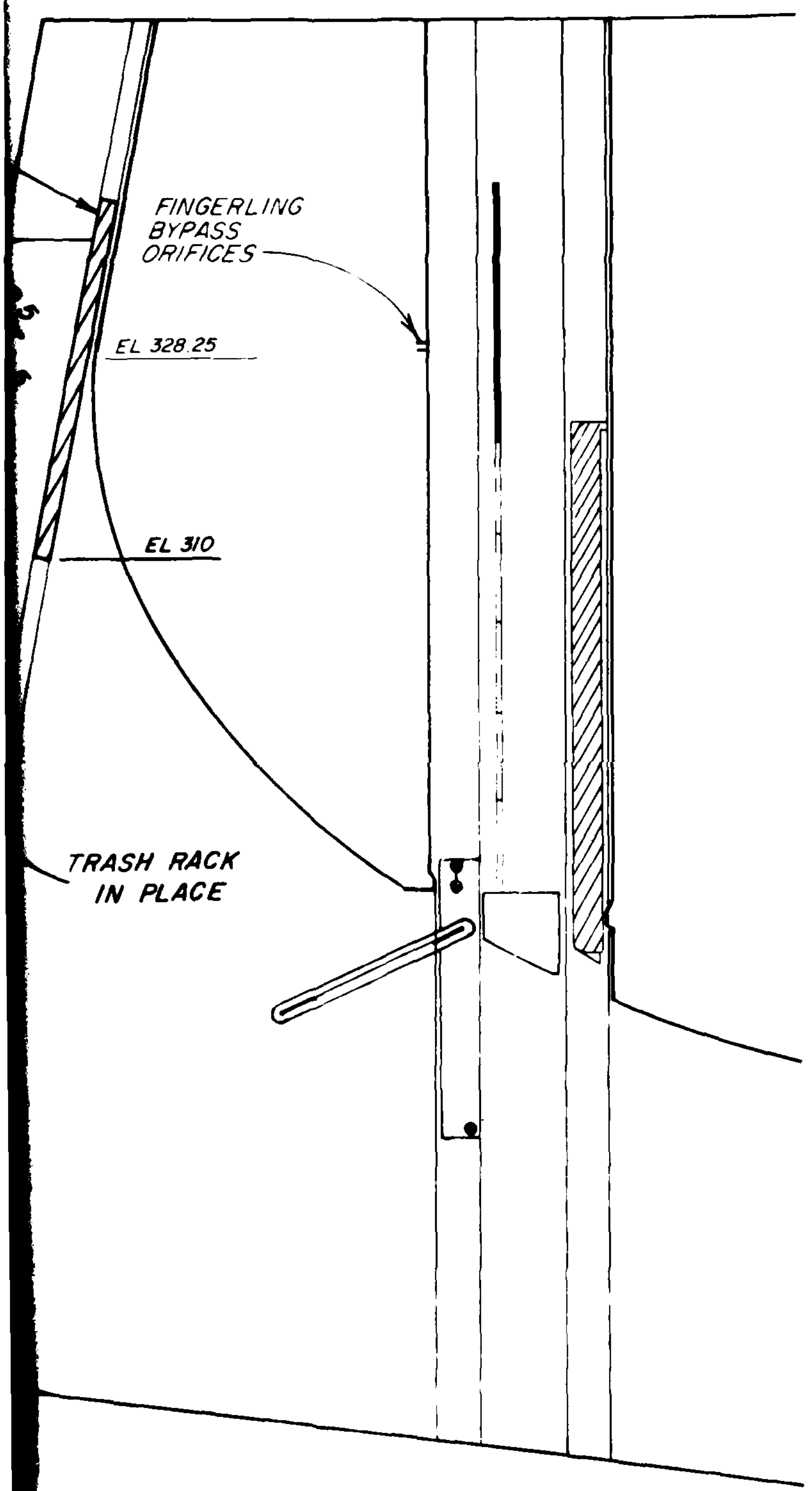
CENTER LINE VELOCITY PROFILE

JOHN DAY INTAKES

WITHOUT PASSIVE BARRIERS



SIMULATED
JOHN DAY
HEADWALL
FINGERLING
BYPASS
ORIFICES
EL 340
EL 328.25
EL 310
0.5
0.5
1.0
2.0
3.0
3.0
3.5
4.0
4.0
4.5
5.0
TRASH RACK
IN PLACE
EL 233.62



LEGEND

2.0 → VELOCITY IN FPS

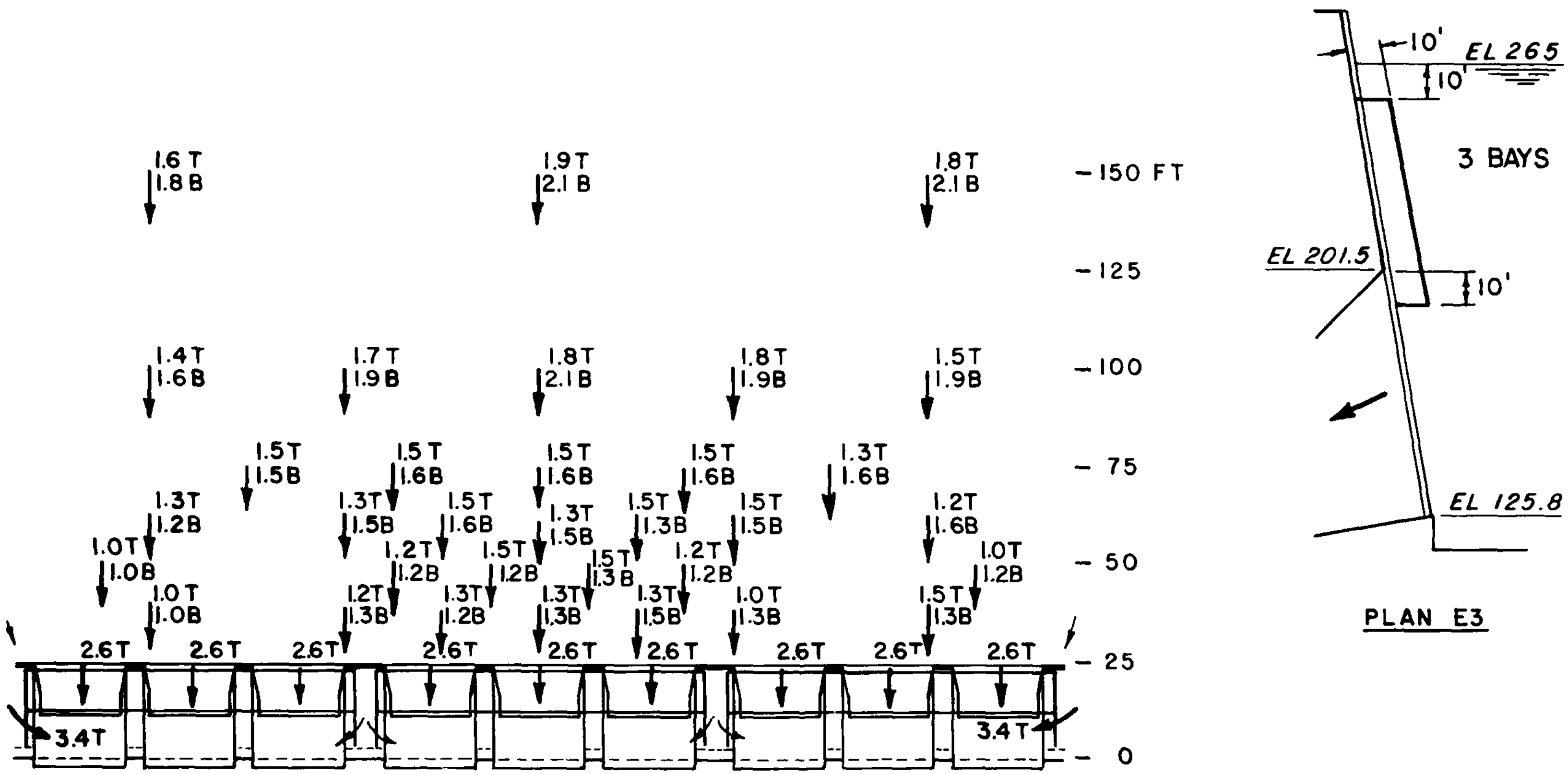
DISCHARGES

PER BAY	7,560	CFS

FLOW CONDITIONS

SIMULATED JOHN DAY INTAKE

WITHOUT PASSIVE BARRIER



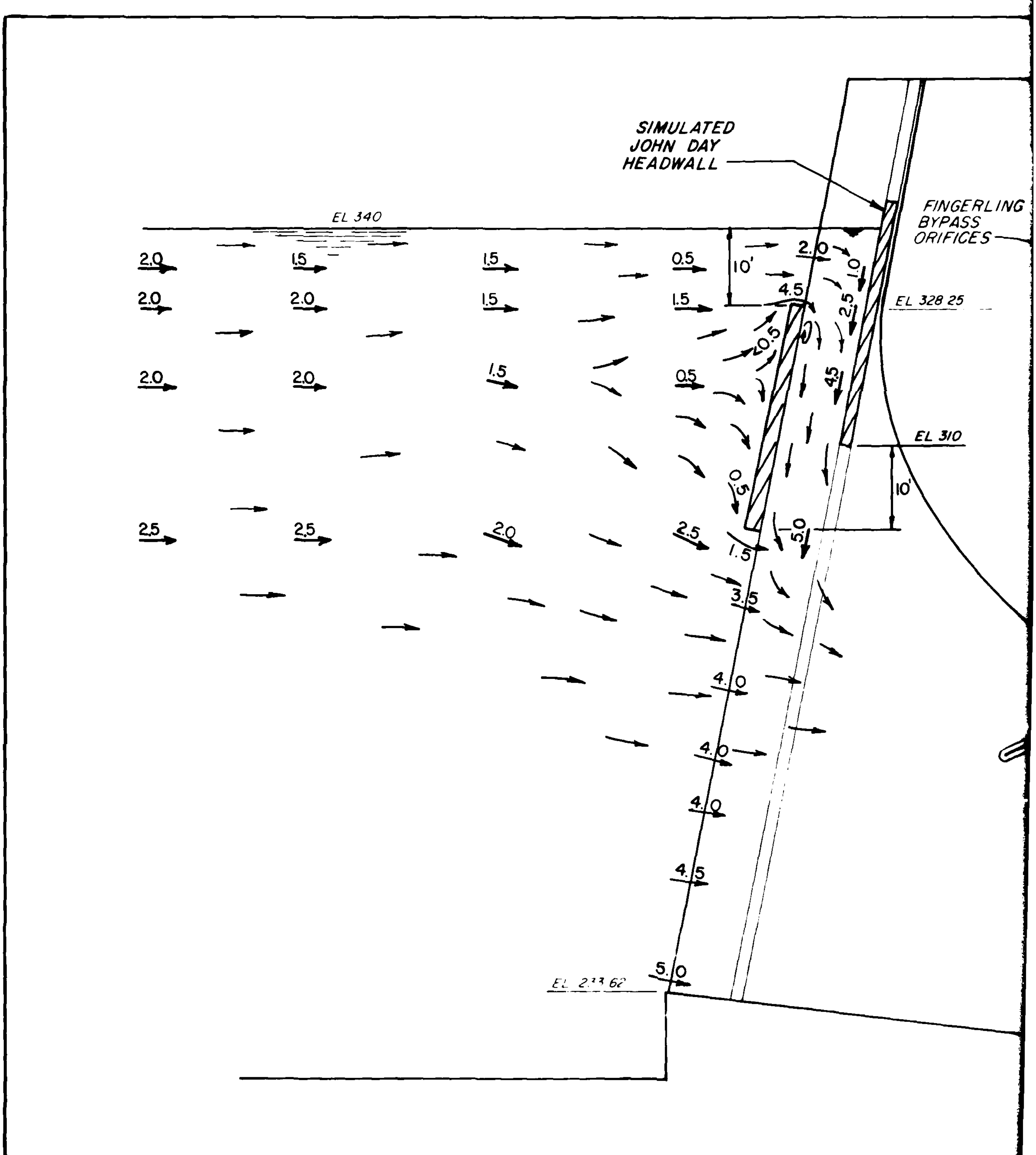
LEGEND

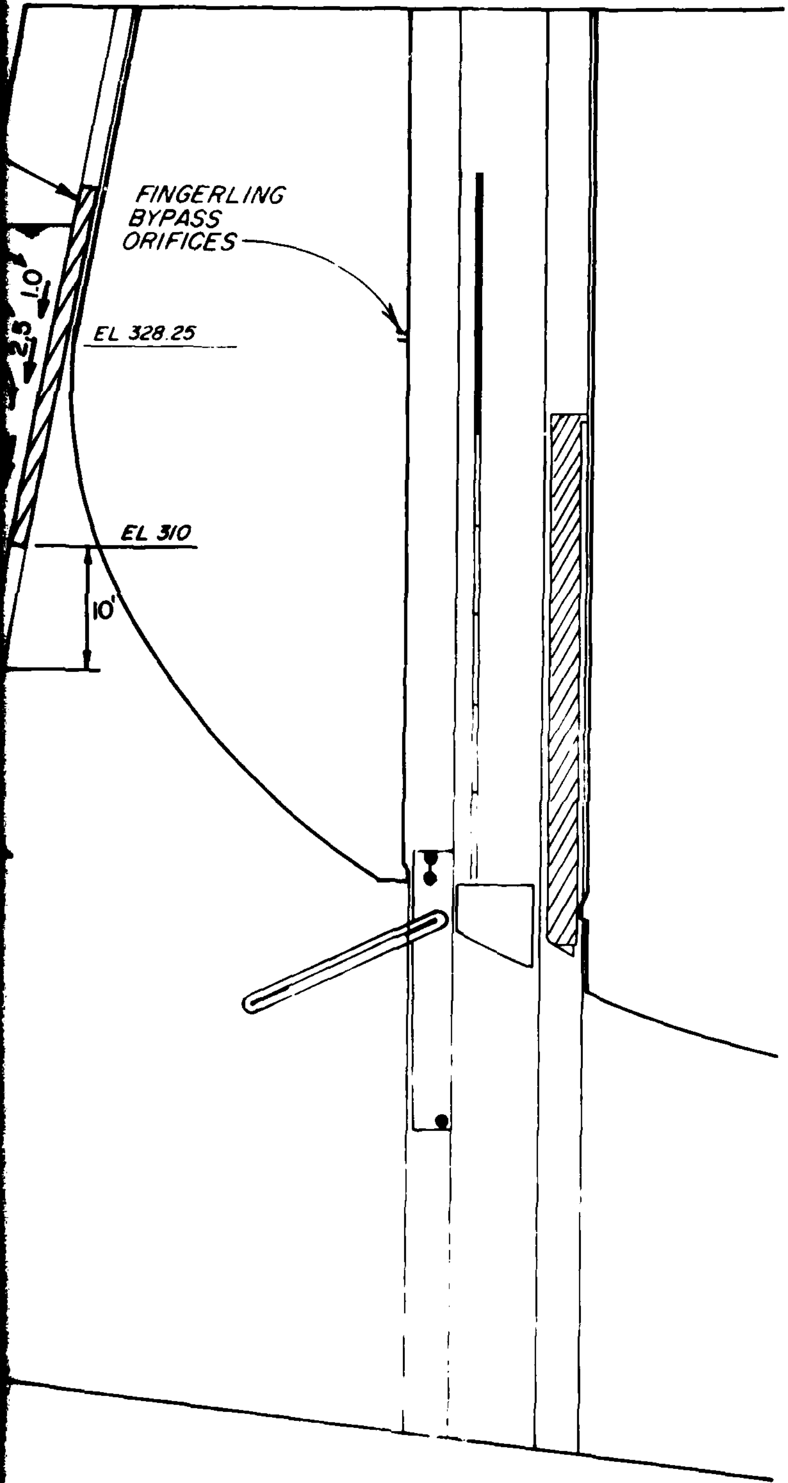
2 VELOCITY, FPS
T 5-FT DEPTH
B 15-FT DEPTH

VELOCITIES

JOHN DAY INTAKES

PASSIVE BARRIER PLAN E3


SIMULATED
JOHN DAY
HEADWALL
FINGERLING
BYPASS
ORIFICES
EL 340
EL 328.25
EL 310
10'
10'
EL 233.62
2.0
1.5
1.5
0.5
2.0
1.0
2.0
2.0
1.5
1.5
4.5
2.5
0.5
2.0
2.0
1.5
0.5
4.5
0.5
2.5
2.5
2.0
2.5
5.0
1.5
3.5
4.0
4.0
4.0
4.5
5.0



LEGEND

20 VELOCITY IN FPS

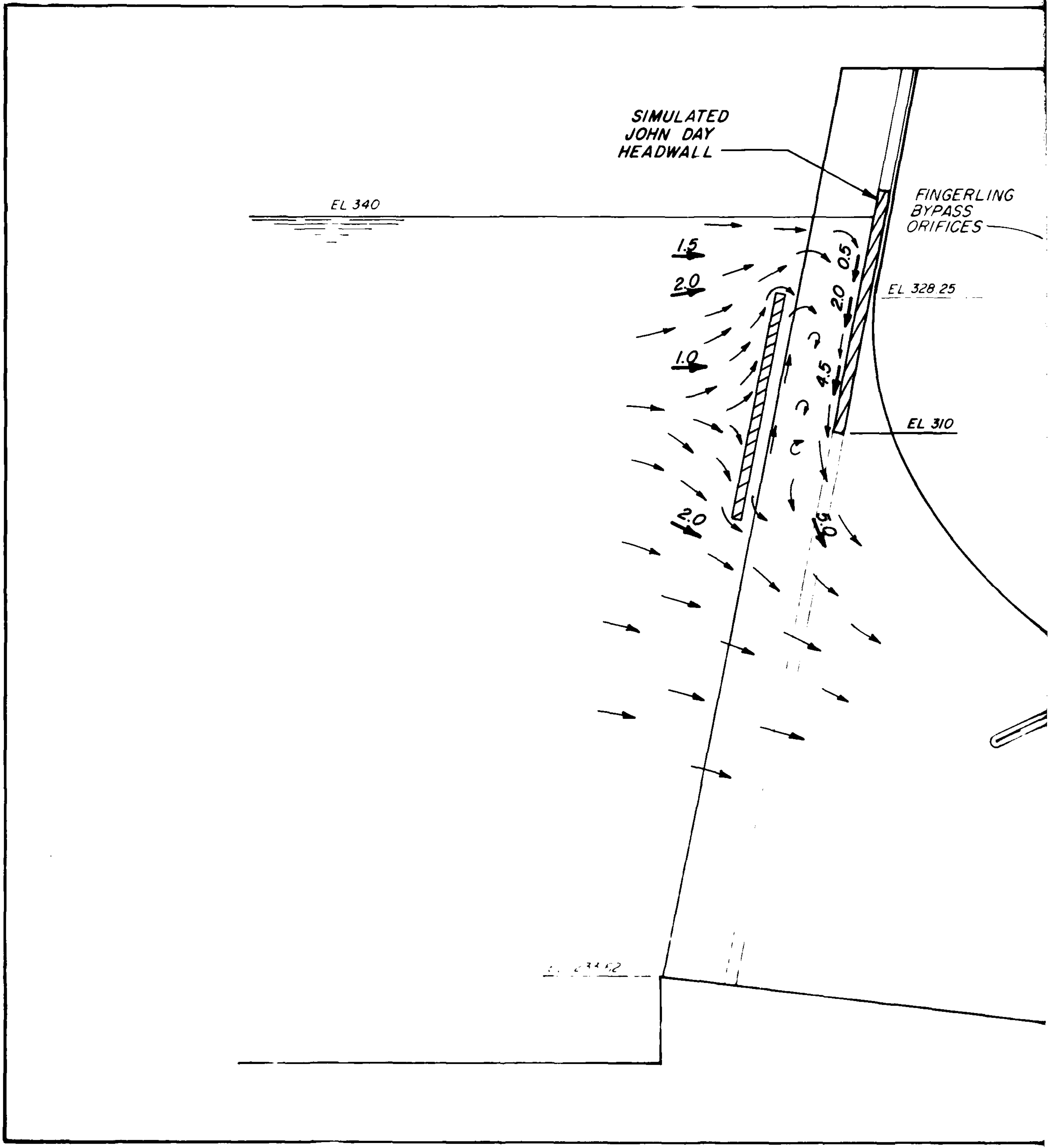
VORTEX

DISCHARGES

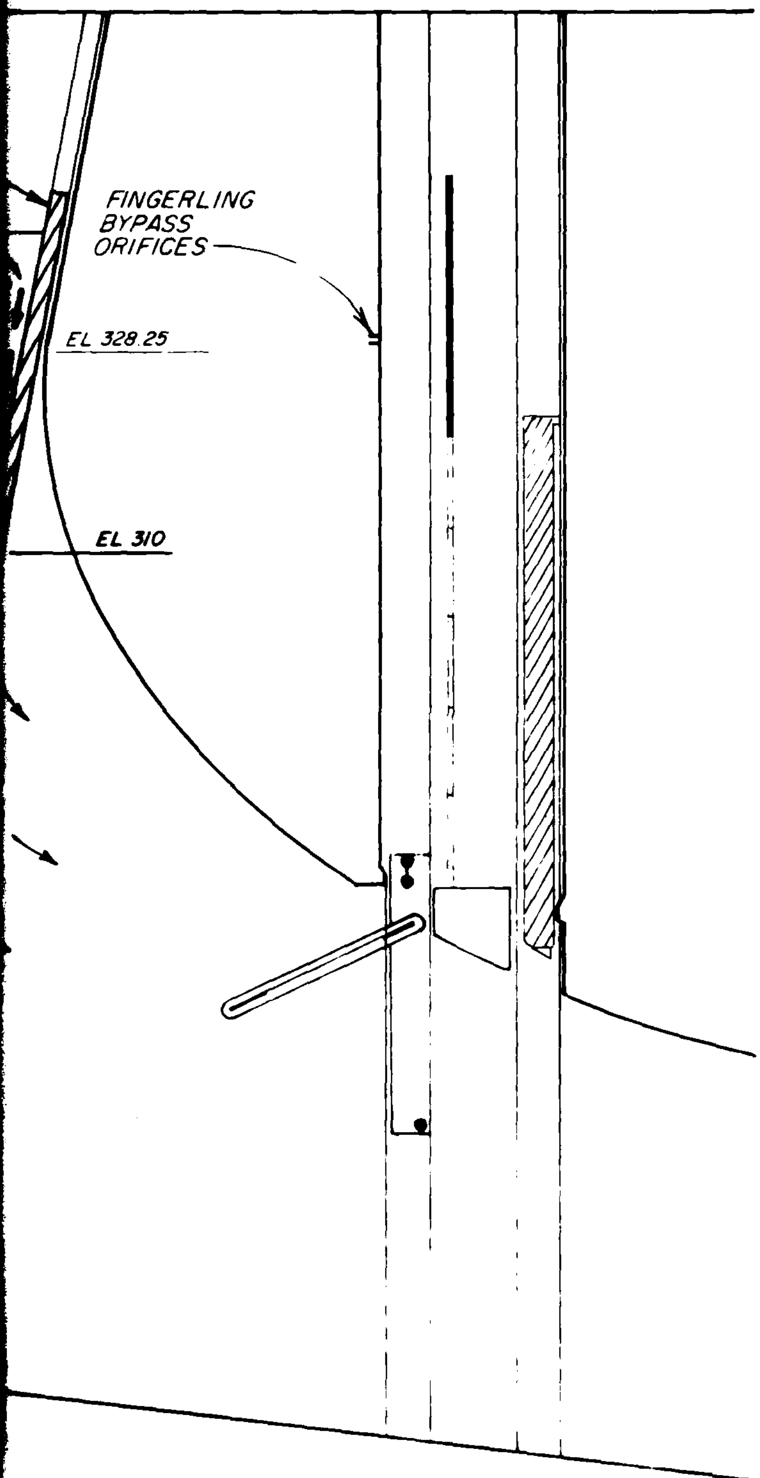
PER BAY	7,560	CFS

FLOW CONDITIONS

SIMULATED JOHN DAY INTAKE
WITH PASSIVE BARRIER
10.0 FEET UPSTREAM



SIMULATED JOHN DAY HEADWALL
FINGERLING BYPASS ORIFICES
EL 340
EL 328.25
EL 310
1.5
2.0
1.0
2.0
0.5
2.0
4.5



LEGEND

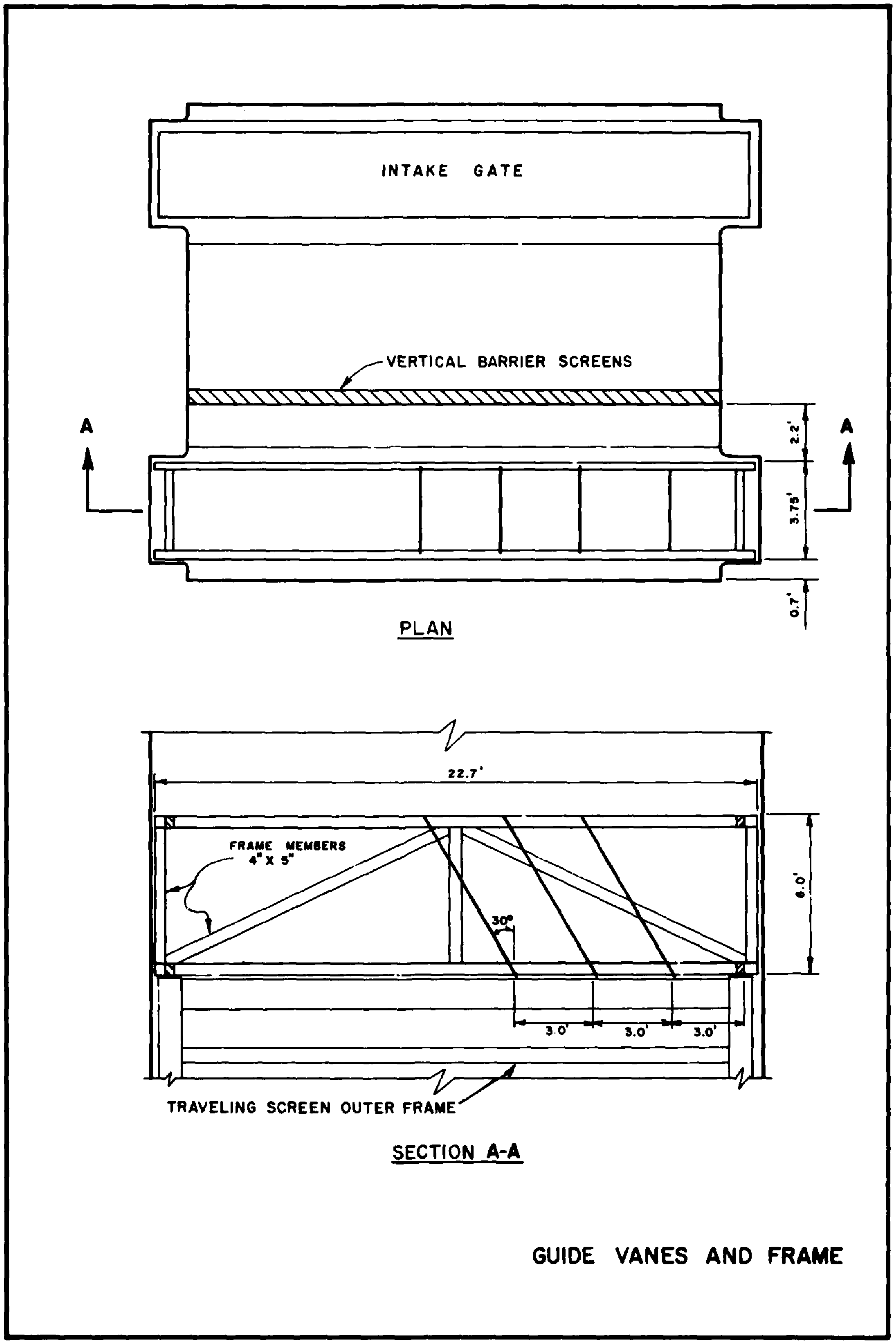
2.0 → VELOCITY IN FPS

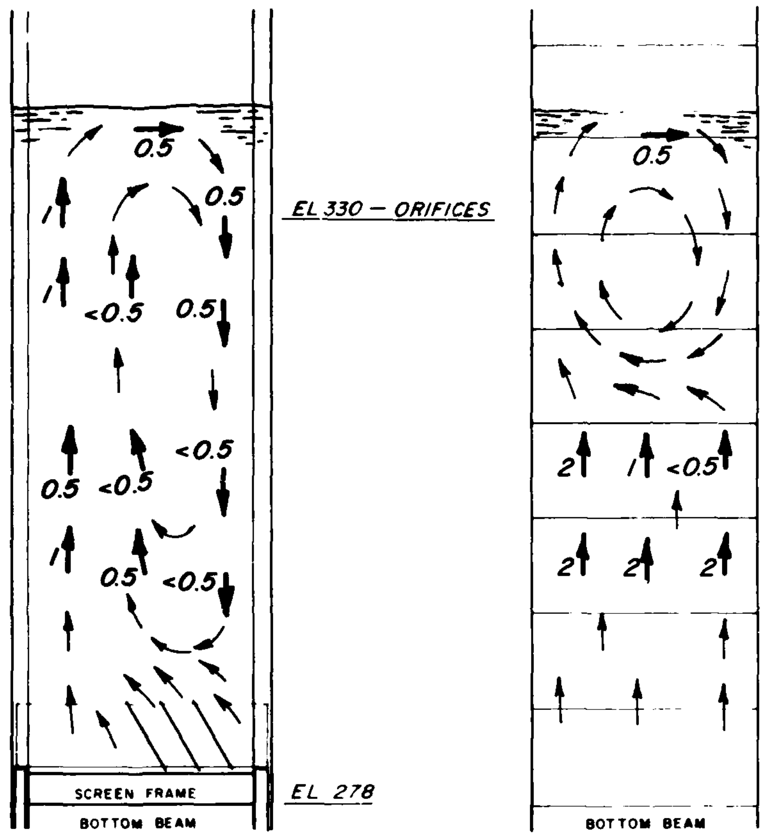
DISCHARGES

PER BAY 7,560 CFS

FLOW CONDITIONS

SIMULATED JOHN DAY INTAKE
WITH PASSIVE BARRIER
12.5 FEET UPSTREAM


INTAKE GATE
VERTICAL BARRIER SCREENS
A
A
2.2'
3.75'
0.7'
PLAN
22.7'
FRAME MEMBERS 4" X 5"
30°
6.0'
3.0'
3.0'
3.0'
TRAVELING SCREEN OUTER FRAME
SECTION A-A
GUIDE VANES AND FRAME



CENTER LINE OF SLOT

0.5 FT UPSTREAM FROM
VERTICAL BARRIER SCREENS

SECTIONS THROUGH BULKHEAD SLOT
LOOKING DOWNSTREAM

LEGEND

4 ← VELOCITY IN FPS

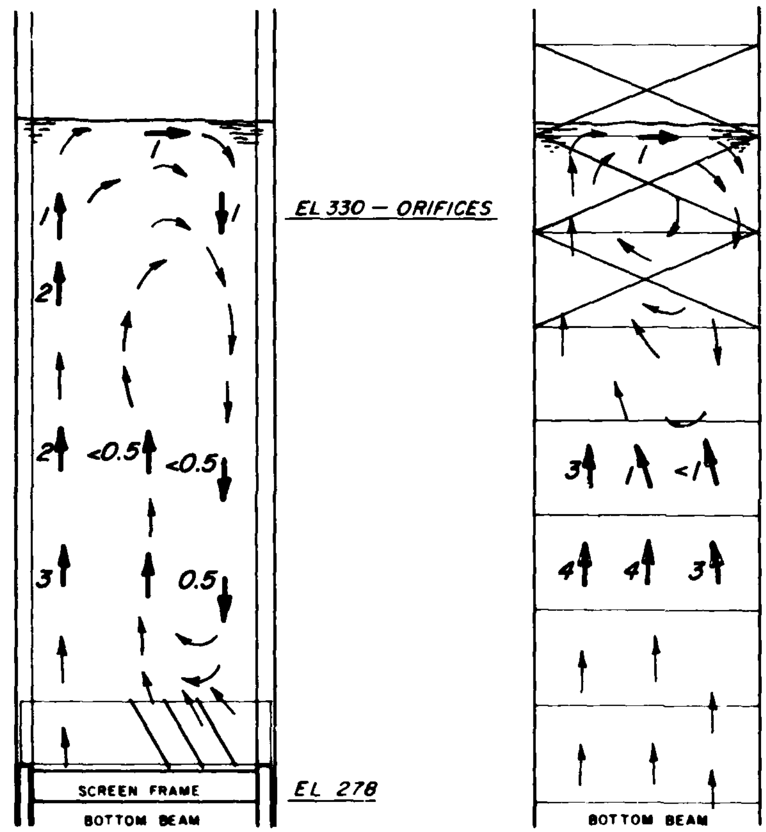
DISCHARGE

PER BAY 5 914 CFS

NOTE

VELOCITIES OF ALL FLOW THROUGH VERTICAL BARRIER SCREENS LESS THAN 0.5 FPS

FLOW CONDITIONS
IN BULKHEAD SLOT
McNARY INTAKE
WITH 30 PERCENT POROSITY
PERFORATED PLATE ON
VERTICAL BARRIER SCREENS
AND VANES IN SLOTS



CENTER LINE OF SLOT

0.5 FT UPSTREAM FROM
VERTICAL BARRIER SCREENS

SECTIONS THROUGH BULKHEAD SLOT
LOOKING DOWNSTREAM

LEGEND

4 ← VELOCITY IN FPS

DISCHARGE

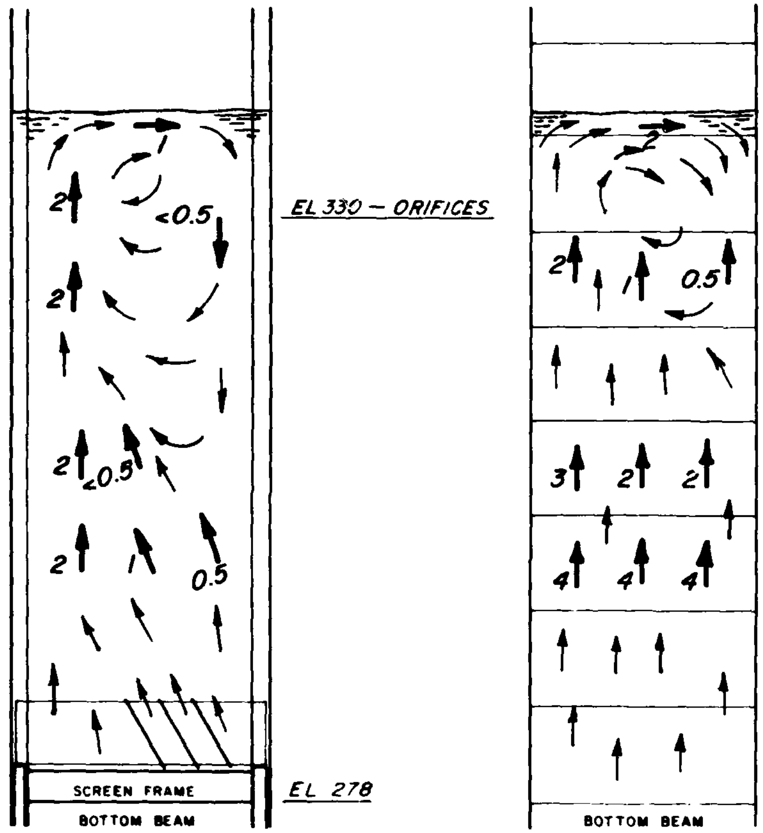
PER BAY 5 914 CFS

NOTE

VELOCITIES OF ALL FLOW THROUGH VERTICAL BARRIER SCREENS LESS THAN 0.5 FPS

FLOW CONDITIONS
IN BULKHEAD SLOT
McNARY INTAKE

SIMULATED JOHN DAY CONDITIONS
WITH 15 PERCENT POROSITY
PERFORATED PLATE ON
VERTICAL BARRIER SCREENS
SOLID PANELS IN TOP THREE POSITIONS
AND VANES IN SLOTS



CENTER LINE OF SLOT

0.5 FT UPSTREAM FROM VERTICAL BARRIER SCREENS

SECTIONS THROUGH BULKHEAD SLOT

LOOKING DOWNSTREAM

LEGEND

VELOCITY IN FPS

DISCHARGE

PER BAY 5 914 CFS

NOTE

VELOCITIES OF ALL FLOW THROUGH VERTICAL BARRIER SCREENS LESS THAN 0 5 FPS

FLOW CONDITIONS
IN BULKHEAD SLOT
McNARY INTAKE

SIMULATED JOHN DAY CONDITIONS
WITH 15 PERCENT POROSITY
PERFORATED PLATE ON
VERTICAL BARRIER SCREENS
WITH SCREENS IN TOP THREE POSITIONS
AND VANES IN SLOTS

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