UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF THE OUTLET WORKS STILLING BASIN--SLY PARK DAM AMERICAN RIVER DIVISION CENTRAL VALLEY PROJECT, CALIFORNIA

Hydraulic Laboratory Report No. Hyd-383

ENGINEERING LABORATORIES

OFFICE OF THE ASSISTANT COMMISSIONER AND CHIEF ENGINEER
DENVER, COLORADO

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Office of the Assistant Commissioner
and Chief Engineer
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Laboratory Report No. Hyd-383
Hydraulic Laboratory
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Checked and
reviewed by: J. W. Ball

Subject: Hydraulic model studies of the outlet works slide gates and stilling basin--Sly Park Dam--American River Division--Central Valley Project, California

PURPOSE

To investigate the hydraulic characteristics of the bifurcation, gate structure, and stilling basin proposed for the outlet works of Sly Park Dam to ensure satisfactory operation.

CONCLUSIONS

1. The stilling basin performs satisfactorily without the triangular-shaped stilling basin baffles and dividing wall (Figure 6). The baffles did not appreciably improve the basin's operation and slightly increased the head loss through the structure (Figure 9).

2. The operation of the basin with equal or unequal gate openings is satisfactory with or without the baffles installed. Adequate stilling is obtained even when one gate is fully closed and the other fully open.

3. The accumulated head loss through the bifurcation slide gates, stilling basin, and bellmouth is shown in Figure 9.

4. No negative pressures severe enough to cause cavitation will occur on the gate leaf, frame, or the roof of the conduit below the gate. The pressure data for those piezometers yielding the lowest readings are presented in the nondimensional form of pressure coefficients in Figure 10.

5. The preliminary design outlet works, with the triangular-shaped baffles and the dividing wall omitted, will give satisfactory operation.

ACKNOWLEDGMENT

The recommended stilling basin design is the result of cooperative efforts of the Dams Branch and the Engineering Laboratories of the Office

of the Assistant Commissioner and Chief Engineer, Denver, Colorado.

INTRODUCTION

Sly Park Dam is located on Sly Park Creek in Eldorado County about 12 air line miles east of Placerville, California (Figure 1). The principal construction features are an earth- and rock-fill dam, an earth- and rock-fill dike, a concrete-lined spillway on the left abutment of the dike, an outlet works through the dam, and the Camino Conduit (Figure 2).

The spillway will consist of an uncontrolled overflow crest, a channel with a roadway bridge across it, and a chute which terminates in a shallow ski-jump bucket. Hydraulic model studies on the spillway are reported in Hydraulic Laboratory Report No. Hyd-370.

The outlet works is contained in the main dam and will consist of an intake structure, a 48-inch pressure conduit, a gate chamber, a downstream conduit containing a 36-inch steel pipe, and a control structure (Figures 2 and 3). The control structure will include a bifurcation, two 27- by 27-inch high-pressure slide gates, and a stilling basin. The difference in head from the maximum reservoir elevation, 3476.15, to the center line of the 36-inch conduit at the basin, 3307.25, is 168.90 feet. The elevation of the high point of the 48-inch conduit downstream from the basin is 3341.05 which submerges the basin a minimum of 33.80 feet.

The Camino Conduit will consist of approximately 6 miles of concrete pipe and a number of appurtenant structures, including a Venturi meter for measuring the rate of flow and a wasteway for limiting the conduit head and discharging any excess waters released through the outlet gates (Figure 4). The wasteway is about 147 feet downstream from the stilling basin and is on the side of the hill above the basin structure. The wasteway overflow crest is set at the hydraulic grade line for the normal flow of 125 cfs (Figure 5). If the outlet gates are inadvertently opened completely under maximum reservoir head, a flow of 240 cfs will occur and about 115 cubic feet per second will be wasted at the structure.

The preliminary design of the outlet works stilling basin included triangular-shaped baffles similar to those developed for the stilling basin of the pump-turbine bypass valve at Flatiron Power and Pumping Plant, Colorado-Big Thompson Project (Report No. Hyd-328). Hydraulic model studies were made to determine the appropriateness of the baffles for the Sly Park structure and to determine the characteristics of the over-all design. A discussion of these model studies and the results obtained are presented in this report.

INVESTIGATION

The Model

A 1:6.75 scale model was constructed, and a transparent top and right side placed on the stilling basin to permit observation of the flow within the basin. The observations were facilitated by injecting air or a dye into the flow as it entered the basin. The length and depth of the box incorporating the basin were made greater than required by the preliminary design so that a larger basin could be accommodated if it were found necessary. A false floor and downstream wall formed the preliminary basin dimensions. An elliptically shaped bellmouth was provided for the entrance to the 48-inch (7.11-inch model) Sly Park-Camino Conduit. Two 4- by 4-inch regulating gates immediately upstream of the basin represented the 27- by 27-inch regulating slide gates of the prototype structure. The model scale was based on the available 4- by 4-inch gate used for the model studies of the Trenton Dam outlet works (Report No. Hyd-300). A second gate was fabricated (Figure 7). Gate and conduit piezometers were installed as shown on Figures 6 and 7. The assembled model without the triangular baffles and dividing wall is shown in Figure 8.

In the preliminary design the included angle between the bifurcation branches was 40° (Figure 6), and all model tests were made with this bifurcation. Later the angle for the prototype bifurcation was increased to 60° but the model was not changed because the influence of this difference was considered negligible (Figure 3).

Initial tests were conducted with the model inlet connected to a turbine-type pump (Figure 6). The inlet was later connected to a constant-head tank for reasons discussed on subsequent pages of this report.

Tests with Model Inlet Connected to Pump

Surge in Flow

The first model tests were made with the triangular baffles removed from the stilling basin (Figure 8). Good performance seemed to occur, but measurements with a total head tube in the outlet conduit (Figure 6) showed a pressure surge of about 5 feet, prototype. The surge was approximately the same with either symmetrical or unsymmetrical gate openings and was undesirable because of the possible interference with pressure measurements at the Venturi meter and because it might cause unnecessary spilling at the wasteway.

The triangular baffles were installed in the basin and the test repeated. Pressure surges occurred with about the same average magnitude as without the baffles.

The source of the surges was obscure, but it appeared that it might be the turbine pump which was directly connected to the model by

30 feet of lightweight steel pipe (Figure 6). The system was therefore modified so that the pump supplied water to an elevated constant-head tank which in turn supplied water to the model basin (Figure 6).

Tests with Model Inlet Connected to Constant Head Tank

Surge in Flow

Pressure surges of approximately 4.6 feet of water occurred in the 48-inch conduit when about 175 cfs was represented, even though the model was arranged with the inlet connected to the constant-head tank. The basin and gate assembly were subsequently removed from the pipe line and a section of straight pipe was installed in its place. The surge was about 1.5 feet at discharges up to 120 cfs but became about 5 feet at discharges above 200 cfs. The basin and gate assembly were reinstalled and measurements were made of the surge frequency by means of pressure cells and oscillograph records. No regularly occurring pressure pulse was detected, but over a period of time a number of irregularly spaced surges occurred and the average frequencies of these were determined. With the baffles installed in the basin the frequency was about 1 cycle every 2-1/2 seconds (prototype). With the baffles removed, the frequency was about 1 cycle every 2 seconds. The baffles apparently did not exert much influence on either the surge frequency or amplitude.

The above tests were conducted with an outlet conduit which had no vents or standpipes between the stilling basin and the downstream control valve. In the prototype conduit a standpipe exists in the form of the wasteway conduit and box (Figure 5). The water column within the standpipe will be free to rise and fall as the surges occur in the conduit, and in so doing will moderate the surges. Relatively small rises in the standpipe column will be adequate to provide the storage needed during a pressure rise, and conversely, only a small decline in the standpipe column will be sufficient to smooth out the rarefactions following the pressure peaks. To determine the moderating effect of a standpipe in the model, a 5-inch inside-diameter pipe was placed on the outlet conduit 6 feet downstream from the basin (Figure 8). The surges decreased considerably in magnitude and the water level fluctuation in the model standpipe was only about 1-1/2 inches (10 inches prototype). The actual field fluctuation should be even less because the standpipe area at the overflow weir is about 3-1/2 times that of the conduit, whereas in the model it was only about one-half that of the conduit (Figure 5). The frequency of surging decreased to about once every 9 seconds, prototype. It was believed that neither the magnitude nor the frequency of this minor surging would be troublesome in the field structure, and no further model studies were made on it.

Head Losses

The loss in head through the gate assembly and stilling basin, measured from a point 1.13 feet prototype above the bifurcation in the 36-inch conduit to a point 4-1/2 feet downstream from the bellmouth in the 48-inch outlet conduit was determined for a range of flows embracing the normal of 125 cfs (Figure 9A). Tests were made with and without the baffles installed. Lower losses occurred with the baffles removed.

The loss from the stilling basin through the bellmouth to the point 4-1/2 feet downstream was also determined (Figure 9B). Slightly smaller losses occurred with the baffles removed.

On the basis of the above head loss data where smaller losses occurred when the baffles were omitted from the basin, and because the baffles had little, if any, moderating effect on the pressure surges in the outlet conduit, it was decided that the baffles need not be included in the prototype structure.

Pressures in the Sly Park Slide Gate

The pressures on the sloped and horizontal bottom surfaces of the Sly Park gate leaf, and on the right side wall of the downstream frame near the gate floor, and on the roof of the conduit downstream from the gate were measured at gate openings of 10 to 100 percent (Figures 7 and 10). In these tests the flow was confined to the left branch of the bifurcation in order that the rate of flow through the gate be known. The lowest leaf pressure was found on the horizontal bottom surface near the downstream edge (Piezometer 4). The lowest wall or conduit pressure occurred just downstream from the gate slot 1.7 inches (prototype) above the floor (Piezometer 6).

The pressure data for these two piezometers are presented in the nondimensional form of pressure coefficients (Figure 10). This presentation was adopted in lieu of presenting the actual pressure values because the values could not be accurately determined at the time of the tests due to uncertainties concerning the conduit back pressure, these back pressures directly affecting the local pressures in the structure. The pressure coefficient is defined as the difference between a reference pressure and the pressure at a given piezometer divided by the velocity head at the reference station. The reference station was taken in the 32-inch conduit at the end of the bifurcation branch, and the reference pressure was the average of the piezometric readings at the inside and outside of the bend. The pressure data may be used to determine the minimum pressures which will occur on the leaf or on the frame of this gate in this or other installations with submerged flow and known upstream and downstream pressures. In the case of the Sly Park outlet works, there appears to be no danger of cavitation occurring on either the leaf or the frame of the gates, or in the conduit downstream.

No calibration curves, relating the discharge with the reservoir head and the gate openings, were prepared for the outlet works because all flow measurements will be made with the Venturi meter at Station 3+80 in the Camino Conduit (Figure 4).

Interior - Reclamation - Denver, Colo.

FIGURE 1
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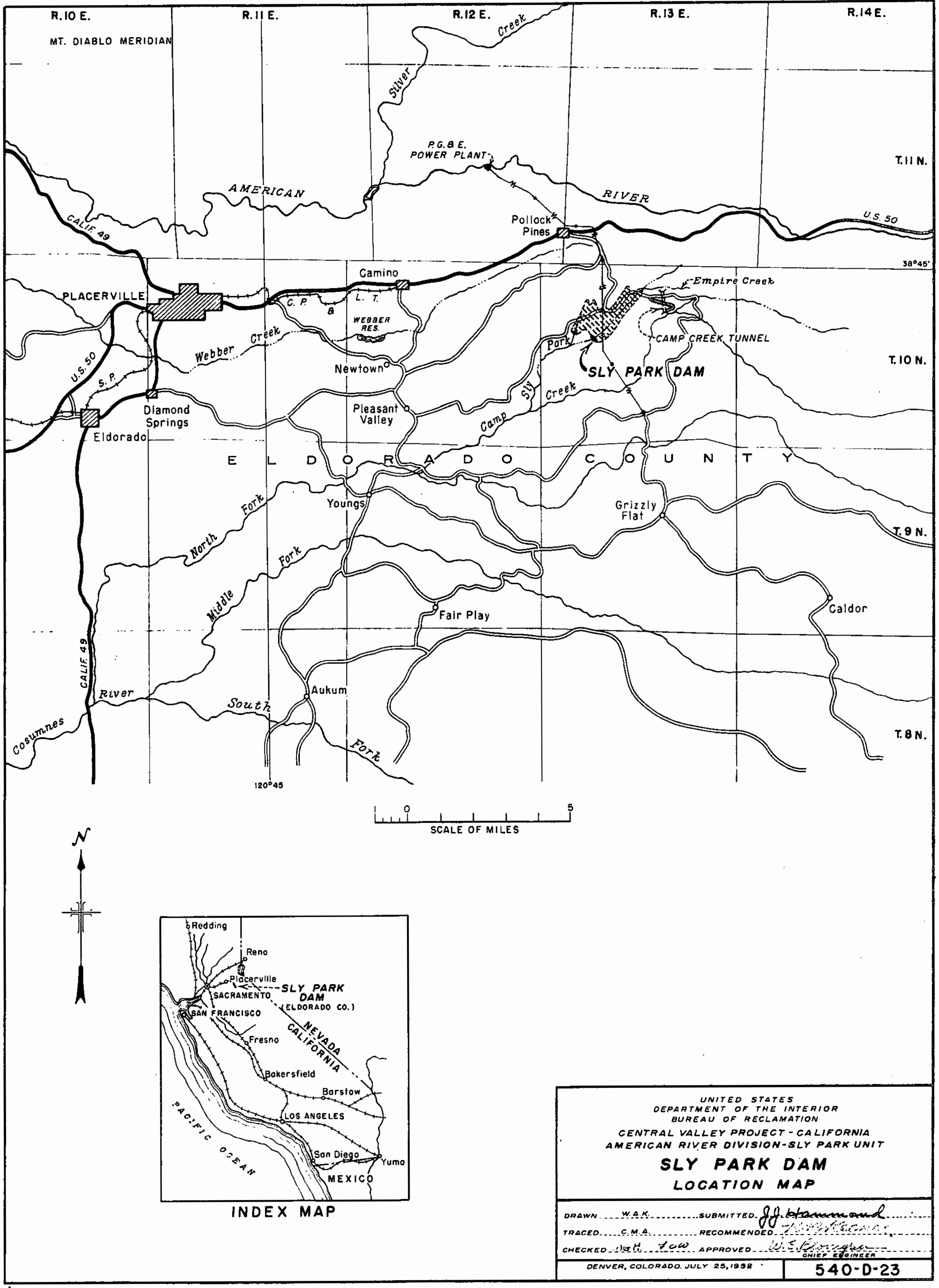
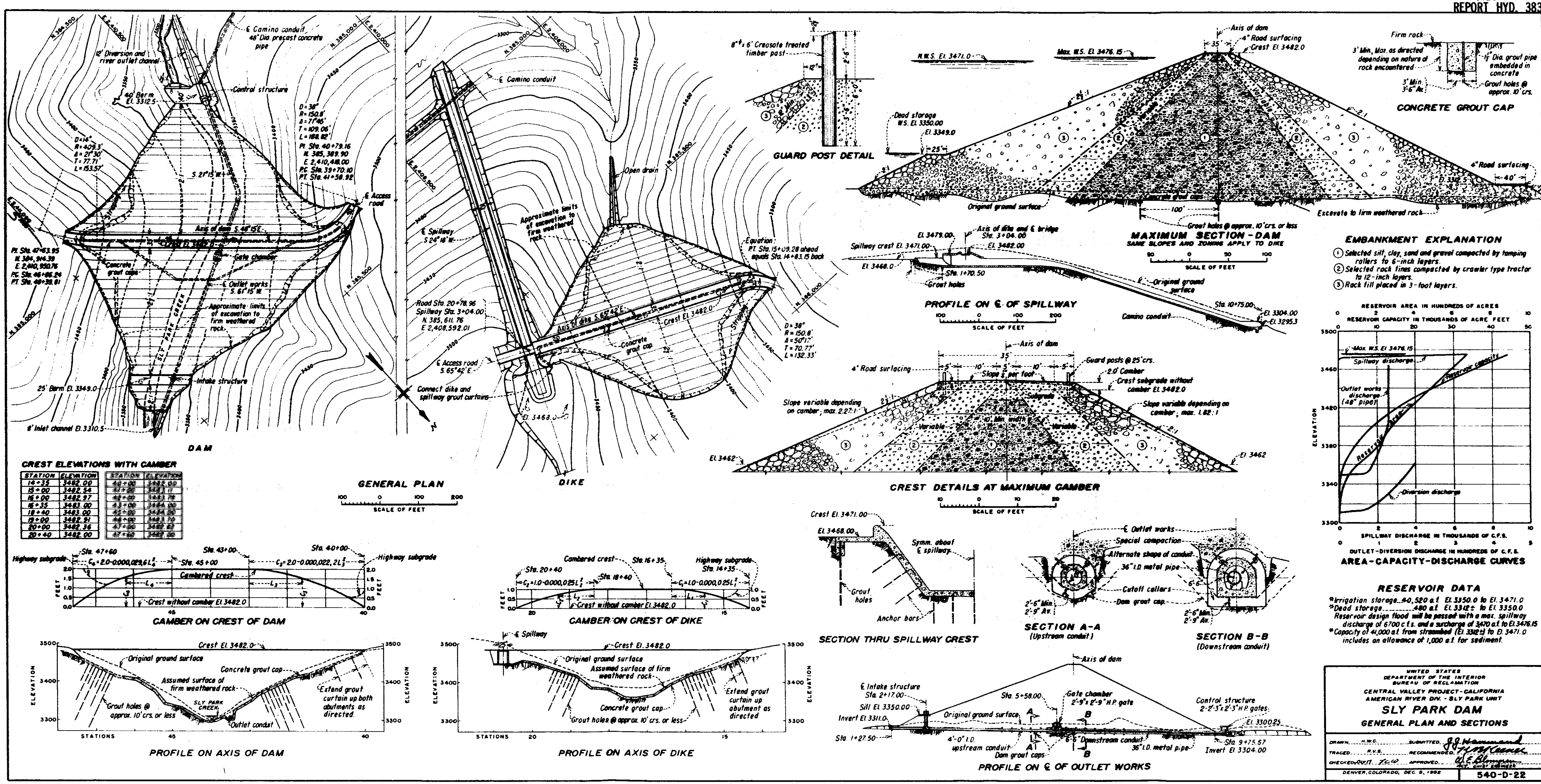
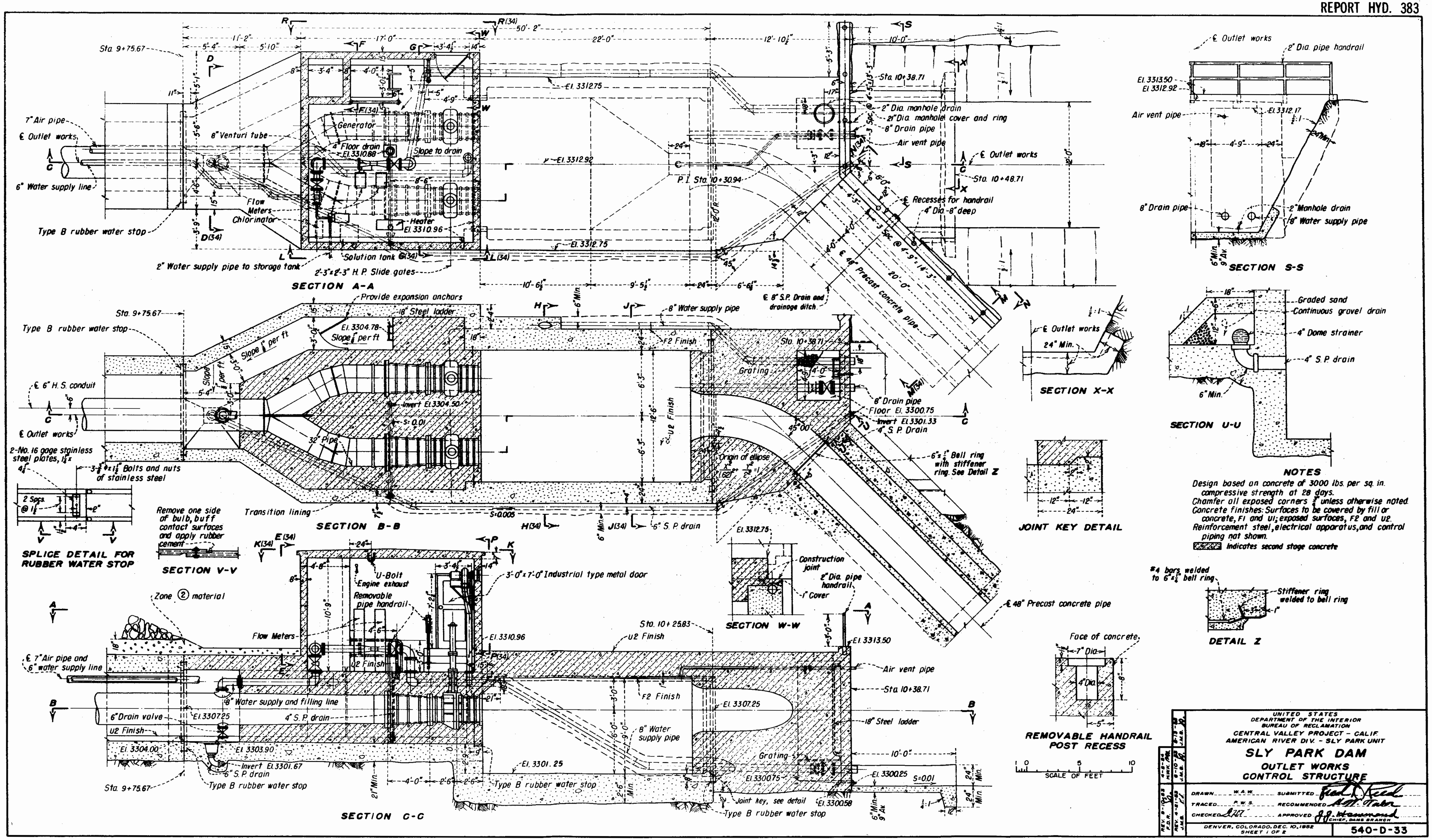




CREST ELEVATIONS WITH CAMBER

STATION	ELEVATION	STATION	ELEVATION
14+35	3482.00	[illegible]	[illegible]
15+00	3482.54	[illegible]	[illegible]
16+00	3482.97	[illegible]	[illegible]
16+35	3483.00	[illegible]	[illegible]
18+40	3483.00	[illegible]	[illegible]
19+00	3482.91	[illegible]	[illegible]
20+00	3482.36	[illegible]	[illegible]
20+40	3482.00	[illegible]	[illegible]


SECTION A-A
SECTION B-B
SECTION C-C
SECTION S-S
SECTION X-X
SECTION U-U
SECTION V-V
SECTION W-W
SPLICE DETAIL FOR RUBBER WATER STOP
JOINT KEY DETAIL
DETAIL Z
REMOVABLE HANDRAIL POST RECESS
SCALE OF FEET
NOTES
Design based on concrete of 3000 lbs. per sq. in. compressive strength at 28 days.
Chamfer all exposed corners ¾" unless otherwise noted.
Concrete finishes: Surfaces to be covered by fill or concrete, F1 and U1; exposed surfaces, F2 and U2.
Reinforcement steel, electrical apparatus, and control piping not shown.
Indicates second stage concrete
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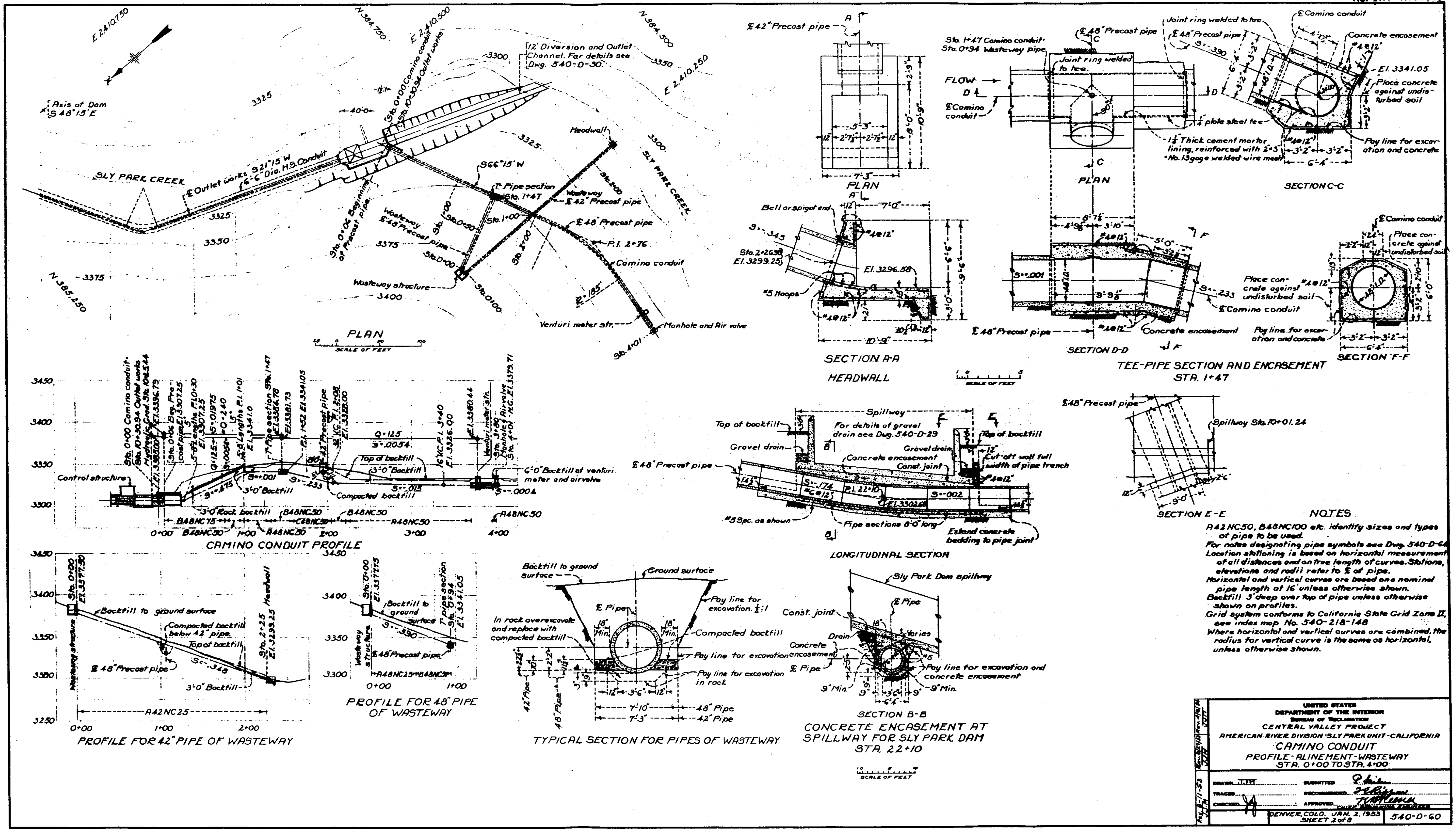
CENTRAL VALLEY PROJECT - CALIF.
AMERICAN RIVER DIV. - SLY PARK UNIT
SLY PARK DAM
OUTLET WORKS
CONTROL STRUCTURE
DENVER, COLORADO, DEC. 10, 1952
SHEET 1 OF 2
540-D-33
Generator
8" Venturi tube
Flow Meters
Chlorinator
Heater
Solution tank
2'-3"x2'-3" H.P. Slide gates
Type B rubber water stop
7" Air pipe
6" Water supply line
2" Water supply pipe to storage tank
48" Precast concrete pipe
Recesses for handrail 4" Dia.-8" deep
2" Dia. manhole drain
2" Dia. manhole cover and ring
8" Drain pipe
Air vent pipe
Provide expansion anchors
18" Steel ladder
6" H.S. conduit
2-No. 16 gage stainless steel plates
Transition lining
Remove one side of bulb, buff contact surfaces and apply rubber cement
Zone ② material
3'-0"x7'-0" Industrial type metal door
Engine exhaust
Removable pipe handrail
8" Water supply and filling line
6" Drain valve
4" S.P. drain
Graded sand
Continuous gravel drain
4" Dome strainer
Construction joint
Stiffener ring welded to bell ring


PLAN
SLY PARK CREEK
Axis of Dam S 48°15' E
Outlet works S21°15' W
6'-6" Dia. H.S. Conduit
12' Diversion and Outlet Channel. For details see Dwg. 540-D-30.
Headwall
Wasteway 42" Precast pipe
48" Precast pipe
P.I. 2+76
Camino conduit
Wasteway structure
Venturi meter str.
Manhole and Air valve
CAMINO CONDUIT PROFILE
Control structure
6'-0" Backfill at venturi meter and airvalve
Compacted backfill
3'-0" Rock backfill
PROFILE FOR 42" PIPE OF WASTEWAY
Backfill to ground surface
Compacted backfill below 42" pipe
Top of backfill
48" Precast pipe
3'-0" Backfill
PROFILE FOR 48" PIPE OF WASTEWAY
TYPICAL SECTION FOR PIPES OF WASTEWAY
Backfill to ground surface
Ground surface
Pay line for excavation. ½:1
In rock overexcavate and replace with compacted backfill
Compacted backfill
Pay line for excavation
Pay line for excavation in rock
SECTION A-A
HEADWALL
PLAN
Bell or spigot end
#5 Hoops
TEE-PIPE SECTION AND ENCASEMENT
STA. 1+47
SECTION C-C
SECTION D-D
SECTION F-F
Joint ring welded to tee
Concrete encasement
Place concrete against undisturbed soil
Pay line for excavation and concrete
1½" Thick cement mortar lining, reinforced with 2"×3" No. 13 gage welded wire mesh
½" plate steel tee
Spillway
LONGITUDINAL SECTION
For details of gravel drain see Dwg. 540-D-29
Top of backfill
Gravel drain
Concrete encasement
Const. joint
Cut-off wall full width of pipe trench
Pipe sections 6'-0" long
Extend concrete bedding to pipe joint
SECTION E-E
Spillway Sta. 10+01.24
SECTION B-B
CONCRETE ENCASEMENT AT SPILLWAY FOR SLY PARK DAM
STA. 22+10
Sly Park Dam spillway
Pay line for excavation and concrete encasement
NOTES
A42NC50, B48NC100 etc. identify sizes and types of pipe to be used.
For notes designating pipe symbols see Dwg. 540-D-64.
Location stationing is based on horizontal measurement of all distances and on true length of curves. Stations, elevations and radii refer to ℄ of pipe.
Horizontal and vertical curves are based on a nominal pipe length of 16' unless otherwise shown.
Backfill 3' deep over top of pipe unless otherwise shown on profiles.
Grid system conforms to California State Grid Zone II, see index map No. 540-218-148.
Where horizontal and vertical curves are combined, the radius for vertical curve is the same as horizontal, unless otherwise shown.
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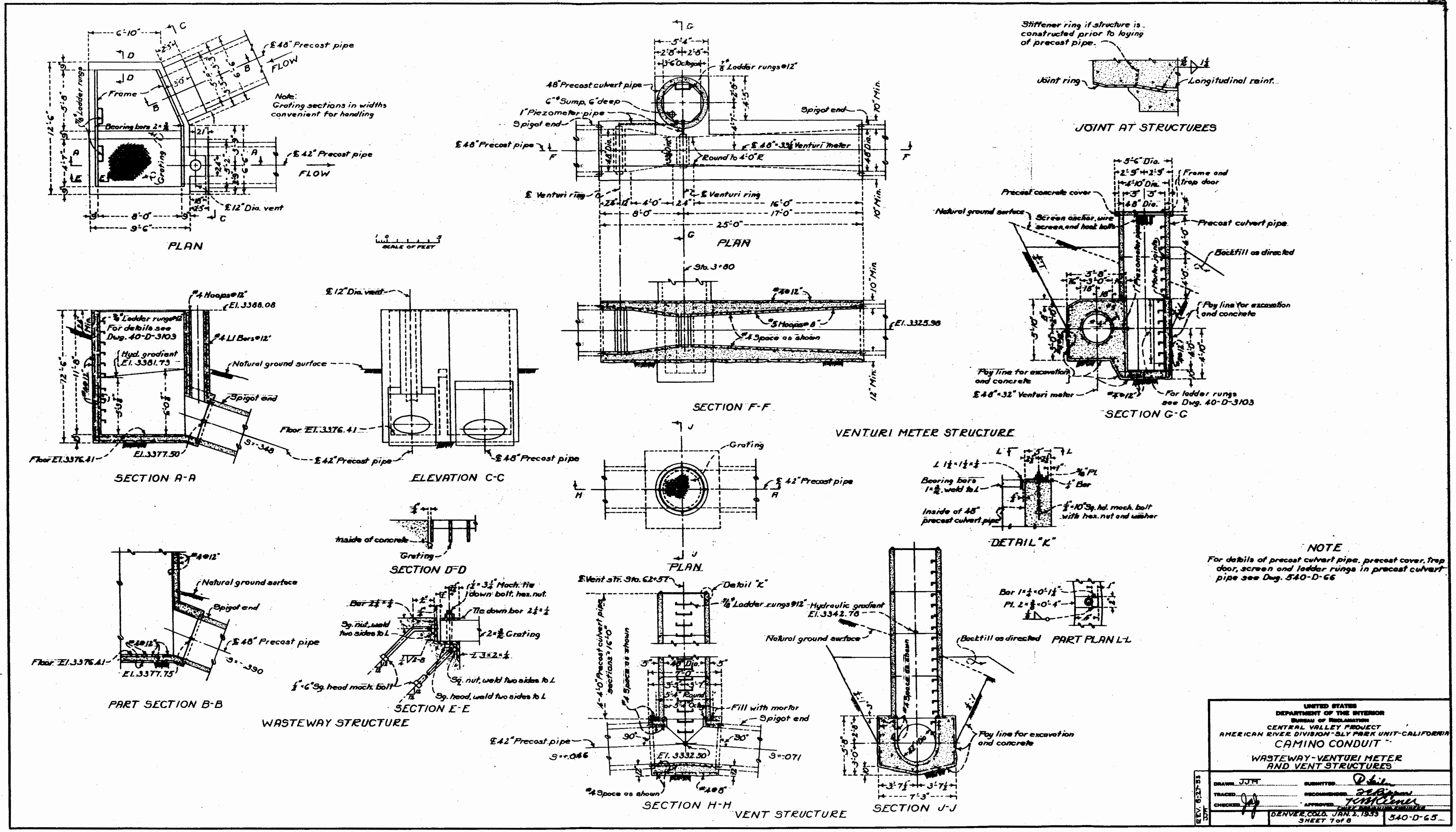
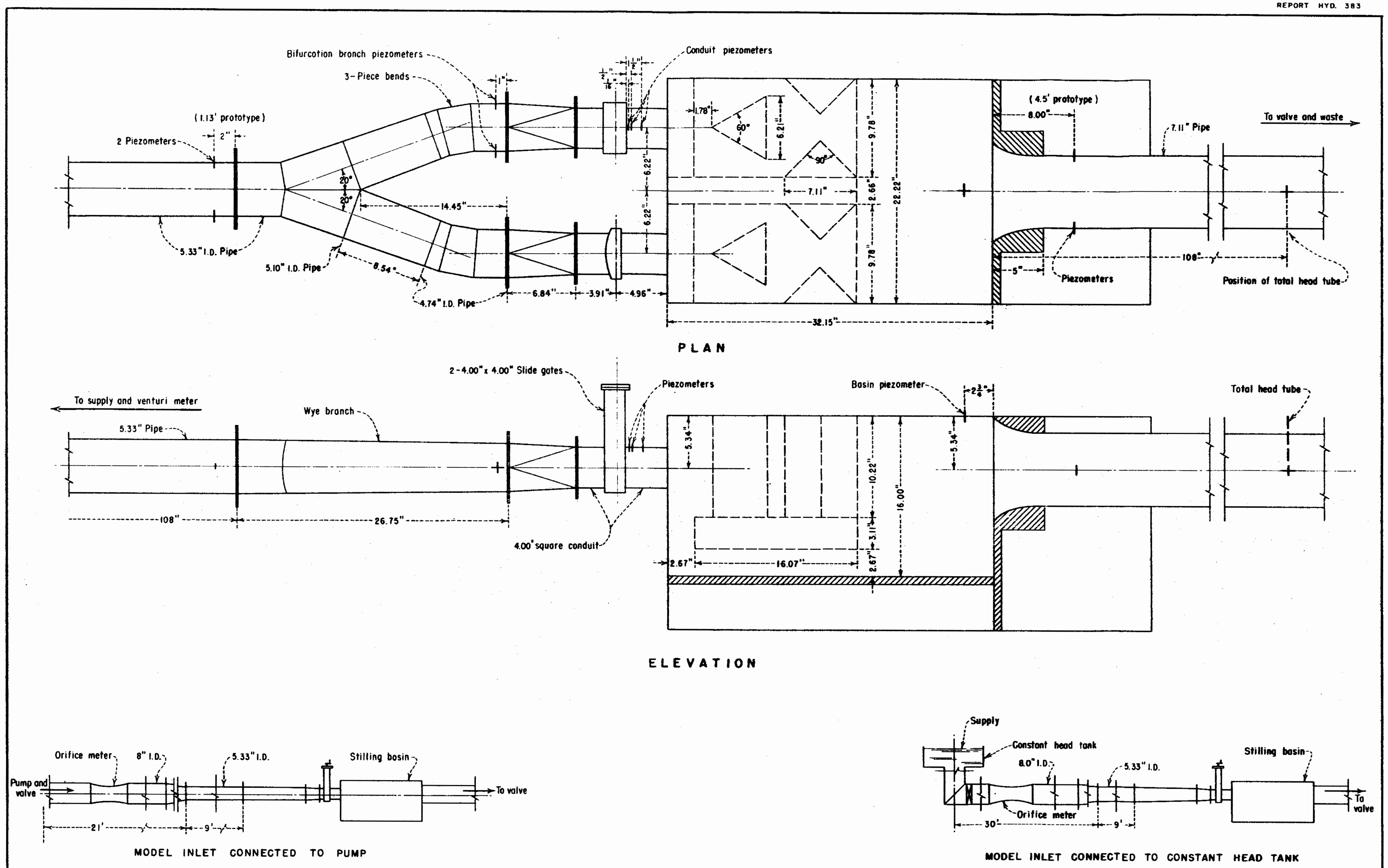
CENTRAL VALLEY PROJECT
AMERICAN RIVER DIVISION-SLY PARK UNIT-CALIFORNIA
CAMINO CONDUIT
PROFILE-ALINEMENT-WASTEWAY
STA. 0+00 TO STA. 4+00
DRAWN J.J.M.
DENVER, COLO. JAN. 2, 1953
SHEET 2 of 8
540-D-60

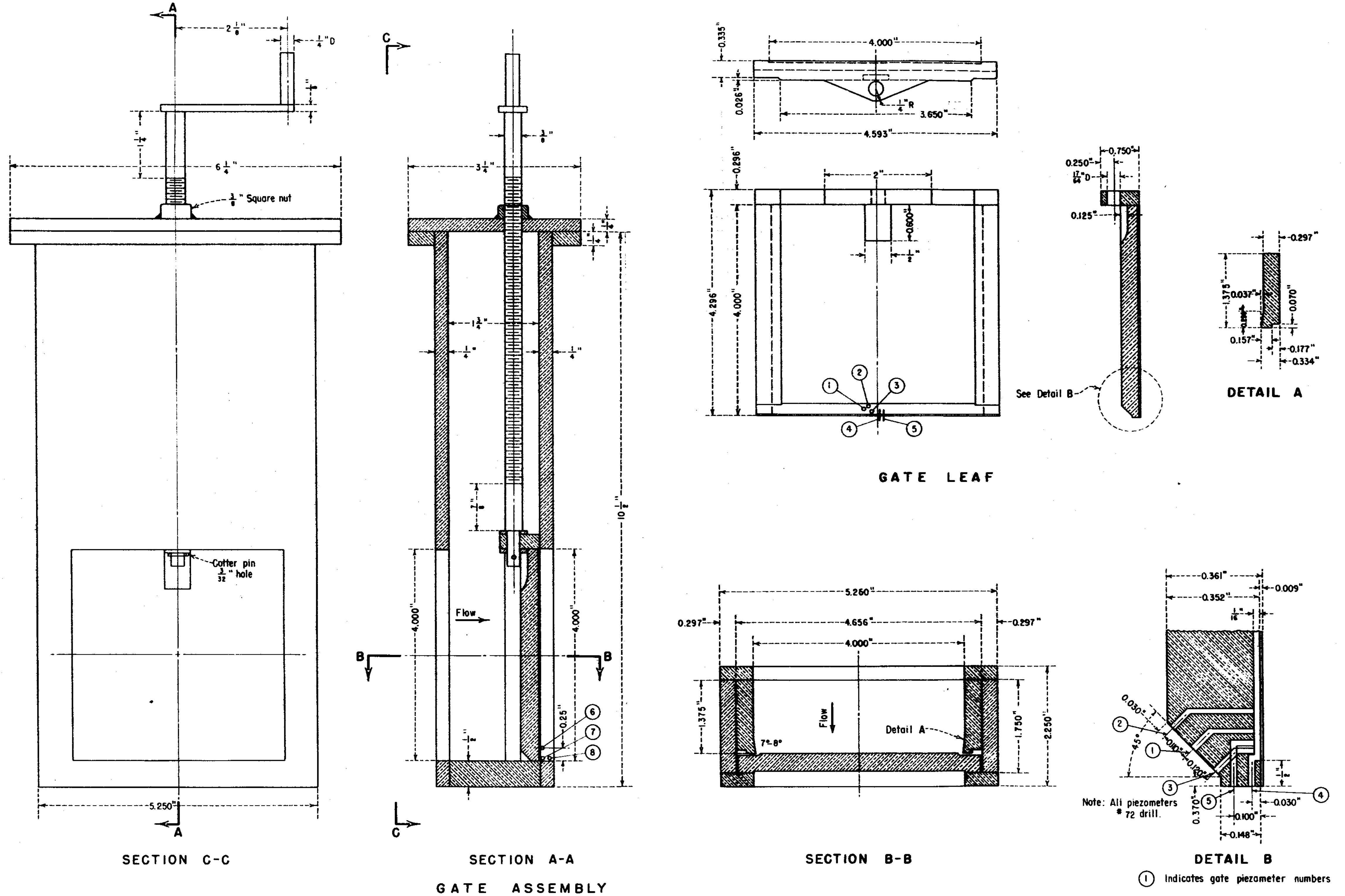
FIGURE 5
REPORT HYD. 383





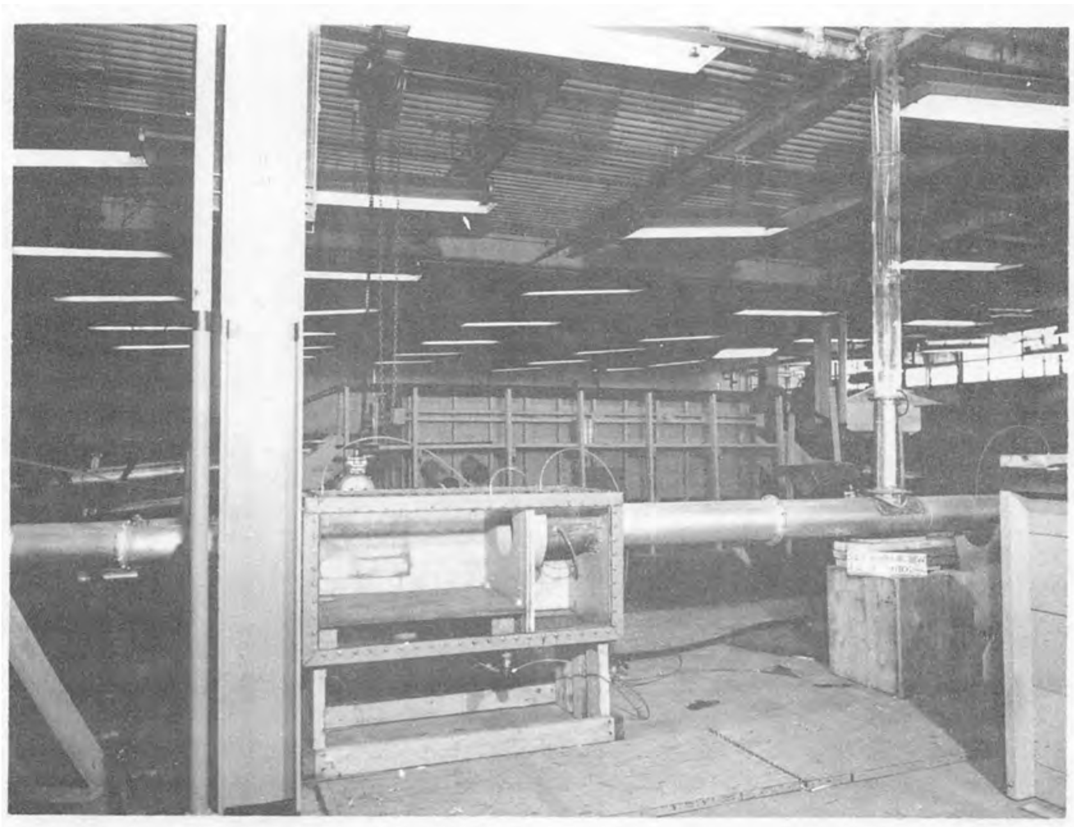
SLY PARK OUTLET WORKS

ARRANGEMENT OF 1:6.75 MODEL CONTROL STRUCTURE



SLY PARK OUTLET WORKS

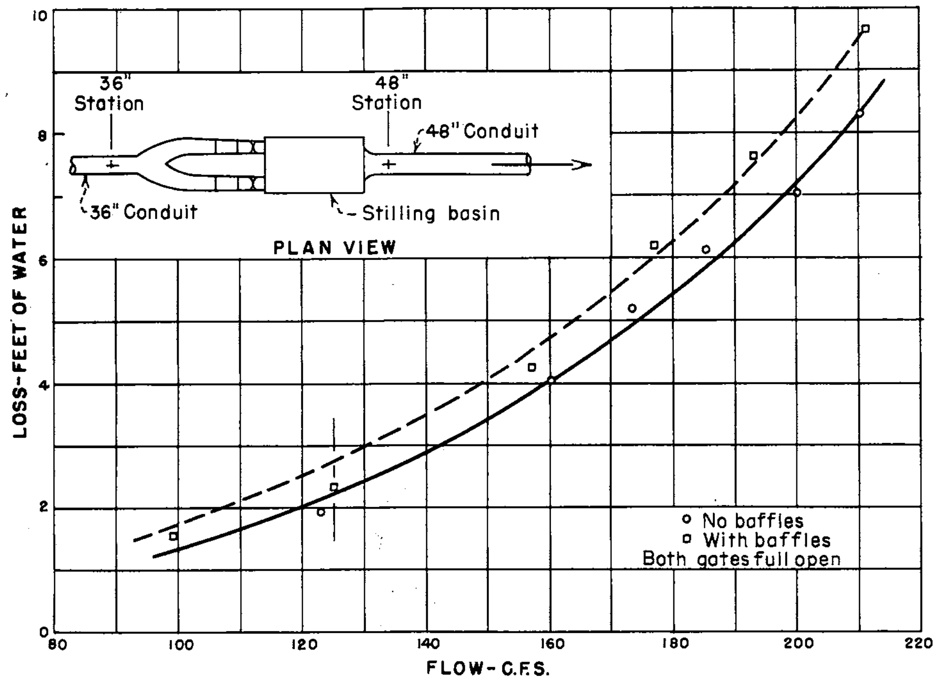
DETAILS OF 1:6.75 MODEL SLIDE GATE



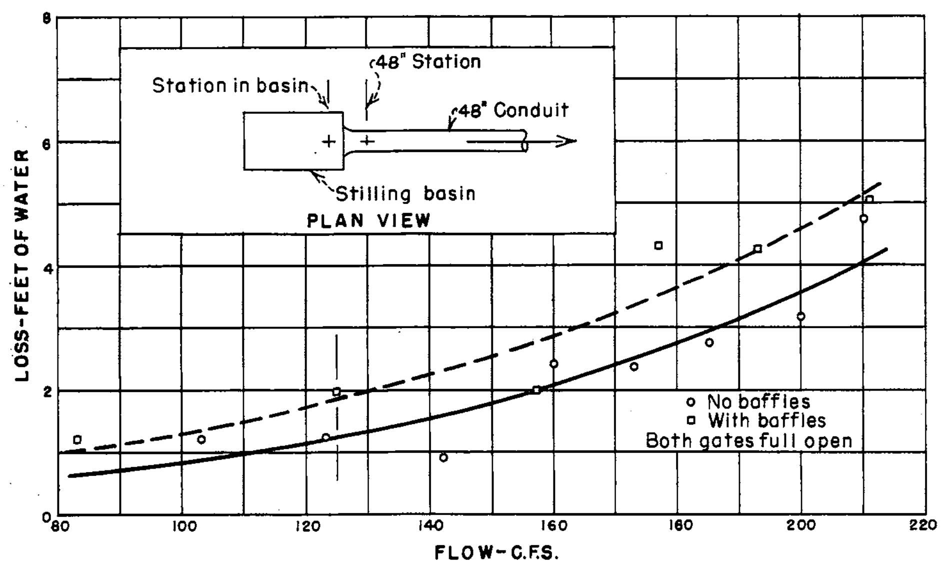
Model without baffles in stilling basin.

SLY PARK OUTLET WORKS

Assembled 1:6.75 Scale Model



A. LOSS THROUGH BIFURCATION, GATES, AND STILLING BASIN

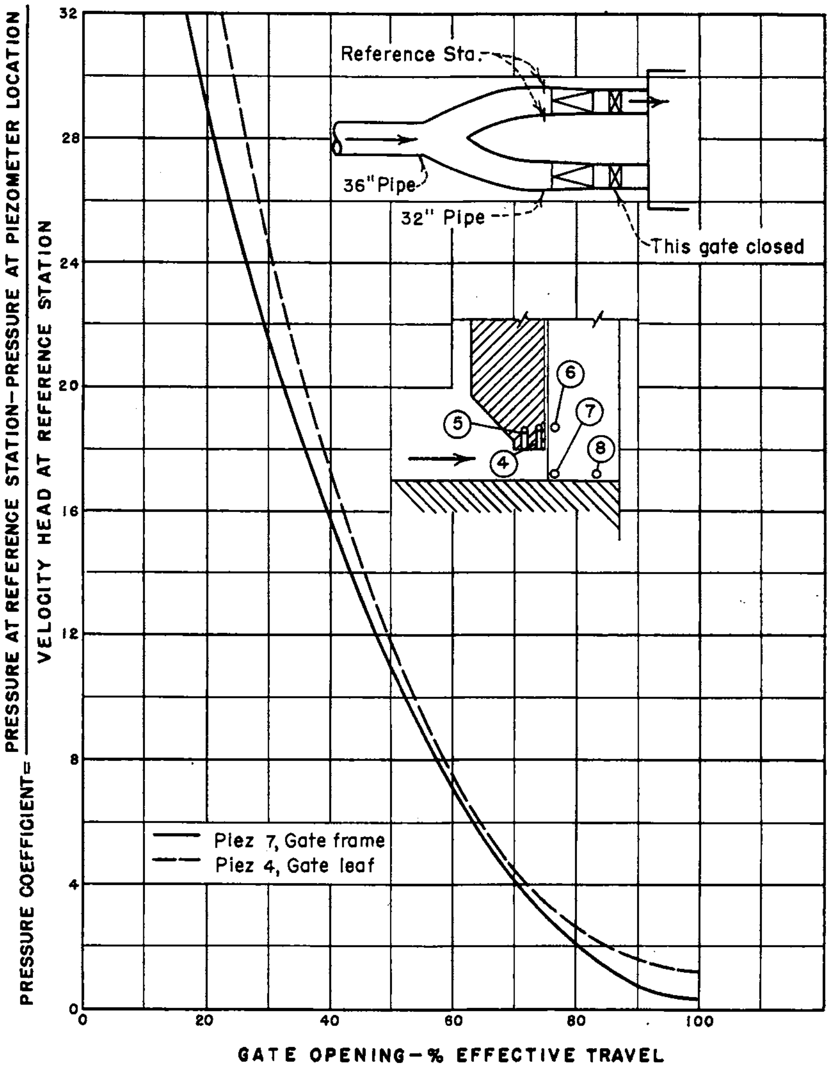


B. LOSS FROM STILLING BASIN TO 48" CONDUIT

SLY PARK OUTLET WORKS

LOSSES THROUGH OUTLET GATE AND STILLING BASIN STRUCTURES

DATA FROM 1:6.75 SCALE MODEL



Note : Pressure at piezometer 7 is less than at 6 and 8. Pressure at piezometer 4 is less than at 5
See Figure 7 for details of piezometer location

SLY PARK OUTLET WORKS

PRESSURE COEFFICIENTS FOR GATE LEAF AND FRAME

DATA FROM 1:6.75 SCALE MODEL