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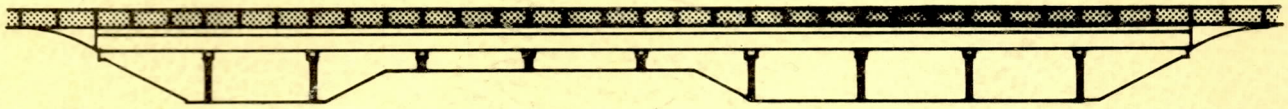
# 35TH AVENUE BRIDGE



OVER

## SALT RIVER

FOR

## CITY OF PHOENIX

BY

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AUGUST 1981

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# 35TH AVENUE BRIDGE
# OVER SALT RIVER

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August, 1981

INTERNATIONAL ENGINEERING COMPANY, INC.
2966 WEST CLARENDON AVENUE
PHOENIX, ARIZONA 85017

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# I. INTRODUCTION

The series of large magnitude floods which occurred in the Salt River in 1978, 1979, and 1980 revealed new information about behavior of the river. The lateral range of meanders and depth of scour considerably exceeded design criteria on many bridges crossing the Salt. As a result of the floods of 1978-1980, the City of Phoenix has developed new design criteria for river crossing structures. The goal of the new criteria is to provide replacement bridges which will not be subject to scour or overtopping failure and which will provide access consistent with optimization of bridge construction costs and economic dislocation costs due to flooding.

## A. PURPOSE OF THE PROJECT

The 35th Avenue Bridge Project is expected to ultimately provide access across the Salt River at 35th Avenue during passage of a 100-year flood. For the immediate future; however, the assurance of access during passage of a 10-year flood seems to be consistent with the degree of development along 35th Avenue near the Salt River. This report therefore defines bridge installation possibilities that provide for a structure which accommodates the 10-year flood flow and which can be subsequently expanded to accommodate the 100-year flood. The existing state of the river, as well as possible interaction between the proposed structures and the river, are analyzed and discussed.

## B. BACKGROUND

The reach of Salt River Channel which influences flow at the 35th Avenue Bridge site extends upstream from close to 43rd Avenue, nearly to 27th Avenue, as shown on Figure 1. Data supporting this study were obtained from the City of Phoenix, the Salt River Project, aerial mapping companies and field surveys.

During the flood of February 1980, the existing bridge at 35th Avenue was essentially totally destroyed. It was flanked at the south end and undercut by scour. The south half of the bridge was carried downstream; and the north half, while remaining in place, has lost support of the foundation piling due to scour. In considering possibilities for re-design of the bridge, the City of Phoenix has found that access can be most economically maintained at the present time by providing a bridge which will accommodate 47,000 cubic feet per second (cfs), a flow with a 10 percent probability of occurrence. In view of the liklihood of further development in the vicinity of 35th Avenue and the Salt River, expansion of the bridge to provide access 99 percent of the time may be required in the future. Therefore, one of the criteria for the smaller bridge is that it be adaptable to expansion, with a minimum of rework, to accommodate a flood of 200,000 cfs.

The 35th Avenue site is well adapted to a two-phased bridge construction. There is a divided channel, with the main channel on the right side of an island. A location of

minimum elevation of the existing temporary roadway coincides with the left side channel. The existing approach roadway on the south half of the river may thus be readily used as a section which can be deliberately failed for flows substantially in excess of 47,000 cfs. With a bridge in place, the right side channel could carry around 70,000 cfs before surcharge of the south roadway (at existing grade) would occur. With the current meander pattern of the river, major discharges flow at right angles to the 35th Avenue alignment. As long as the island remains in place in the river, no problems due to thalweg migration should be experienced with a short bridge.

In the event of passage of two or three more floods in excess of 100,000 cfs, it is likely that the island would be washed out. If the long bridge were not in place following such an incident, additional river control measures would be required on the south approach to the short bridge.

The presence of the island in the streambed effectively limits consideration of bridge lengths. The effect of the island in reduction of available cross-sectional area requires that the minimum length of bridge over the channel be around 1100 feet. Length reduction based on a modular size of the 1100 foot bridge gives a shortened bridge of around 300 foot length to accommodate the lower range of discharges. The following sections present the hydraulic and structural analyses developed for the 35th Avenue site.

# II. HYDRAULIC STUDIES

## A. SUMMARY

The hydraulic studies for the 35th Avenue Bridge consisted of analyses of flow profiles, velocities, and scour over a wide range of discharges. While the discharges providing the design conditions for two different bridge configurations were specified, it was necessary to investigate effects of various levels, up to the maximum specified, to identify which discharges pose the critical conditions for surface elevation, velocity, and scour potential.

Hydraulic modeling was done mathematically by use of the HEC-2 program. Results of the modeling gave water surface profiles and velocities for all of the discharges and bridge configurations studied. Modeling was done iteratively, computing scour for a given condition, and then using results of the scour analysis to describe the subsequent condition. Scour was computed by two of the most widely used methods for scour analysis in alluvial channels. Results of the analyses are given in subsequent sections.

## B. ANAYLSIS WITH THE HEC-2 MODEL

The water surface profiles and bridge losses were computed with the aid of the HEC-2 computer program, developed at the Hydrologic Engineering Center, U.S. Corps of Engineers, Davis, California by Bill S. Eichert. The computational procedure is similar to Method 1. Backwater Curves in River Channels, Engineering Manual 1110-2-1409, U. S. Army Corps of Engineers, December 7, 1959.

### 1. Available Data:

The hydraulic analysis was based on the following information sources:

1. Aerial photographs by Aerial Mapping Company - dated January 6, 1981. (Utilized for digitizing cross-sections)

2. Aerial photographs by Kenney Aerial Mapping, dated December 19, 1978. (Utilized for calibration of 105,000 cfs flow)

3. 1"=50; 1' contour interval contour maps, by Aerial Mapping Company, dated January 6, 1981.

4. Design discharges of 47,000 cfs and 200,000 cfs, per City of Phoenix.

5. Digitized cross-sections based on January 6, 1981 conditions, by Aerial Mapping Company.

2. Calibration:

The calibration procedure for the hydraulic model was based on obtaining close similitude between our current computed and photogrammetrically determined water surface elevations for the December 19, 1978 - 105,000 cfs flow event.

The photogrammetrically determined average water surface elevation at Section 8, (approximately 1,000 feet downstream of the 35th Avenue centerline) of 1026.6 ± 0.5' was subject to possible vertical elevation variations due to standing waves. The computed water surface elevation at the same location is 1026.13, with an average Mannings "n" value of 0.030, using our January 6, 1981 cross-sections, and 105,000 cfs flow.

Considering that the above mentioned standing wave caused possible mapping problems and that our mathematical model represents current (1/6/81) conditions modified by several flow events since the December 19, 1978 photo date, the similitude can be considered adequate for the purposes of this report.

In support of the selection of n=0.030 for an average channel roughness coefficient, the same value has provided satisfactory results at the 16th Street Bridge, 24th Street Bridge and 51st Avenue Bridge hydraulic studies, on the Salt River.

## C. FLOW ANALYSIS

Since the 35th Avenue Bridge crosses an alluvial channel, it is necessary to determine the initial and long-term effects of the bridge upon flow in the channel, as well as to determine possible responses of the channel to flow paths caused by the bridge. In the first case, a hydraulic analysis must be performed to compute the influence of the bridge on flows in the channel. The hydrologic inputs of a flow of 47,000 cfs at a probability of 0.10 and a flow of 200,000 cfs at a probability of 0.01 are taken as givens. Since two bridge configurations have been specified for analysis, it is necessary to examine both configurations under a wide spectrum of flow conditions in order to identify the most critical condition from a hydraulic standpoint. The hydraulic analyses are initially based upon an analogy to rigid-boundary flow using the HEC-2 program. Subsequent analyses then consider effects of sediment transport.

Sediment transport effects result generally in increases of channel cross-sectional area under the bridge. Over time, it can be expected that flow profiles will be lower than the initial profiles calculated for a condition of no bridge in place. Such lowering is due to scour which takes place under the bridge. The extent of scour must be evaluated for an appreciation of its effects upon the water surface level, but more importantly, for its effects upon the foundation of the bridge. The results of the hydraulic and scour analyses are given in the subsequent sections.

1. Bridge Hydraulics

Effects of flow through possible bridge openings were evaluated by a series of HEC-2 computer runs for the bridge reach. The actual cross-sections just above, at, and just below the bridge were modified to reflect the possible effects of scour where flow rises to a peak of 200,000 cfs. Based upon sediment transport capacity, initial estimates of cross-section geometry were altered until a stable sediment transport capacity through the reach was attained. The sections thus modified indicated that the water surface elevation with the bridge in place would be not more than one foot higher than the water surface elevation through the unaltered section.

The modified sections were determined by a trial-and-error analysis. Starting with the measured cross-sections at section numbers 12, 13, 14 and 15, cross-sectional areas were successively altered until a stable sediment transport capacity through the reach was indicated. The criteria used for channel alteration included local sediment transport capacity and field indications of channel configuration during flood passage. The final channel configuration used for the bridge analysis had an invert elevation of 1011 feet in the right channel and 1013 feet in the left channel. Channel side slopes used were 3:1, which is a conservative approximation based upon a submerged angle of repose for angular sand of 32° and the effect of secondary currents along the bankline in lowering the bank

$Q = 16.09$

slope. The invert elevations agreed well with field observations; actual bank slope appeared to have been locally steeper than the bank slopes used in the computations. Thus the computation results tend toward the conservative side for computaton of potential scour. The cross-sections thus derived were used on subsequent analyses of hydraulics for a 1125 foot bridge. The bridge in place has 9 piers, each 1 1/2 ft. wide, with 4 ft. of debris on either side, and spans 112.5 ft. long.

Another set of runs involve a shorter bridge to pass a flow of 47,000 cfs. The spans are again 112.5 ft. long, but there are only two 1 1/2 ft. piers, with the same amount of debris as before. The first trial with this configuration satisfied the requirement that the water surface elevation not be raised more than one foot above the water surface elevation through the section with no bridge in place for a flow of 200,000 cfs.

A second run changed this cross-section slightly, so as to decrease the steepness of the bridge approach. Again, the 1 ft. requirement was met, thus, this cross-section was adopted for use on the other runs involving a 337.5 ft. long bridge.

Once these two cross-section configurations were established, several series of trial runs were made. The first series used the shorter bridge configuration and gradually increasing flows. The flows used were 47,000, 55,000, 75,000, 105,000 and 200,000 cfs. None of these flows had a water surface elevation which

exceeded the 100 year profile at the bridge, i.e., that given for a flow of 200,000 cfs and no bridge in place. Table 1. following summarizes a few of the important results.

Table 1. Hydraulic Study Results - Short Bridge with 1.5 foot Piers

| Flow (cfs) | Velocity (Ft./Sec.) | | | Dist. to 100 Yr. Profile Limit | | |
|---|---|---|---|---|---|---|
| | Sec. 13 | Sec. 14 | Sec. 15 | Sec. 13 | Sec. 14 | Sec. 15 |
| 47,000 | 14.63 | 16.57 | 7.07 | 10.4 | 11.0 | 8.3 |
| 55,000 | 17.57 | 18.60 | 7.18 | 10.6 | 10.6 | 6.8 |
| 75,000 | 13.30 | 19.55 | 7.26 | 5.6 | 7.6 | 3.5 |
| 105,000 | 14.78 | 14.23 | 6.47 | 4.2 | 2.6 | -0.7 |
| 200,000 | 17.71 | 16.49 | 5.23 | 0.7 | 1.0 | -11.1 |

The second series increased the pier width from 1.5 feet to 6 feet. The same variation in flow amounts was made and the results are summarized below.

Table 2. Hydraulic Study Results - Short Bridge with 6 Foot Caissons

| Flow (cfs) | Velocity (Ft./Sec.) | | | Dist. to 100 Yr. Profile Limit | | |
|---|---|---|---|---|---|---|
| | Sec. 13 | Sec. 14 | Sec. 15 | Sec. 13 | Sec. 14 | Sec. 15 |
| 47,000 | 14.63 | 16.57 | 6.43 | 9.4 | 11.0 | 7.3 |
| 55,000 | 17.57 | 18.60 | 6.52 | 9.6 | 10.6 | 5.7 |
| 75,000 | 13.30 | 19.55 | 6.33 | 4.6 | 7.6 | 2.3 |
| 105,000 | 14.78 | 14.23 | 5.68 | 3.2 | 2.6 | -2.1 |
| 200,000 | 17.71 | 16.49 | 4.69 | -0.3 | 1.0 | -12.9 |

These results indicate that the shorter bridge is adequate to accommodate floods up to 75,000 cfs without adverse backwater conditions and that a bridge grade elevation, based on the 100-year flood profile would be safe from submergence.

The longer bridge configuration was used in the third series of runs. As in the first series, 1.5 ft. piers were assumed. A summary of the results follows.

Table 3. Hydraulic Study Results - Long Bridge with 1.5 Foot Piers

| Flow (cfs) | Velocity (Ft./Sec.) | | | Dist. to 100 Yr. Profile Limit | | |
|---|---|---|---|---|---|---|
| | Sec. 13 | Sec. 14 | Sec. 15 | Sec. 13 | Sec. 14 | Sec. 15 |
| 55,000 | 5.89 | 5.99 | 6.37 | 7.0 | 8.2 | 8.4 |
| 75,000 | 7.30 | 7.42 | 7.83 | 5.8 | 7.0 | 7.1 |
| 105,000 | 9.23 | 9.38 | 9.78 | 4.4 | 5.6 | 5.6 |
| 150,000 | 11.63 | 12.01 | 12.17 | 2.8 | 4.0 | 3.7 |

Six-foot piers were used on the fourth series of runs. Flows varied from 55,000 to 150,000 cfs and the long bridge configuration was assumed as in the third series. A summary of velocities and water surface elevations compared to the 100 year profile follows.

Table 4. Hydraulic Study Results - Long Bridge with 6 Foot Caissons

| Flow (cfs) | Velocity (Ft./Sec.) | | | Dist. to 100 Yr. Profile Limit | | |
|---|---|---|---|---|---|---|
| | Sec. 13 | Sec. 14 | Sec. 15 | Sec. 13 | Sec. 14 | Sec. 15 |
| 55,000 | 5.89 | 5.99 | 6.34 | 7.5 | 7.7 | 7.8 |
| 75,000 | 7.30 | 7.42 | 7.79 | 6.8 | 7.0 | 7.1 |
| 105,000 | 9.23 | 9.38 | 9.68 | 5.4 | 5.6 | 5.5 |
| 150,000 | 11.63 | 12.01 | 11.88 | 3.8 | 4.0 | 3.3 |

Three additional runs were made to evaluate the effect of deeper scour occurring at a flow rate of 75,000 cfs. The short bridge configuration with 1.5 ft. wide piers were used. The first run assumed the lowest channel elevation to be 1,005 ft., the second 1,000 ft., and the third 975 ft.

## 2. Scour Analysis

Scour at bridges is of two types. General scour is a general lowering of the streambed due to an increase in transport power which results from increased velocity through the contraction caused by the bridge. General scour can also occur due to mining of sands and gravels from the stream environment. Local scour results from an increase in sediment transport in eddies around flow obstructions. Local scour at bridges occurs both around abutments and around piers.

The extent of scour is primarily dependent upon velocity, depth of flow, and characteristics of the bed sediment. The hydraulic analyses of the proposed bridge site have indicated the following extreme conditions for the "ultimate" 1,125 foot bridge and the "temporary" 337.5 foot bridge.

Table 5. Extreme Hydraulic Conditions For Scour

| Bridge Length (ft) | Discharge (cfs) | Flow Depth (ft) | Initial Velocity (fps) | Initial Froude No. |
|---|---|---|---|---|
| 1,125 | 200,000 | 13.0 | 14.2 | 0.54 |
| 337.5 | 75,000 | 15.5 | 19.5 | 0.88 |

For the 1,125 foot bridge, channel contraction is relatively small, so general scour is correspondingly small. Local scour is relatively large. Local scour, due to both abutments and piers, is additive at the outside support structures because of bridge and scour hole geometries. At inside support structures, local scour around the structures has been increased by adding one-half dune amplitude (calculated as one-half the flow depth) to the calculated scour to give a minimum bed elevation.

Of several generally accepted methods for computation of scour, the methods of Lacey, Laursen, and Richardson et al are used. Some comparisons are made to work of D. B. Simons on a similar type of stream.

Long Bridge

General Scour

Lacey - with a silt factor f = 5.42 for $d_{50}$ bed material of 9.5 mm, general scour depth is 4.3 feet.

Laursen - Based on a long contraction of width ratio $B_1/B_2$ = 1300/1040 and Fr = 0.23, $d_s = 0.17_{yo} = 0.17 \times 31.2 = 5.3$ feet.

Local Scour

Abutments

Richardson, et al, give the equation for abutment scour as

$$y_s/y_1 = 1.1\ (\underline{a}/y_1)^{0.4}(Fr_1)^{0.33}$$

where a is approach embankment length and $y_1$ is depth of upstream flow. The calculated equilibrium scour should be increased by a factor of 1.3 to reflect maximum scour, and should be decreased by a factor which is a function of the possible angle of attack. For the north abutment, with an angle of attack of 15°, the abutment scour is computed as:

$$y_s = 1.3 \times 0.3 \times 1.1 \times \left(\frac{50}{28.7}\right)^{0.4} \times (0.324)^{0.33}(28.7) = \underline{10.6}$$

for the south abutment, with an angle of attack of 30 , the abutment scour is computed as:

$$y_s = 1.3 \times 0.5 \times 1.1 \times \left(\frac{150}{28.7}\right)^{0.4} \times (0.324)^{0.33} \times 28.7 = \underline{30.2}$$

Laursen's effective length (l) of abutment = $\frac{Q_o}{V_o y_o}$

is 892/(1.5 x 18.7) = 31.8, and $l/7y_o$ = 31.8/18.7 = 1.7

then, $d_s = 1.9\ y_o = (1.9) \times (18.7) = 35.5$

which applies to a vertical wall abutment. For a spill-through abutment, the factor is 0.8, so that calculated depth is 28.9 for the south abutment. A similar calculation for the north abutment, with $Q_o$ = 4166, $V_o$ = 2.5 and $Y_o$ = 23.7 gives a depth of <u>26.9</u>.

The conservative approach to abutment scour design would be to use the depths calculated for the south abutment in order to provide for possible changes in stream geometry.

Piers

Richardson, et al, compute scour around piers as:

$$Y_s/Y_1 = (\underline{a}/y_1)^{0.65} FR^{0.43}$$

where $\underline{a}$ is pier diameter. Scour is then computed based on multipliers of 1.3 for maximum depth and 2.0 for a 15 skew angle to the flow. For a 1.5 foot diameter pier grouping and no trash accumulation at the scour level, scour =

$$Y_s = 1.3 \times 2.0 \times 0.18 \times 28.7 = \underline{13.5} \text{ feet.}$$

For a 6 foot caisson,

$$Y_s = 1.3 \times 0.45 \times 28.7 = \underline{16.6} \text{ feet.}$$

Laursen computes pier scour as a function of $Y_o$ (approach depth) and b (diameter). For a 1.5 foot diameter pier grouping and an angle of attack of 15°,

$$Y_o/b = 19.1 \longrightarrow d_s = 4.83 \times 1.5 \times 0.9 \times 2.4 = \underline{15.6}$$

for a 6 foot caisson

$$Y_o/b = 4.8 \longrightarrow d_s = 2.4 \times 6 \times 0.9 = \underline{13.0}$$

Considering the total effects of application of the methods of Richardson et al (using Lacey's general scour approach) and Laursen gives the following results for the long bridge:

Table 6. Computed Scour For the Long Bridge

| | Richardson et al & Lacey (ft.) | Laursen (ft.) |
|---|---|---|
| General Scour | 4.3 | 5.3 |
| Local Scour | | |
| Abutments | | |
| North | 10.6 | 26.9 |
| South | 30.2 | 28.4 |
| Piers | | |
| 1.5-foot | 13.5 | 15.6 |
| Caisson | 16.6 | 13.0 |
| TOTALS | | |
| North Outside | | |
| 1.5' piers | 28.4 | 47.8 |
| Caisson | 31.5 | 45.2 |
| South Outside | | |
| 1.5' piers | 48.0 | 49.3 |
| Caisson | 51.5 | 46.7 |
| Middle | | |
| 1.5' piers | 28.5 | 31.6 |
| Caisson | 31.6 | 28.9 |

The scour of the outside pier groups could be substantially lowered by upstream installations of spurs and guide banks, which would straighten stream lines going through the bridge section. The decision to consider such an approach would be based upon costs of spur and guide bank construction compared to costs of constructing foundations to lower evaluations to provide scour protection.

The most severe design condition is imposed at the short bridge prior to failure of the approach. After approach failure, depth increases to 16.5 ft. as a result of degradation in both right and left channels; and velocity decreases to around 8 feet per second as a result of bed degradation and formation of an additional channel. The maximum potential for scour occurs

prior to the time that the approach is fully breached, when flow is predominantly concentrated in the right channel under the bridge. For purposes of this analysis, the initial condition of 75,000 cfs flowing in a channel with a bottom width of 195 feet with 1:3 side slopes at a depth of 16.5 ft. is assumed.

Short Bridge Located Right Side of Main Channel

General Scour - Short Bridge

Lacey - Use of a silt factor, f = 5.42 for median diameter bed material of 9.5 mm results in a general scour depth of <u>10.2 ft.</u>

Laursen - On the basis of a long contraction with $B_1/B_2{}^2 = 550/330$ and $Fr_1 = 0.24$, $d_s = 0.61\ y_o = (0.61)(21.4) =$ <u>13.0 ft.</u>

Simons calculated <u>12.0</u> ft. on Bijou Creek in Colorado - a similar stream and bridge situation.

Local Scour

Abutments

Using Richardson, et al, with <u>a</u> = approach embankment length of 21 feet on the north end and 170 feet on the south end results in the following:

For the north end,

$$y_s = 1.1\ (0.312)^{0.33}(21.38) = \underline{16.0}$$

For the south end, with an angle of attack of 37°,

$$y_s = 1.1\ (170/21.4)^{0.4}(0.312)^{0.33}(21.38)(1.3)(0.6) = \underline{28.6}$$

Using Laursen with

$$l = \frac{500}{2.6 \times 14} = 13.7 \text{ on the north end, } l/y_o = 13.7/14 = 0.98$$

and considering a spill-through abutment,

$$d_s = 0.8 \times 1.4 \times 21.4 = \underline{24.0}$$

For the south end with $l = \dfrac{25000}{21.4 \times 14} = 142$, $l/y_o = 142/21.4 = 6.6$

and, for a spill-through case,

$$d_s = 0.8 \times 3.8 \times 21.4 = \underline{65.0}$$

The last figure is extremely high. Since the effects of approach angle and velocity are not considered in Laursen's method, use of such a high figure is not recommended. An amply conservative approach would be use of the depth calculated from Richardson, et al for the south abutment.

Piers

Applying the equation of Richardson et al to a depth of 21.4 feet with velocity equal to 8.2 feet per second, and considering angle of attack and maximum scour, gives for 1.5-foot pier,

$$y_s = 2.0 \times 1.3 \times 0.21 \times 21.4 = \underline{12.0}$$

And similarly for a 6-foot caisson,

$$y_s = 1.3 \times 11.3 = \underline{14.8}$$

Laursen's method gives, for a 1.5-foot pier with round nose and 15° angle of attack,

$$y_o/b = 14.3 \longrightarrow d_s = 0.9 \times 2.4 \times 4.2 \times 1.5 = \underline{13.6}$$

and similarly for a 6-foot caisson,

$$y_o/b = 3.6 \longrightarrow d_s = 0.9 \times 2.1 \times 6 = \underline{11.3}$$

A comparison of both methods gives the following results for the short bridge on the right side of the main channel:

Table 7. Computed Scour For a Short Bridge on the Right Side of the Main Channel

| | Richardson et al & Lacey (ft.) | Laursen (ft.) |
|---|---|---|
| General Scour | 10.2 | 13.0 |
| Local Scour | | |
| Abutments | | |
| North | 16.0 | 24.0 |
| South | 28.6 | 65.0 |
| Piers | | |
| 1.5-foot | 12.0 | 13.6 |
| Caisson | 14.8 | 11.3 |
| TOTALS | | |
| North | | |
| 1.5' piers | 38.2 | 50.6 |
| Caisson | 41.0 | 48.3 |
| South | | |
| 1.5' piers | 50.8 | 91.6 |
| Caisson | 53.6 | 89.3 |

Short Bridge Located Left Side of Main Channel

During the discussion following submittal of the draft report the City engineering staff reguested an analysis of a short bridge located on the left side of the main flow channel. The three primary changes from the previous scour analysis for the short bridge are:

1. Flow angle around the north end abutment is 90° instead of 15°.

2. Flow angle around the south end abutment is 7° instead of 35°.

3. Median diameter ($d_{50}$) of bed material is 64 mm instead of 9.5 mm.

General Scour

Lacey - Use of a silt factor F = 14.08 for median diameter bed material of 64 mm results in a general scour depth of 2.0 ft.

Laursen's Method is not sensitive to grain size so that the same value calculated for the bridge located on the north side of the channel still applies; that value was 13.0 ft.

Local Scour

Abutments

Using Richardson, et al, with a = approach embankment length of 180 feet on the north end and 10 feet on the south end results in the following:

For the north end,

$$y_s = 1.1\ (180/21.4)^{0.4}(0.312)^{0.33}(21.38)(1.3) = \underline{49.1}$$

For the south end,

$$y_s = 1.1\ (0.312)^{0.33}(21.38) = \underline{16.0}$$

Using Laursen with

$$l = \frac{180/550(75,000)}{7.75 \times 18.75} = 170 \text{ on the north end,}$$

$$l/y_o = \frac{170}{18.75} = 9.00, \text{ and considering}$$

a spill-through abutment,

$$d_s = 0.8 \times 4.4 \times 21.4 = \underline{75.3}$$

For the south end, with

$$l = \frac{10/550(75000)}{862 \times 18.75} = 8.44,$$

$$l/y_o = \frac{8.44}{18.75} = 0.45; \text{ with}$$

a spill-through abutment,

$$d_s = 0.8 \times 0.9 \times 21.4 = \underline{15.4}$$

Piers

Calculations for scour around support structures are the same as for a bridge located on the right side of the channel.

A comparison of both methods gives the following results for the short bridge following results for the short bridge located to the left side of the main channel.

Table 8. Computed Scour For a Short Bridge on the Left Side of the Main Channel

| | Richardson et al & Lacey (ft.) | Laursen (ft.) |
|---|---|---|
| General Scour | 2.0 | 13.0 |
| Local Scour | | |
| Abutments | | |
| North | 49.1 | 75.3 |
| South | 16.0 | 15.4 |
| Piers | | |
| 1.5-foot | 12.0 | 13.6 |
| Caisson | 14.8 | 11.3 |
| TOTALS | | |
| North | | |
| 1.5' piers | 63.1 | 101.9 |
| Caisson | 65.9 | 99.6 |
| South | | |
| 1.5' piers | 30.0 | 42.0 |
| Caisson | 32.8 | 39.7 |

Table 9. Recommended Design Scour

Right Side Short Bridge Scour Depths (datum el. 1010)

| | |
|---|---|
| Abutments | 40 ft. |
| Piers | 50 ft. |
| Caisson | 54 ft. |

Left Side Short Bridge Scour Depths

| | |
|---|---|
| Abutments | 50 ft. |
| Piers | 63 ft. |
| Caisson | 66 ft. |

Long Bridge Scour Depths (datum el. 1010)

| | |
|---|---|
| Abutments | 35 ft. |
| Outside piers | 50 ft. |
| Inside piers | 30 ft. |
| Outside caissons | 51 ft. |
| Inside caissons | 32 ft. |

## III. PRELIMINARY BRIDGE DESIGN

The extensive hydraulics and scour analyses prepared for the 35th Avenue Bridge site are detailed elsewhere in this report. Based on the results of the hydraulics analysis, 1125 feet was chosen as the bridge's optimum future length. Spans of 112'-6" were chosen in order to reduce the scour depth that would occur with shorter spans and still be within the range of the materials commonly used for bridge systems.

This preliminary structural design is limited to a three-span section of the future bridge which is adequate to pass the ten-year design flow of 47,000 cfs. Abutments will be designed such that additional spans can be added in the future to complete the 1,125 feet of bridge needed to pass the 100-year design flow. The bridge initially will be composed of two lanes with shoulders and a sidewalk for a width of 39'-3"; this is one-half of the ultimate width of 78'-6". The hydraulics study indicates that three 112'-6" spans with 3 to 1 slopes at the abutments will be adequate for the design flow. Seven additional spans will be added in the future, but until that time, an embankment will be used in place of the remaining spans. The sizing parameters, as determined by present need and hydraulics, are:

1. A width of 39'-3"

2. A length of 337'-6" including allowances for the abutments.

## A. SUPERSTRUCTURE

The criteria used for the preliminary design were the 1977 AASHTO "STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES", including the subsequent interims up to 1980, plus the Arizona Department of Transportation (ADOT) specifications. The bridge loadings and the stresses for the different materials used in the preliminary design are shown in Appendix B, Fig. B-2.

Based on the sizing parameters, three alternates were considered for a three-span structure and one alternate for a two-span structure. These alternates are:

1. 3-span welded composite steel girder with a cast-in-place concrete deck. (Fig. B-3)

2. 3-span prestressed concrete girder with a cast-in-place concrete deck. (Fig. B-4)

3. 3-span cast-in-place concrete box girder. (Fig. B-5)

4. 2-span welded composite steel girder with a cast-in-place concrete deck. (Fig. B-6)

The steel girders are built-up sections using 50,000 psi steel and are designed by the Load Factor method. The cast-in-place concrete deck is designed by Working Stress Design for both the steel and prestressed girder alternates and will utilize 4,500 psi concrete.

An AASHTO Type VI beam designed by the Working Stress method would be used for the prestressed alternate. The Type VI girder is readily available in the Phoenix area and has been used successfully in other area bridges.

The cast-in-place concrete box girder was designed by the Load Factor method. The preliminary design uses a three-cell configuration with sloping sides. This alternate will use conventionally reinforced concrete in lieu of post-tensioned concrete. The post-tensioned option was studied and was found to be unsatisfactory if the remaining seven spans were to be built. The future spans would have to be stressed from the south end only. The large prestressing losses incurred by this method would offset the advantage of post-tensioning.

All of the alternates were designed as continuous structures with the exception of the prestressed alternate. The prestressed girders were designed as simple beams for their own dead loads while the slab has been made continuous for live load and superimposed dead load.

## B. SUBSTRUCTURE

The minimum opening used in this study constricts the design flow thus creating a high velocity which produces extensive scouring at the piers. The results of the scour analysis show approximately 52 feet of scour for a three-span bridge and approximately 45 feet for a two-span

## C. EVALUATIONS

All the alternates were evaluated based on their intrinsic characteristics and cost comparisons. The cost analyses were based on bid history for several ADOT projects with an inflation factor added. The unit price for the Type VI prestressed beams was supplied by the Prestressed Concrete Division of the Tanner Company.

### 1. Three-Span Welded Composite Steel Girder

The use of high strength steel and Load Factor Design combine to give this alternate the least depth. This will result in a lower approach fill, and therefore, a cost savings. Another advantage to this alternate is that falsework will not be required once the substructure is completed and the girders are in place.

### 2. Three-Span Prestressed Concrete Girder

Since they are simple beams, the prestressed girders do not require field connections like the steel alternates do. The girders are available locally and should not present problems with material availability and fabrication delay.

The prestressed alternate has the deepest section of all the alternates resulting in higher approach fills and increased embankment costs. The prestressed alternate also has the greatest dead loads which increases substructure costs.

3. Three-Span Cast-in-Place Concrete Box Girder

Having the next lowest depth, the concrete box girder is also the most aesthetically pleasing when viewed from the side. This structure will also be constructed of locally available materials.

This alternate requires extensive falsework to support the structure during construction which can be a disadvantage. There would be a small increase in substructure costs due to the large dead loads.

4. Two-Span Welded Composite Steel Girder

The two-span steel alternate has many of the advantages of the three-span steel alternate plus it has fewer piers. With fewer piers, local scour from the abutment does not overlap with that from the middle pier. The overlapping effect is cumulative and results in the deeper scour for the three-span alternates.

The longer spans require girders approximately 14 inches deeper than those of the three-span steel bridge thus increasing the approach fill heights and leading to increased steel costs. Using the present bridge sizing parameters, there would be an odd span if the future extension of the bridge is to be made up of a series of two-span sections.

# IV. CONCLUSIONS AND RECOMMENDATIONS

## A. HYDRAULICS

It appears that a bridge length of around 1100 feet will ultimately be necessary to span the channel - this primarily due to the presence of an island in the channel. Shorter lengths are possible, but would result in higher costs due to purchase and removal of the island. For the immediate future, three spans of an ultimate ten-span bridge will be adequate to pass a flow of 47,000 cfs. In order to provide room for a full-depth riprap abutment of 3:1 side slopes, the span length on the short bridge will need to be 112.5 feet. The ultimate bridge would then be 1125 feet long and would still fit in well with stream morphology.

Regarding abutment geometry, both a sloping riprap abutment and a vertical concrete wall have been considered. In this case, a sloping riprap abutment is favored for two reasons. First, scour depths at vertical wall abutments are generally up to two times the depths at sloping abutments. Secondly, the use of riprap around an abutment designed as a future midstream support at the south end of the short bridge will facilitate bridge extension with a minimum of demolition work. It is advisable to limit abutment slopes to no steeper than 3:1 so that riprap grain size required for the toe of the abutment remains manageable.

The recommended configuration is then a total length of 1125 feet, with ten spans of 112.5 feet supported on nine piers and two pile supported stub abutments protected to the full depth of flow by riprap placed on a 3:1 slope.

During review of the draft concept design report, a question arose about possible advantages that may be associated with moving the short bridge to the left side of the main channel. As indicated in the section on scour computation, extending the north abutment into the channel generally aggravates the scour problem because it makes an abrupt encroachment upon the thalweg of the main channel. It therefore appears that moving the short bridge further to the south offers no real advantage and is accompanied by at least two major disadvantages -- those being increased scour and higher costs of future modifications. The remaining recommendations relating to the short bridge are therefore based upon a right side location.

## B. SCOUR

If no hydraulic training structures upstream of the bridge are provided, the recommended scour depths shown on page 16 should be used. The recommended depths take no account of effects due to gravel mining along the stream. In order to account for gravel mining effects, the potential volume of sediment which would be transported into a gravel pit must be considered, along with the potential reach of river which would supply the sediment. An estimate of general scour resulting from gravel mining could be obtained by dividing available pit volume (pit volume below the existing bed elevation) by the product of length of the supply reach and average width of the supply reach.

Abutment scour depths can be reduced by providing spur and guide bank structures upstream of the bridge. Economic feasibility for use of such structures depends upon costs of riprap construction. Final design scour depths are then dependent upon ultimate gravel mining effects and the feasibility of flow training structures upstream of the bridge.

For construction of the short bridge, it would be possible to use the existing roadway up to the tangent point of the vertical curve for the south approach ramp. The recommended approach failure mechanism is to trigger failure on the low side of the south approach by digging a pilot channel with a bulldozer or backhoe upon notification that a flood exceeding 55,000 cfs is expected in the river. Other approach failure mechanisms were considered to be either unreliable or ineffective in comparison to failure inducement.

## C. BRIDGE

The 35th Avenue project requires a structural system that will meet not only the requirements of the present construction phase but also allow for the future optimum bridge. Four bridge alternates were considered, and, based on the analysis and study of each, it appears that the prestressed concrete girder alternate would be the preferred structural system. The prestressed concrete Type VI girder with a poured-in-place concrete deck is recommended for the final design. This alternate would be combined with the caisson substructure as the most practical option for the bridge.

The cast-in-place concrete box girder is comparable in cost but requires extensive falsework and formwork. This would lead to a longer construction phase. Neither the two-span nor three-span steel alternates compare favorably in cost and are not recommended for further consideration.

Summary cost estimates are shown on Tables 10 through 12 which follow. More detailed estimates are included in Appendix C.

## REFERENCES

Lacey, G. "Flow in Alluvial Channels with Sandy Mobile Beds", from Proceedings, Institution of Civil Engineers, Vol. 9; discussion, Vol. 11, 1958.

Laursen, Emmett M., Predicting Scour at Bridge Piers and Abutments, General Report No. 3, for Arizona Department of Transportation, Engineering Experimental Station, University of Arizona, Tucson, February, 1980.

Richardson, E. V., et al, Highways in the River Environment - Hydraulic and Environmental Design Considerations, for U. S. Dept. of Transportation, Engineering Research Center, Colorado State University, May 1975.

## LIST OF FIGURES

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11. Site Contours - South short bridge
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14. Short Bridge Geometrics

FIGURE 1

**STUDY LIMITS AND CROSS SECTION LOCATIONS**

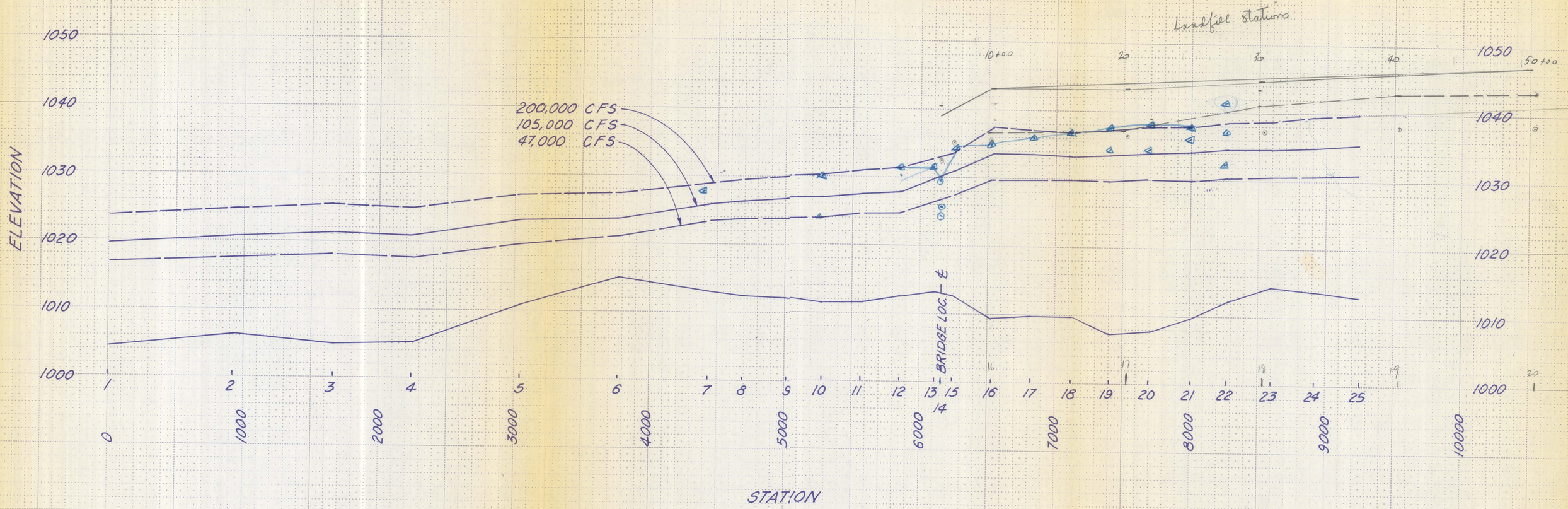



FIGURE 2
**FLOOD PROFILES FOR EXISTING CONDITIONS**

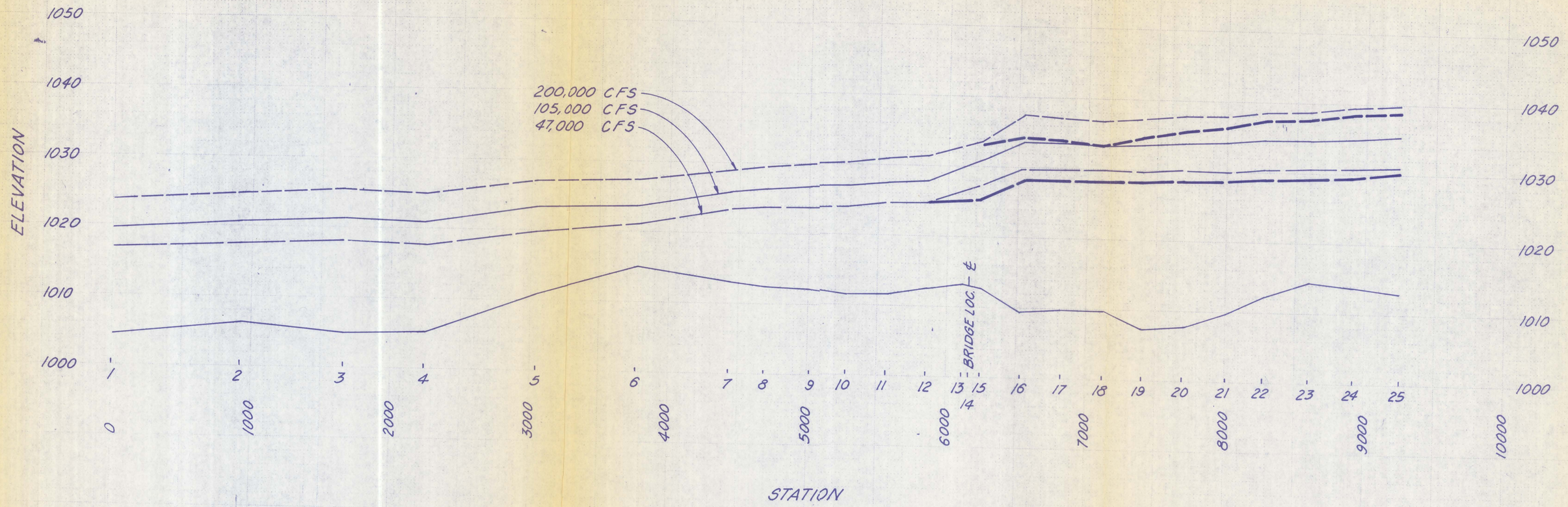



FIGURE 3
**FLOOD PROFILE WITH LONG BRIDGE IN PLACE**

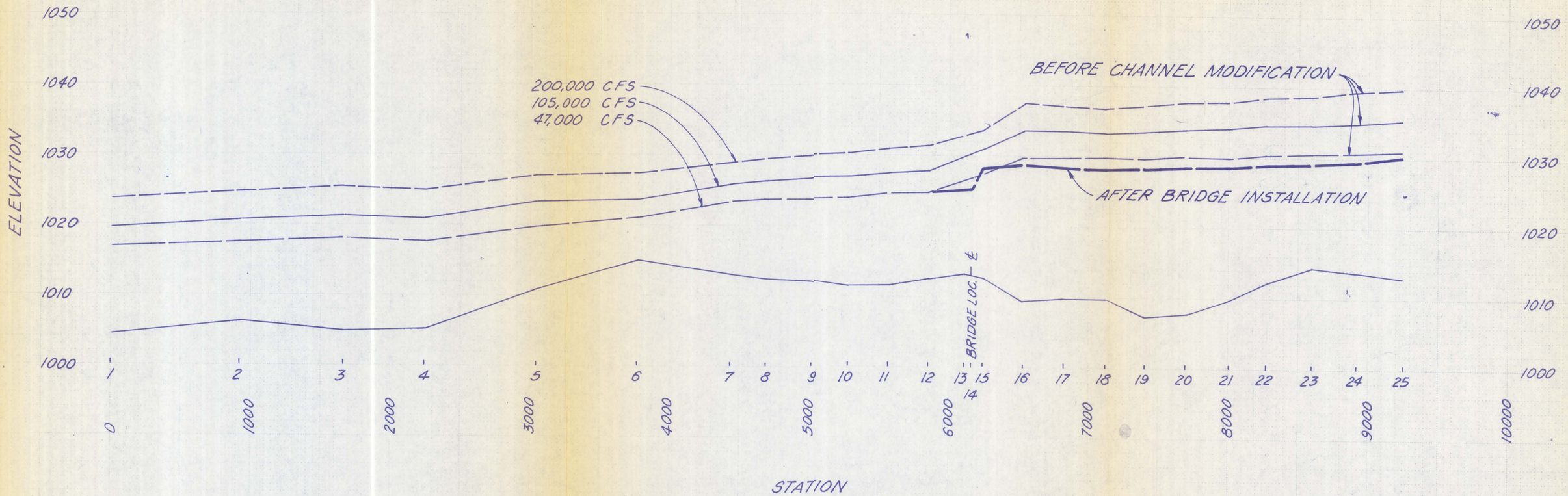



FIGURE 4
**FLOOD PROFILE WITH SHORT BRIDGE IN PLACE**

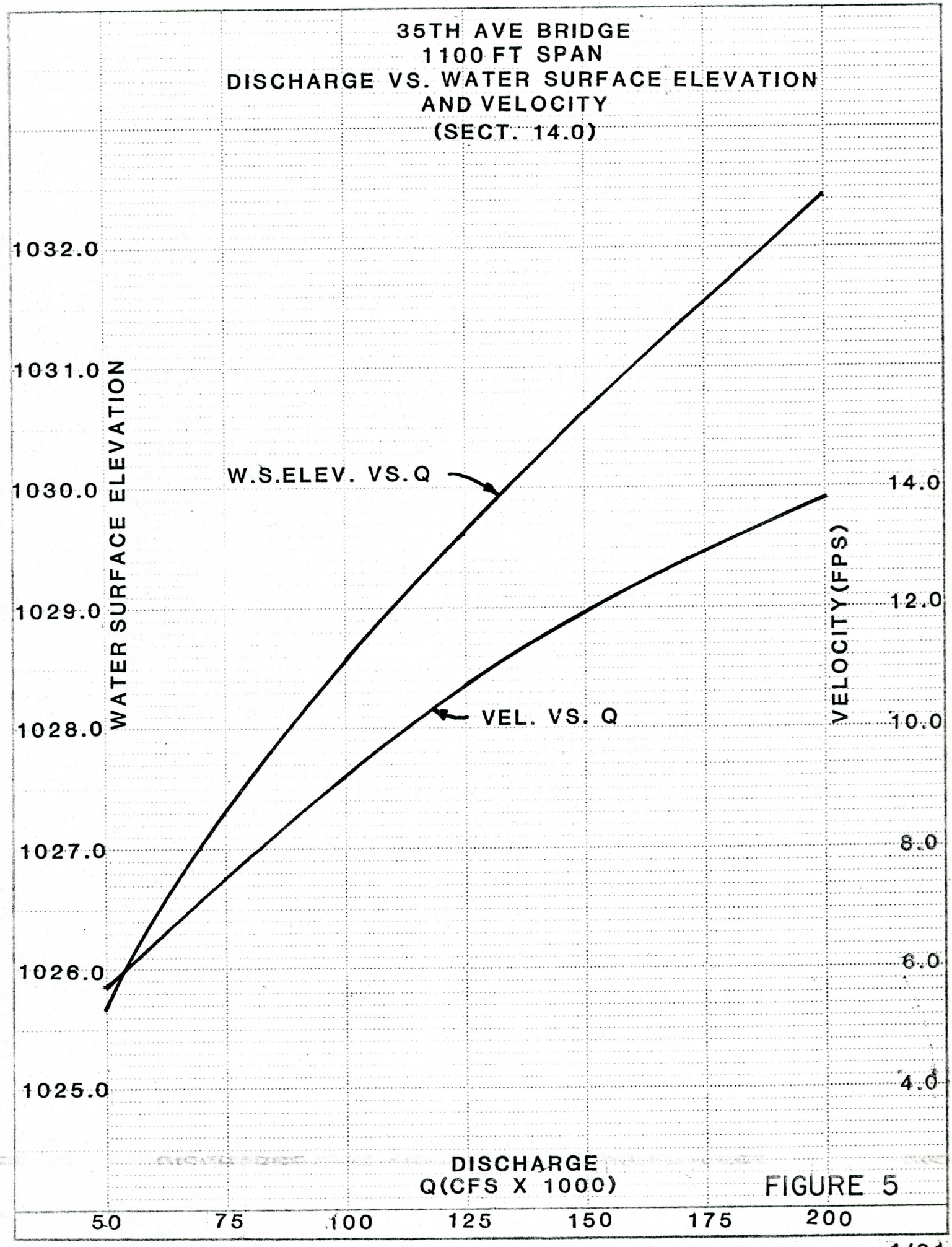

35TH AVE BRIDGE
1100 FT SPAN
DISCHARGE VS. WATER SURFACE ELEVATION
AND VELOCITY
(SECT. 14.0)
WATER SURFACE ELEVATION
1032.0
1031.0
1030.0
1029.0
1028.0
1027.0
1026.0
1025.0
W.S.ELEV. VS.Q
VEL. VS. Q
VELOCITY(FPS)
14.0
12.0
10.0
8.0
6.0
4.0
DISCHARGE
Q(CFS X 1000)
50
75
100
125
150
175
200

FIGURE 5

4/81

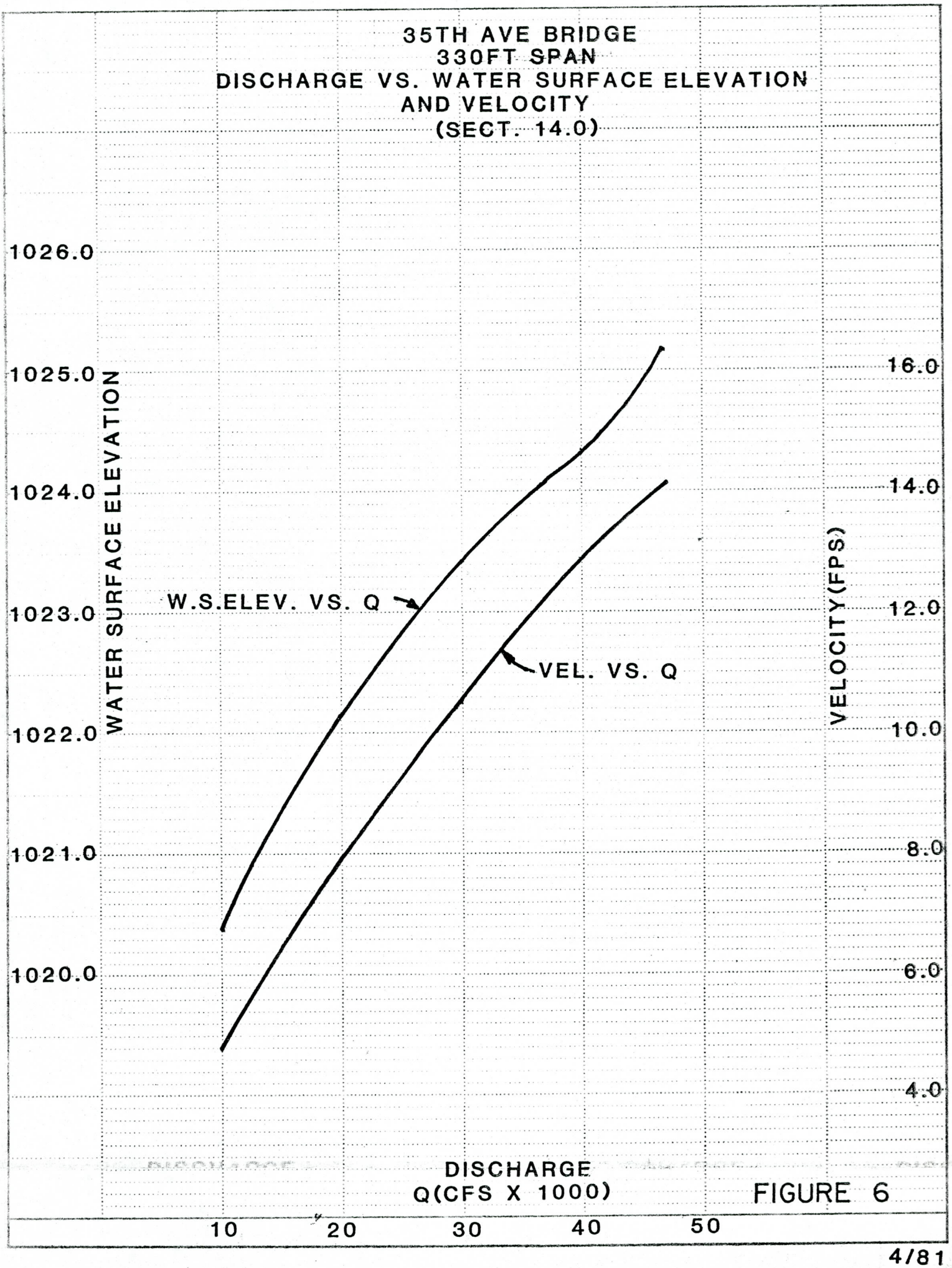
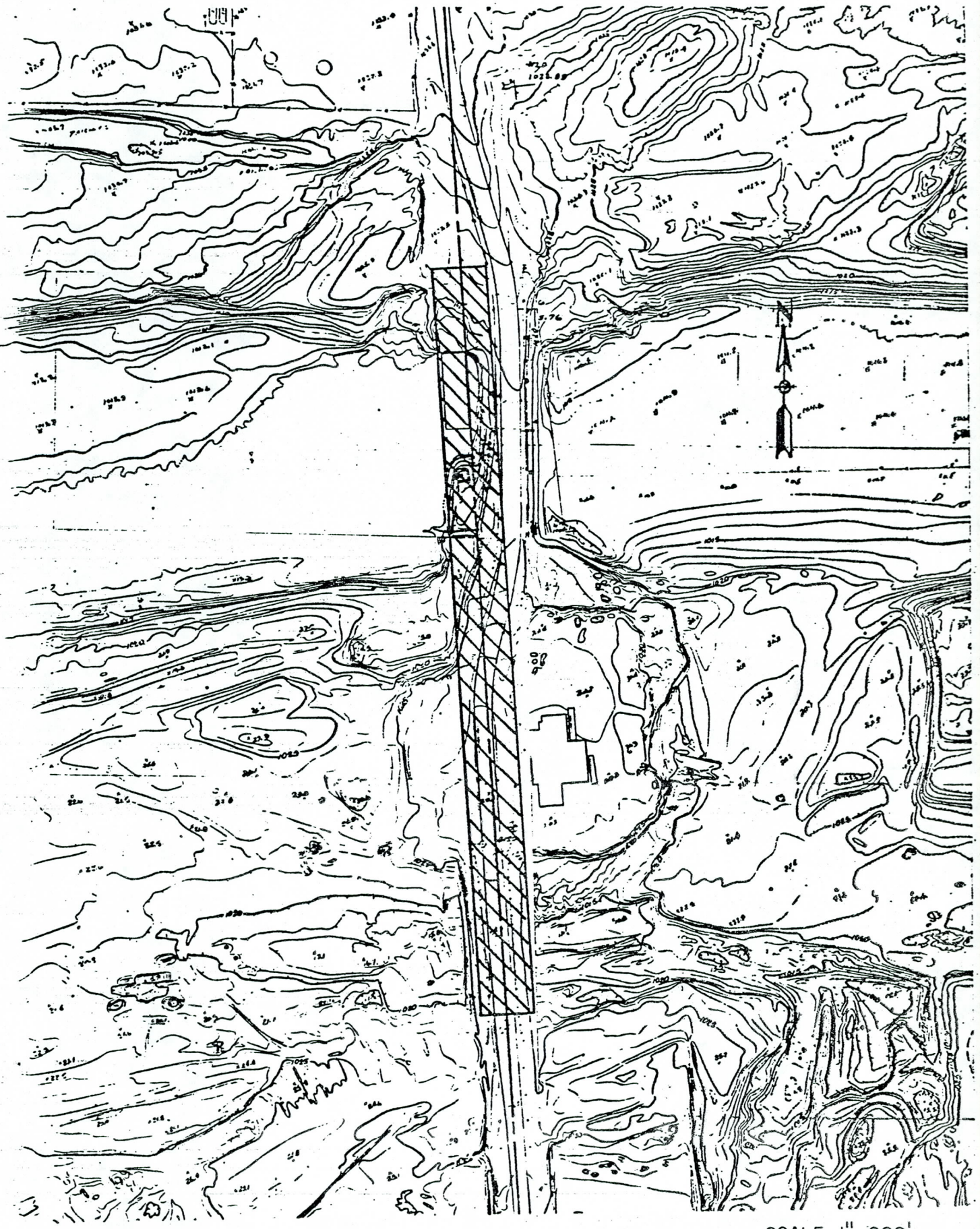

35TH AVE BRIDGE
330FT SPAN
DISCHARGE VS. WATER SURFACE ELEVATION
AND VELOCITY
(SECT. 14.0)
WATER SURFACE ELEVATION
1026.0
1025.0
1024.0
1023.0
1022.0
1021.0
1020.0
VELOCITY(FPS)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
W.S.ELEV. VS. Q
VEL. VS. Q
DISCHARGE
Q(CFS X 1000)
10
20
30
40
50

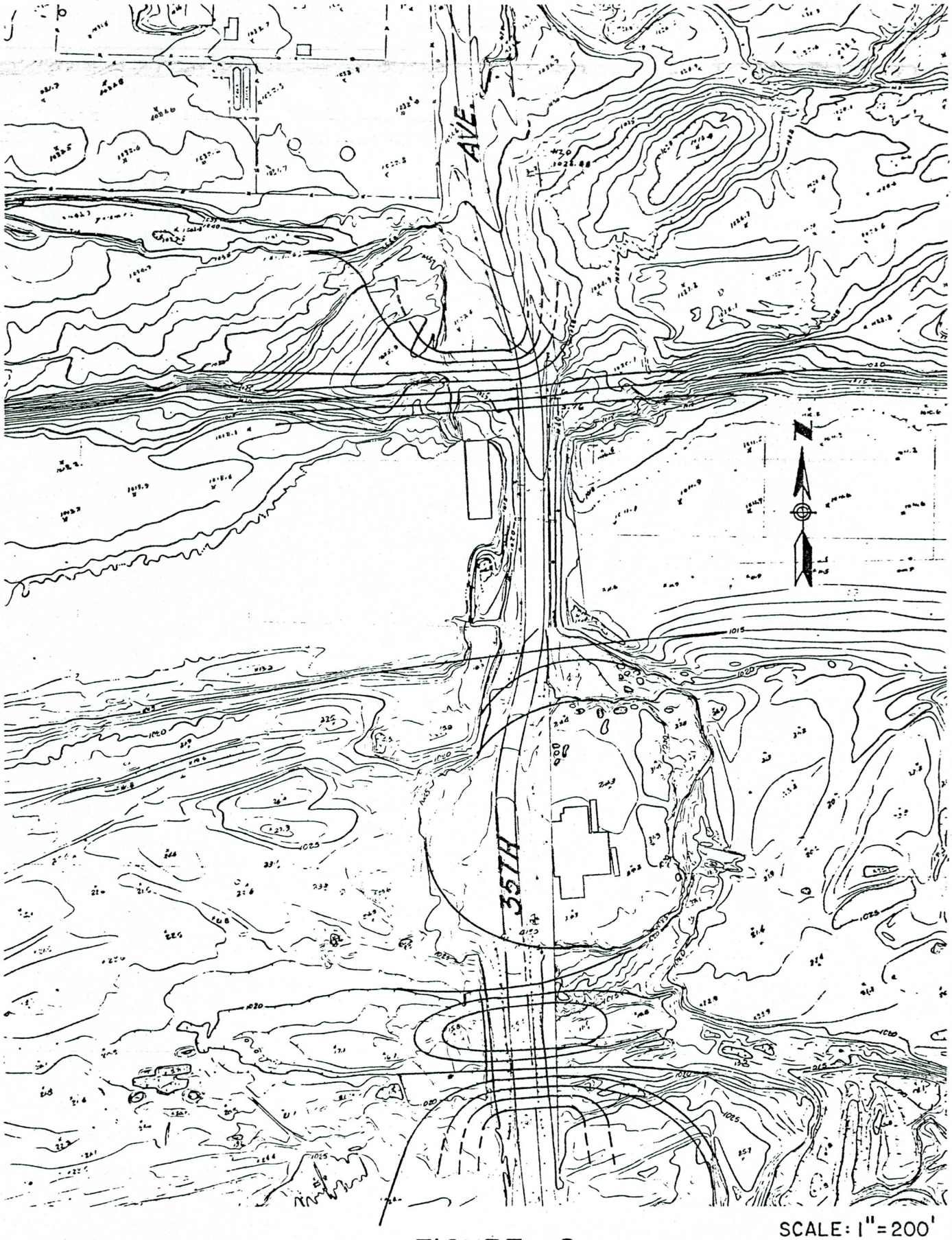
FIGURE 6




SCALE: 1" = 200'

FIGURE 7

BRIDGE SITE LAYOUT - LONG BRIDGE




SCALE: 1" = 200'

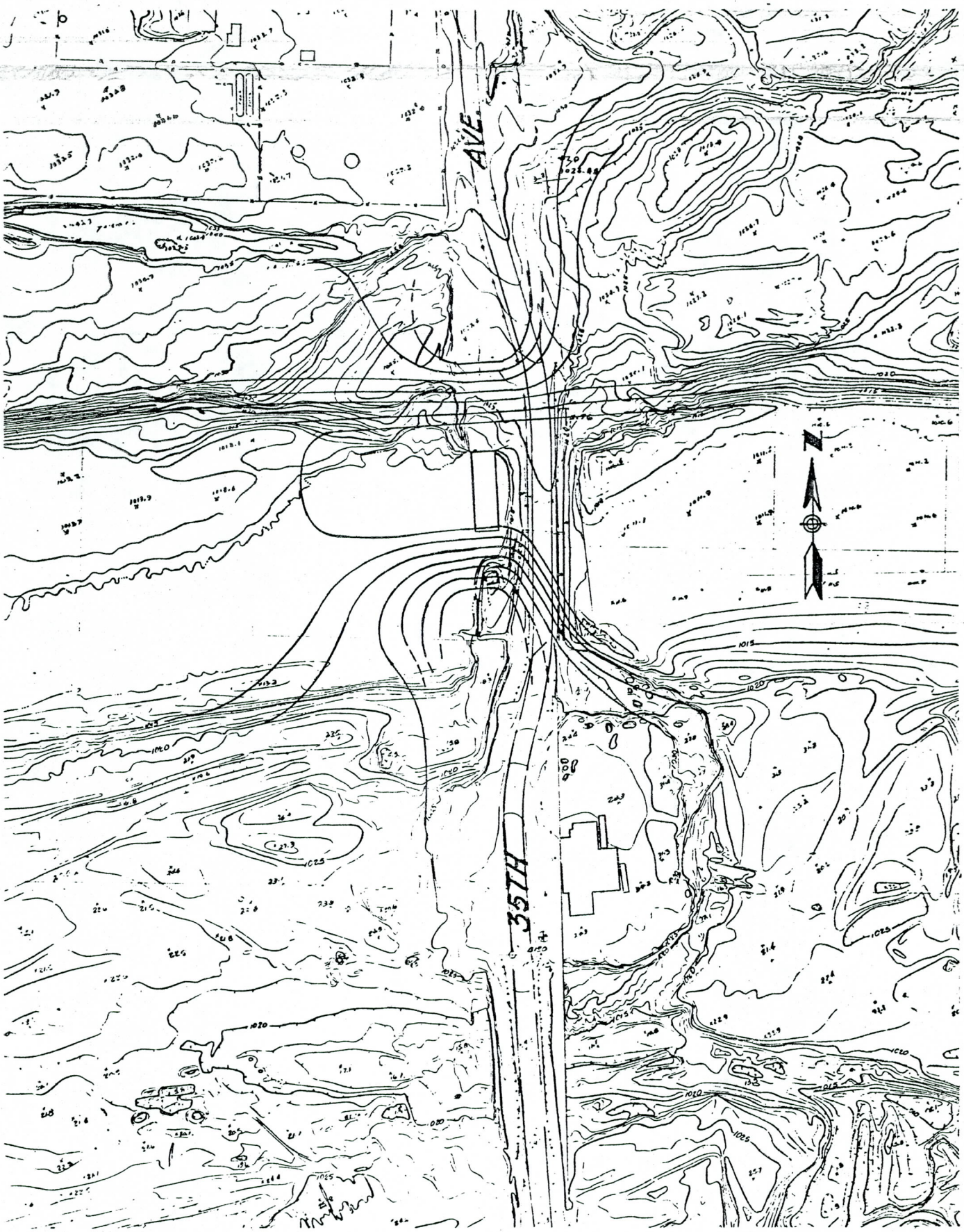
FIGURE 8

SITE CONTOURS - LONG BRIDGE

SCALE: 1" = 200'

FIGURE 9

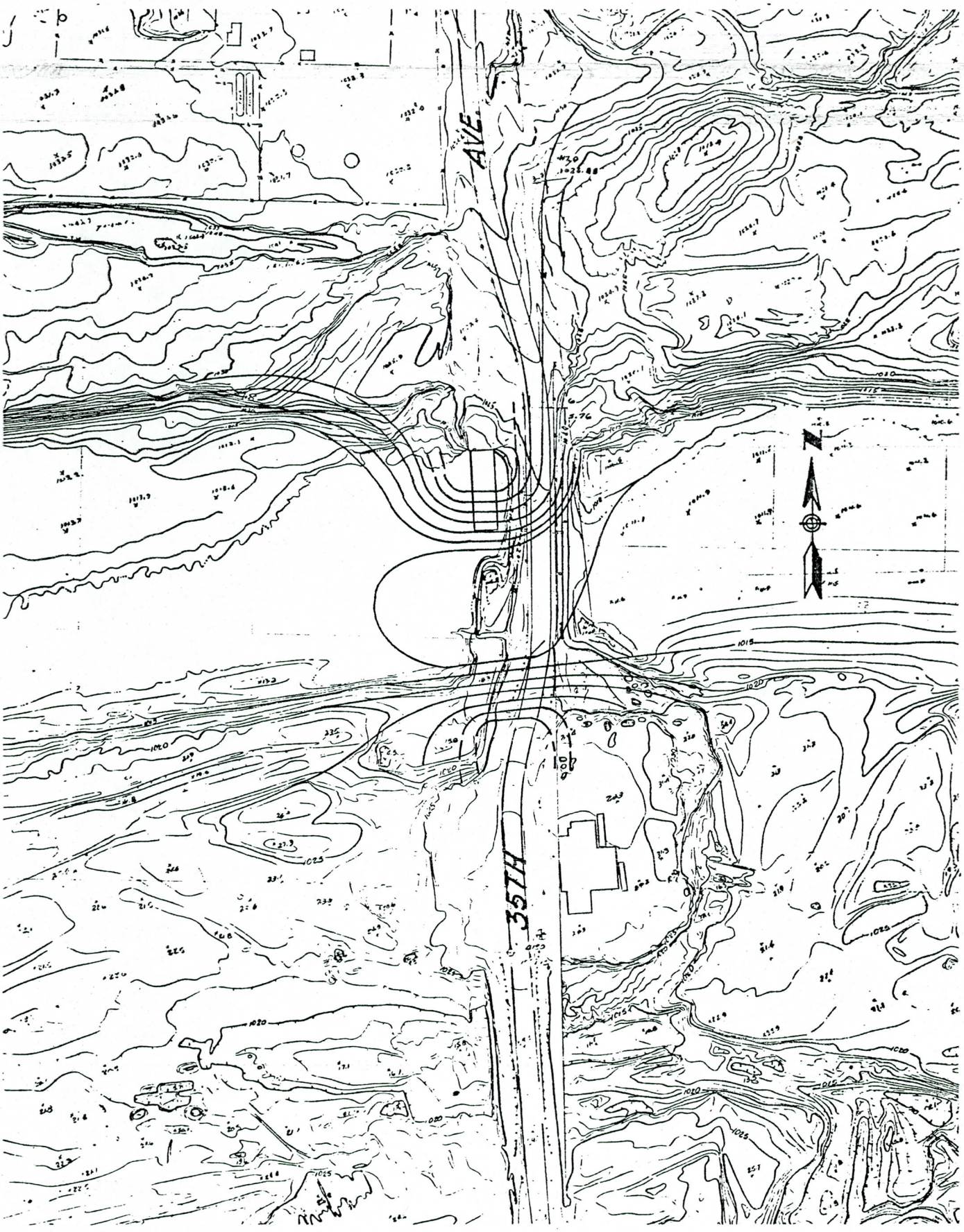
BRIDGE SITE LAYOUT - SHORT BRIDGE LOCATED AT RIGHT SIDE OF MAIN CHANNEL




SCALE: 1" = 200'

FIGURE 10

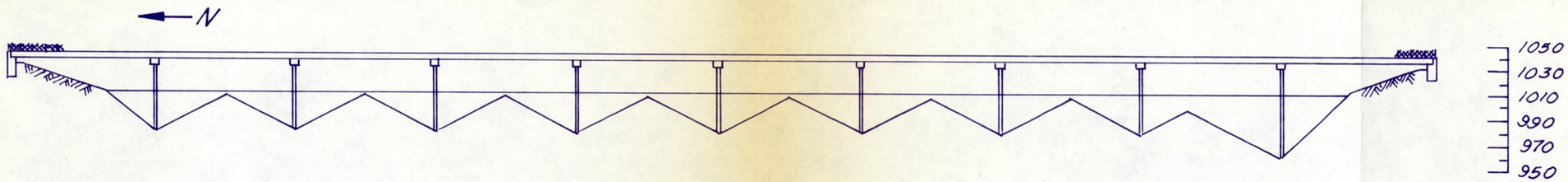
SITE CONTOURS – NORTH SHORT BRIDGE



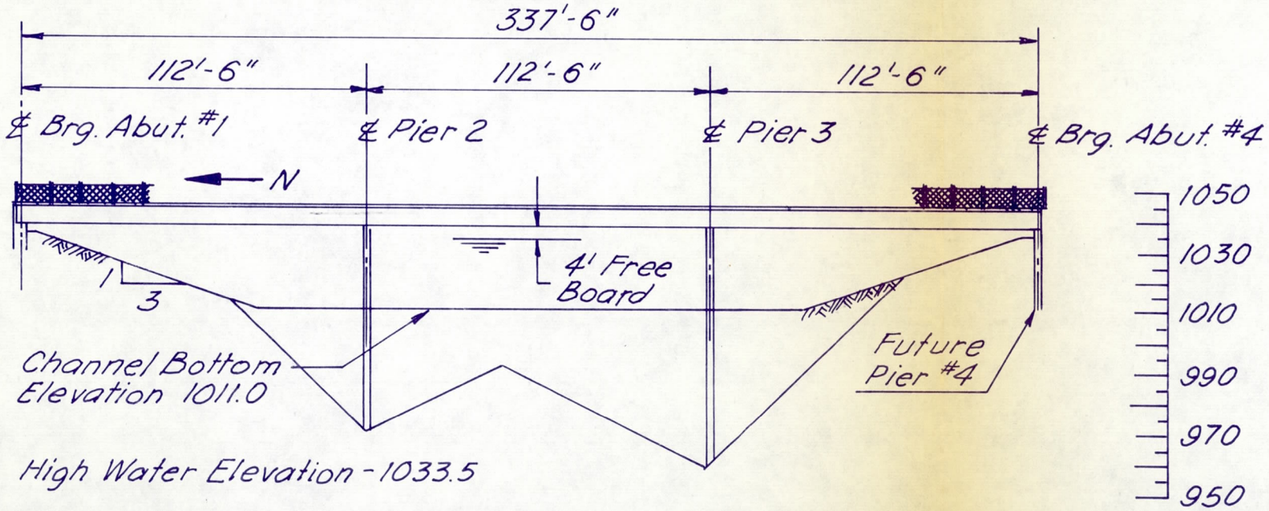

SCALE: 1" = 200'

FIGURE 11

SITE CONTOURS – SOUTH SHORT BRIDGE




LONG BRIDGE EXTREME SCOUR PATTERN




NORTH SIDE

SHORT BRIDGE EXTREME SCOUR PATTERN

FIGURE 12

COMPUTED SCOUR PATTERNS

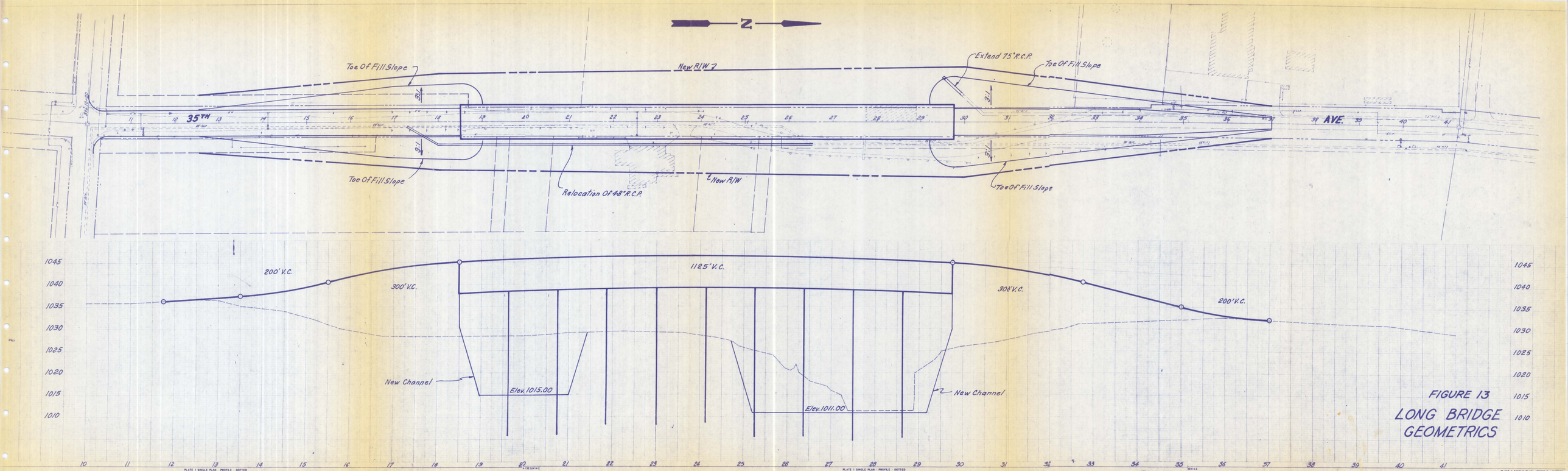



FIGURE 13
LONG BRIDGE GEOMETRICS

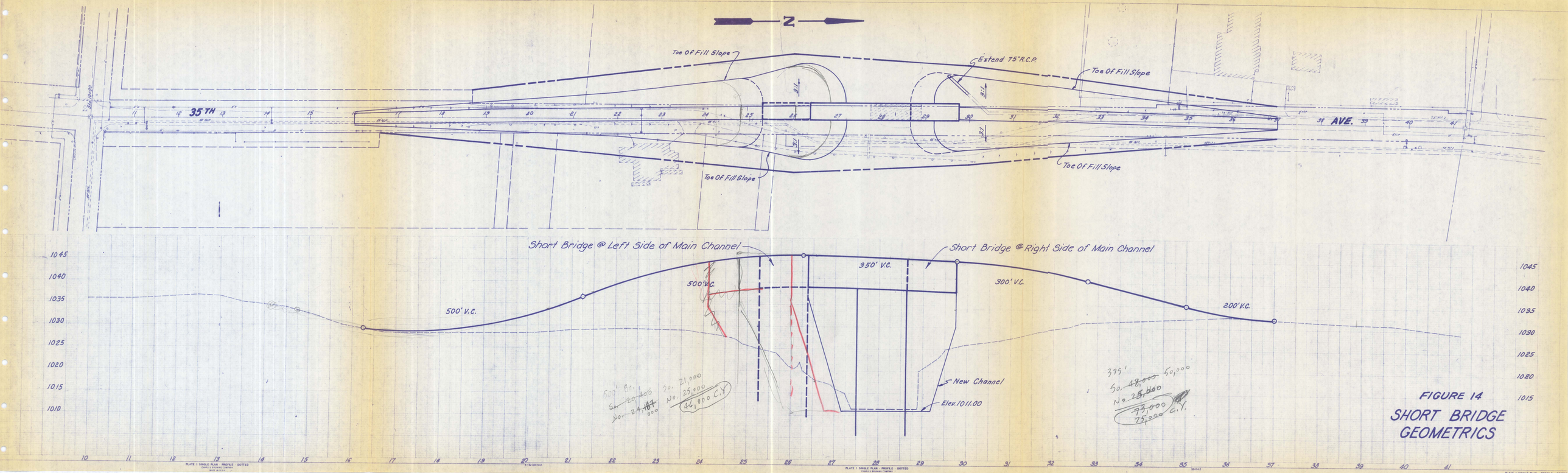



FIGURE 14
SHORT BRIDGE GEOMETRICS

TABLE 10. COST ESTIMATES SUMMARY

337.5 FT., 2-LANE BRIDGE ALTERNATES

| Bridge Type | Substructure Type | Superstructure Cost | | Substructure Cost | | TOTAL | |
|---|---|---|---|---|---|---|---|
| | | Left Bridge | Right Bridge | Left Bridge | Right Bridge | Left Bridge | Right Bridge |
| 3-Span Welded Composite Steel Girder | Caisson | $463,375<br>$34.62/SF | $463,375<br>$34.62/SF | $426,020<br>$31.83/SF | $372,320<br>$27.82/SF | $ 889,395<br>$66.45/SF | $ 835,695<br>$62.44/SF |
| | Pile | $463,375<br>$34.62/SF | $443,375<br>$34.62/SF | $730,820<br>$54.60/SF | $624,382<br>$46.65/SF | $1,194,195<br>$89.22/SF | $1,087,757<br>$81.27/SF |
| 2-Span Welded Composite Steel Girder | Caisson | $552,825<br>$41.30/SF | $552,825<br>$41.30/SF | $345,621<br>$25.82/SF | $318,031<br>$23.76/SF | $ 898,446<br>$67.12/SF | $ 870,856<br>$65.06/SF |
| | Pile | $552,825<br>$41.30/SF | $552,825<br>$41.30/SF | $587,385<br>$43.89/SF | $478,210<br>$35.73/SF | $1,140,210<br>$85.19/SF | $1,031,035<br>$77.03/SF |
| 3-Span Prestressed Concrete Girder | Caisson | $366,440<br>$27.38/SF | $366,440<br>$27.38/SF | $418,140<br>$31.24/SF | $389,630<br>$29.11/SF | $ 784,580<br>$58.62/SF | $ 756,070<br>$56.49/SF |
| | Pile | $366,440<br>$27.38/SF | $366,440<br>$27.38/SF | $750,860<br>$56.10/SF | $639,060<br>$47.75/SF | $1,117,300<br>$83.48/SF | $1,005,500<br>$75.13/SF |
| 3-Span Cast-In-Place Concrete Box Girder | Caisson | $403,545<br>$30.15/SF | $403,545<br>$30.15/SF | $369,160<br>$27.58/SF | $352,875<br>$26.36/SF | $ 772,705<br>$57.73/SF | $ 756,420<br>$56.51/SF |
| | Pile | $403,545<br>$30.15/SF | $403,545<br>$30.15/SF | $695,960<br>$52.00/SF | $598,250<br>$44.70/SF | $1,099,505<br>$82.15/SF | $1,001,795<br>$74.85/SF |

NOTE: Riprap and north abutment costs are included in the substructure

TABLE 11

COST ESTIMATE

3-SPAN WELDED COMPOSITE STEEL GIRDER BRIDGE
LEFT SIDE MAIN CHANNEL

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 348 | $ 10 | $ 34,800 |
| 501 | Structural Steel | LB. | 285,000 | 0.90 | 256,500 |
| 502 | Structural Concrete | | | | |
| | Class S | C.Y. | 201 | 210 | 42,210 |
| | Class S | C.Y. | 413 | 250 | 103,250 |
| 506 | Reinforcing Steel | LB. | 167,700 | 0.50 | 83,850 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | *Drilled Caisson 6' Ø | L.F. | 316 | 600 | 189,600 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $ 889,395 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 10,400 | $ 8 | $ 83,200 |
| 208 | Special Backfill | C.Y. | 10,140 | 15 | 152,100 |
| 501 | Structural Steel | LB. | 285,000 | 0.90 | 256,500 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 152 | 200 | 30,400 |
| | Class S | C.Y. | 274 | 240 | 65,760 |
| | Class S | C.Y. | 413 | 250 | 103,250 |
| 506 | Reinforcing Steel | LB. | 181,000 | 0.50 | 90,500 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 5,100 | 28 | 142,800 |
| | Driving Piles | L.F. | 5,100 | 15 | 76,500 |
| | Splicing Piles | EACH | 100 | 140 | 14,000 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $1,194,195 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 12

COST ESTIMATE

3-SPAN WELDED COMPOSITE STEEL GIRDER BRIDGE
RIGHT SIDE OF MAIN CHANNEL

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 261 | $ 10 | $ 2,610 |
| 501 | Structural Steel | LB. | 285,000 | 0.90 | 256,500 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 100 | 210 | 21,000 |
| | Class S | C.Y. | 151 | 210 | 31,710 |
| | Class S | C.Y. | 413 | 250 | 103,250 |
| 506 | Reinforcing Steel | LB. | 166,480 | 0.50 | 83,240 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 500 | 20 | 10,000 |
| | Driving Piles | L.F. | 500 | 10 | 5,000 |
| | Splicing Piles | EACH | 10 | 100 | 1,000 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | *Drilled Caisson 6' Ø | L.F. | 237 | 600 | 142,200 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $ 835,695 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 7,800 | $ 8 | $ 62,400 |
| 208 | Special Backfill | C.Y. | 7,605 | 15 | 114,075 |
| 501 | Structural Steel | LB. | 285,000 | 0.90 | 256,500 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 114 | 200 | 22,800 |
| | Class D | C.Y. | 100 | 210 | 21,000 |
| | Class S | C.Y. | 206 | 240 | 49,440 |
| | Class S | C.Y. | 413 | 250 | 103,250 |
| 506 | Reinforcing Steel | LB. | 176,264 | 0.50 | 88,132 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 500 | 20 | 10,000 |
| | Driving Piles | L.F. | 500 | 10 | 5,000 |
| | Splicing Piles | EACH | 10 | 100 | 1,000 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 3,825 | 28 | 107,100 |
| | Driving Piles | L.F. | 3,825 | 15 | 57,375 |
| | Splicing Piles | EACH | 75 | 140 | 10,500 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $1,087,757 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 13

COST ESTIMATE

2-SPAN WELDED COMPOSITE STEEL GIRDER BRIDGE
LEFT SIDE OF MAIN CHANNEL

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 356 | $ 10 | $ 3,560 |
| 501 | Structural Steel | LB. | 407,000 | 0.85 | 345,950 |
| 502 | Structural Concrete | | | | |
| | Class S | C.Y. | 198 | 210 | 41,580 |
| | Class S | C.Y. | 413 | 250 | 103,250 |
| 506 | Reinforcing Steel | LB. | 165,442 | 0.50 | 82,721 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | *Drilled Caisson 6' Ø | L.F. | 237 | 600 | 142,200 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $ 898,446 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 7,800 | $ 8 | $ 62,400 |
| 208 | Special Backfill | C.Y. | 7,605 | 15 | 114,075 |
| 501 | Structural Steel | LB. | 407,000 | 0.85 | 345,950 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 114 | 200 | 22,800 |
| | Class S | C.Y. | 222 | 240 | 53,280 |
| | Class S | C.Y. | 413 | 250 | 103,250 |
| 506 | Reinforcing Steel | LB. | 168,590 | 0.50 | 84,295 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 3,825 | 28 | 107,100 |
| | Driving Piles | L.F. | 3,825 | 15 | 57,375 |
| | Splicing Piles | EACH | 75 | 140 | 10,500 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $1,140,210 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 14

COST ESTIMATE

2-SPAN WELDED COMPOSITE STEEL GIRDER BRIDGE
RIGHT SIDE OF MAIN CHANNEL

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 237 | $ 10 | $ 2,370 |
| 501 | Structural Steel | LB. | 407,000 | 0.85 | 345,950 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 100 | 210 | 21,000 |
| | Class S | C.Y. | 132 | 210 | 27,720 |
| | Class S | C.Y. | 413 | 250 | 103,250 |
| 506 | Reinforcing Steel | LB. | 161,162 | 0.50 | 80,581 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 500 | 20 | 10,000 |
| | Driving Piles | L.F. | 500 | 10 | 5,000 |
| | Splicing Piles | EACH | 10 | 100 | 1,000 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | *Drilled Caisson 6' Ø | L.F. | 158 | 600 | 94,800 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $ 870,856 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 5,200 | $ 8 | $ 41,600 |
| 208 | Special Backfill | C.Y. | 5,070 | 15 | 76,050 |
| 501 | Structural Steel | LB. | 407,000 | 0.85 | 345,950 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 176 | 200 | 35,200 |
| | Class S | C.Y. | 148 | 240 | 35,520 |
| | Class S | C.Y. | 413 | 250 | 103,250 |
| 506 | Reinforcing Steel | LB. | 163,260 | 0.50 | 81,630 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 500 | 20 | 10,000 |
| | Driving Piles | L.F. | 500 | 10 | 5,000 |
| | Splicing Piles | EACH | 10 | 100 | 1,000 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 2,550 | 28 | 71,400 |
| | Driving Piles | L.F. | 2,550 | 15 | 38,250 |
| | Splicing Piles | EACH | 50 | 140 | 7,000 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $1,031,035 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 15

COST ESTIMATE

3-SPAN PRESTRESSED CONCRETE GIRDER BRIDGE
LEFT SIDE OF MAIN CHANNEL

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 348 | $ 10 | $ 3,480 |
| 502 | Structural Concrete | | | | |
| | Class S | C.Y. | 300 | 210 | 63,000 |
| | Class S | C.Y. | 422 | 250 | 105,500 |
| 506 | Reinforcing Steel | LB. | 163,630 | 0.50 | 81,815 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | *Drilled Caisson 6' Ø | L.F. | 316 | 600 | 189,600 |
| 503 | Prestressed Member | | | | |
| | AASHTO Type VI | EACH | 12 | 13,500 | 162,000 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $ 784,580 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 10,400 | $ 8 | $ 83,200 |
| 208 | Special Backfill | C.Y. | 10,140 | 15 | 152,100 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 152 | 200 | 30,400 |
| | Class S | C.Y. | 375 | 240 | 90,000 |
| | Class S | C.Y. | 422 | 250 | 105,500 |
| 506 | Reinforcing Steel | LB. | 163,230 | 0.50 | 81,615 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 5,100 | 28 | 142,800 |
| | Driving Piles | L.F. | 5,100 | 15 | 76,500 |
| | Splicing Piles | EACH | 100 | 140 | 14,000 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| 503 | Prestressed Member, | | | | |
| | AASHTO Type VI | EACH | 12 | 13,500 | 162,000 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $1,117,300 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 16

COST ESTIMATE

3-SPAN PRESTRESSED CONCRETE GIRDER BRIDGE
RIGHT SIDE OF MAIN CHANNEL

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 261 | $ 10 | $ 2,610 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 100 | 210 | 21,000 |
| | Class S | C.Y. | 224 | 210 | 47,040 |
| | Class S | C.Y. | 422 | 250 | 105,500 |
| 506 | Reinforcing Steel | LB. | 161,070 | 0.50 | 80,535 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 500 | 20 | 10,000 |
| | Driving Piles | L.F. | 500 | 10 | 5,000 |
| | Splicing Piles | EACH | 10 | 10 | 1,000 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | *Drilled Caisson 6' Ø | L.F. | 237 | 600 | 142,200 |
| 503 | Prestressed Member | | | | |
| | AASHTO Type VI | EACH | 12 | 13,500 | 162,000 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $ 756,070 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 7,800 | $ 8 | $ 62,400 |
| 208 | Special Backfill | C.Y. | 7,605 | 15 | 114,075 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 114 | 200 | 22,800 |
| | Class D | C.Y. | 100 | 210 | 21,000 |
| | Class S | C.Y. | 280 | 240 | 67,200 |
| | Class S | C.Y. | 422 | 250 | 105,500 |
| 506 | Reinforcing Steel | LB. | 160,730 | 0.50 | 80,365 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 500 | 20 | 10,000 |
| | Driving Piles | L.F. | 500 | 10 | 5,000 |
| | Splicing Piles | EACH | 10 | 100 | 1,000 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 3,825 | 28 | 107,100 |
| | Driving Piles | L.F. | 3,825 | 15 | 57,375 |
| | Splicing Piles | EACH | 75 | 140 | 10,500 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| 503 | Prestressed Member, | | | | |
| | AASHTO Type VI | EACH | 12 | 13,500 | 162,000 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $1,005,500 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 17

COST ESTIMATE

3-SPAN CAST-IN-PLACE CONCRETE BOX GIRDER BRIDGE
LEFT SIDE OF MAIN CHANNEL

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 348 | $ 10 | $ 3,480 |
| 502 | Structural Concrete | | | | |
| | Class S | C.Y. | 112 | 210 | 23,520 |
| | Class S | C.Y. | 921 | 250 | 230,250 |
| 506 | Reinforcing Steel | LB. | 293,340 | 0.50 | 146,670 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | *Drilled Caisson 6' Ø | L.F. | 316 | 600 | 189,600 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $ 772,705 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 10,400 | $ 8 | $ 83,200 |
| 208 | Special Backfill | C.Y. | 10,140 | 15 | 152,100 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 152 | 200 | 30,400 |
| | Class S | C.Y. | 185 | 240 | 44,400 |
| | Class S | C.Y. | 921 | 250 | 230,250 |
| 506 | Reinforcing Steel | LB. | 293,340 | 0.50 | 146,670 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 5,100 | 28 | 142,800 |
| | Driving Piles | L.F. | 5,100 | 15 | 76,500 |
| | Splicing Piles | EACH | 100 | 140 | 14,000 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $1,099,505 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 18

COST ESTIMATE

3-SPAN CAST-IN-PLACE CONCRETE BOX GIRDER BRIDGE
ON RIGHT SIDE OF MAIN CHANNEL

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 261 | $ 10 | $ 2,610 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 100 | 210 | 21,000 |
| | Class S | C.Y. | 83 | 210 | 17,430 |
| | Class S | C.Y. | 921 | 250 | 230,250 |
| 506 | Reinforcing Steel | LB. | 295,490 | 0.50 | 147,745 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 500 | 20 | 10,000 |
| | Driving Piles | L.F. | 500 | 10 | 5,000 |
| | Splicing Piles | EACH | 10 | 100 | 1,000 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | *Drilled Caisson 6' Ø | L.F. | 237 | 600 | 142,200 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $ 756,420 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 7,800 | $ 8 | $ 62,400 |
| 208 | Special Backfill | C.Y. | 7,605 | 15 | 114,075 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 114 | 200 | 22,800 |
| | Class D | C.Y. | 100 | 210 | 21,000 |
| | Class S | C.Y. | 139 | 240 | 33,360 |
| | Class S | C.Y. | 921 | 250 | 230,250 |
| 506 | Reinforcing Steel | LB. | 295,500 | 0.50 | 147,750 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 500 | 20 | 10,000 |
| | Driving Piles | L.F. | 500 | 10 | 5,000 |
| | Splicing Piles | EACH | 10 | 100 | 1,000 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 3,825 | 28 | 107,100 |
| | Driving Piles | L.F. | 3,825 | 15 | 57,375 |
| | Splicing Piles | EACH | 75 | 140 | 10,500 |
| 513 | Metal Handrail Triple | L.F. | 341 | 100 | 34,100 |
| 605 | Riprap (Incl. Filter) | C.Y. | 5,690 | 24 | 136,560 |
| 610 | Chain Link Fence, 72" | L.F. | 341 | 25 | 8,525 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $1,001,795 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 19 COST ESTIMATES

1125 FT., 4-LANE BRIDGE ALTERNATES

| | 10-Span Welded Composite Steel Girder | | 7-Span Welded Composite Steel Girder | | 10-Span Prestressed Concrete Girder | | 10-Span Cast-in-Place Concrete Box Girder | |
|---|---|---|---|---|---|---|---|---|
| | Total | $Ft^2$ | Total | $Ft^2$ | Total | $Ft^2$ | Total | $Ft^2$ |
| Superstructure | $2,889,900.00 | $32.62 | $3,487,650.00 | $39.37 | $2,267,600.00 | $25.60 | $2,483,870.00 | $28.04 |
| Caisson Substructure | 1,498,400.00 | 16.91 | 1,172,865.00 | 13.24 | 1,602,490.00 | 18.09 | 1,382,500.00 | 15.61 |
| Pile Footing Substructure | 3,010,732.00 | 33.99 | 2,140,420.00 | 24.16 | 3,099,040.00 | 34.98 | 2,853,340.00 | 32.21 |
| Total Bridge With Caisson Substructure | $4,388,300.00 | $49.53 | $4,660,515.00 | $52.61 | $3,870,090.00 | $43.69 | $3,866,370.00 | $43.65 |
| Total Bridge With Pile Substructure | $5,900,632.00 | $66.61 | $5,628,070.00 | $63.53 | $5,366,640.00 | $60.58 | $5,337,210.00 | $60.25 |

Riprap costs are included in the substructure

TABLE 20

COST ESTIMATE

10-SPAN WELDED COMPOSITE STEEL GIRDER BRIDGE

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 1,566 | $ 10 | $ 15,660 |
| 501 | Structural Steel | LB. | 1,900,000 | 0.90 | 1,710,000 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 400 | 210 | 84,000 |
| | Class S | C.Y. | 905 | 210 | 190,050 |
| | Class S | C.Y. | 2,866 | 250 | 716,500 |
| 506 | Reinforcing Steel | LB. | 1,060,500 | 0.50 | 530,250 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 2,000 | 20 | 40,000 |
| | Driving Piles | L.F. | 2,000 | 10 | 20,000 |
| | Splicing Piles | EACH | 40 | 100 | 4,000 |
| 605 | Riprap (Incl. Filter) | C.Y. | 7,010 | 24 | 168,240 |
| 610 | Chain Link Fence, 72" | L.F. | 2,256 | 25 | 56,400 |
| | *Drilled Caisson 6' Ø | L.F. | 1,422 | 600 | 853,200 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $4,388,300 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 46,800 | $ 8 | $ 374,400 |
| 208 | Special Backfill | C.Y. | 45,630 | 15 | 684,450 |
| 501 | Structural Steel | LB. | 1,900,000 | 0.90 | 1,710,000 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 684 | 200 | 136,800 |
| | Class D | C.Y. | 400 | 210 | 84,000 |
| | Class S | C.Y. | 1,235 | 240 | 296,400 |
| | Class S | C.Y. | 2,866 | 250 | 716,500 |
| 506 | Reinforcing Steel | LB. | 1,119,184 | 0.50 | 559,592 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 2,000 | 20 | 40,000 |
| | Driving Piles | L.F. | 2,000 | 10 | 20,000 |
| | Splicing Piles | EACH | 40 | 100 | 4,000 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 22,950 | 28 | 642,600 |
| | Driving Piles | L.F. | 22,950 | 15 | 344,250 |
| | Splicing Piles | EACH | 450 | 140 | 63,000 |
| 605 | Riprap (Incl. Filter) | C.Y. | 7,010 | 24 | 168,240 |
| 610 | Chain Link Fence, 72" | L.F. | 2,256 | 25 | 56,400 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $5,900,632 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 21

COST ESTIMATE

7-SPAN WELDED COMPOSITE STEEL GIRDER BRIDGE

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 1,422 | $ 10 | $ 14,220 |
| 501 | Structural Steel | LB. | 2,715,000 | 0.85 | 2,307,750 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 400 | 210 | 84,000 |
| | Class S | C.Y. | 792 | 210 | 166,320 |
| | Class S | C.Y. | 2,866 | 250 | 716,500 |
| 506 | Reinforcing Steel | LB. | 1,028,570 | 0.50 | 514,285 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 2,000 | 20 | 40,000 |
| | Driving Piles | L.F. | 2,000 | 10 | 20,000 |
| | Splicing Piles | EACH | 40 | 100 | 4,000 |
| 605 | Riprap (Incl. Filter) | C.Y. | 7,010 | 24 | 168,240 |
| 610 | Chain Link Fence, 72" | L.F. | 2,256 | 25 | 56,400 |
| | *Drilled Caisson 6' Ø | L.F. | 948 | 600 | 568,800 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $4,660,515 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 31,200 | $ 8 | $ 249,600 |
| 208 | Special Backfill | C.Y. | 30,420 | 15 | 456,300 |
| 501 | Structural Steel | LB. | 2,715,000 | 0.85 | 2,307,750 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 456 | 200 | 91,200 |
| | Class D | C.Y. | 400 | 210 | 84,000 |
| | Class S | C.Y. | 890 | 240 | 213,600 |
| | Class S | C.Y. | 2,866 | 250 | 716,500 |
| 506 | Reinforcing Steel | LB. | 1,041,160 | 0.50 | 520,580 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 2,000 | 20 | 40,000 |
| | Driving Piles | L.F. | 2,000 | 10 | 20,000 |
| | Splicing Piles | EACH | 40 | 100 | 4,000 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 15,300 | 28 | 428,400 |
| | Driving Piles | L.F. | 15,300 | 15 | 229,500 |
| | Splicing Piles | EACH | 300 | 140 | 42,000 |
| 605 | Riprap (Incl. Filter) | C.Y. | 7,010 | 24 | 168,240 |
| 610 | Chain Link Fence, 72" | L.F. | 2,256 | 25 | 56,400 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $5,628,070 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 22

COST ESTIMATE

10-SPAN PRESTRESSED CONCRETE GIRDER BRIDGE

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 1,566 | $ 10 | $ 15,660 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 400 | 210 | 84,000 |
| | Class S | C.Y. | 1,344 | 210 | 282,240 |
| | Class S | C.Y. | 3,023 | 250 | 755,750 |
| 506 | Reinforcing Steel | LB. | 1,021,200 | 0.50 | 510,600 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 2,000 | 20 | 40,000 |
| | Driving Piles | L.F. | 2,000 | 10 | 20,000 |
| | Splicing Piles | EACH | 40 | 100 | 4,000 |
| 605 | Riprap (Incl. Filter) | C.Y. | 7,010 | 24 | 168,240 |
| 610 | Chain Link Fence, 72" | L.F. | 2,256 | 25 | 56,400 |
| | *Drilled Caisson 6' Ø | L.F. | 1,422 | 600 | 853,200 |
| 503 | Prestressed Member, AASHTO Type VI | EACH | 80 | 13,500 | 1,080,000 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $3,870,090 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 46,800 | $ 8 | $ 374,400 |
| 208 | Special Backfill | C.Y. | 45,630 | 15 | 684,450 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 684 | 200 | 136,800 |
| | Class D | C.Y. | 400 | 210 | 84,000 |
| | Class S | C.Y. | 1,680 | 240 | 403,200 |
| | Class S | C.Y. | 3,023 | 250 | 755,750 |
| 506 | Reinforcing Steel | LB. | 1,019,100 | 0.50 | 509,550 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 2,000 | 20 | 40,000 |
| | Driving Piles | L.F. | 2,000 | 10 | 20,000 |
| | Splicing Piles | EACH | 40 | 100 | 4,000 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 22,950 | 28 | 642,600 |
| | Driving Piles | L.F. | 22,950 | 15 | 344,250 |
| | Splicing Piles | EACH | 450 | 140 | 63,000 |
| 605 | Riprap (Incl. Filter) | C.Y. | 7,010 | 24 | 168,240 |
| 610 | Chain Link Fence, 72" | L.F. | 2,256 | 25 | 56,400 |
| 503 | Prestressed Member, AASHTO TYPE VI | EACH | 80 | 13,500 | 1,080,000 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $5,366,640 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

TABLE 23

COST ESTIMATE

10-SPAN CAST-IN-PLACE CONCRETE BOX GIRDER BRIDGE

Bridge with Caisson Substructure

| Item | Description | Unit | Quantity | Unit Cost | Cost |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 1,566 | $ 10 | $ 15,660 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 400 | 210 | 84,000 |
| | Class S | C.Y. | 500 | 210 | 105,000 |
| | Class S | C.Y. | 6,185 | 250 | 1,546,250 |
| 506 | Reinforcing Steel | LB. | 1,947,240 | 0.50 | 973,620 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 2,000 | 20 | 40,000 |
| | Driving Piles | L.F. | 2,000 | 10 | 20,000 |
| | Splicing Piles | EACH | 40 | 100 | 4,000 |
| 605 | Riprap (Incl. Filter) | C.Y. | 7,010 | 24 | 168,240 |
| 610 | Chain Link Fence, 72" | L.F. | 2,256 | 25 | 56,400 |
| | *Drilled Caisson 6' Ø | L.F. | 1,422 | 600 | 853,200 |
| | TOTAL COST WITH CAISSON SUBSTRUCTURE | | | | $3,866,370 |

Bridge with Pile Substructure

| | | | | | |
|---|---|---|---|---|---|
| 208 | Structural Excavation | C.Y. | 46,800 | $ 8 | $ 374,400 |
| 208 | Special Backfill | C.Y. | 45,630 | 15 | 684,450 |
| 502 | Structural Concrete | | | | |
| | Class D | C.Y. | 684 | 200 | 136,800 |
| | Class D | C.Y. | 400 | 210 | 84,000 |
| | Class S | C.Y. | 830 | 240 | 199,200 |
| | Class S | C.Y. | 6,185 | 250 | 1,546,250 |
| 506 | Reinforcing Steel | LB. | 1,947,240 | 0.50 | 973,620 |
| 512 | Furnishing Piles | | | | |
| | HP 12 x 53 | L.F. | 2,000 | 20 | 40,000 |
| | Driving Piles | L.F. | 2,000 | 10 | 20,000 |
| | Splicing Piles | EACH | 40 | 100 | 4,000 |
| 512 | Furnishing Piles | | | | |
| | HP 14 x 89 | L.F. | 22,950 | 28 | 642,600 |
| | Driving Piles | L.F. | 22,950 | 15 | 344,250 |
| | Splicing Piles | EACH | 450 | 140 | 63,000 |
| 605 | Riprap (Incl. Filter) | C.Y. | 7,010 | 24 | 168,240 |
| 610 | Chain Link Fence, 72" | L.F. | 2,256 | 25 | 56,400 |
| | TOTAL COST WITH PILE SUBSTRUCTURE | | | | $5,337,210 |

*This item includes the cost for reinforcing steel and Class S concrete below the ground line.

## HYDRAULIC DESIGN DATA

FIGURE


A-1 Contour map of bridge area
A-2 1978 Flood Photo
A-3 Channel cross-section Nos. 12 and 13
A-4 Channel cross-section Nos. 14 and 15
A-5 Channel cross-section Nos. 16 and 17
A-6 Channel cross-section No. 18
A-7 Channel cross-section No. 13 Modified
A-8 Channel cross-section No. 14 Modified
A-9 Channel cross-section No. 15 Modified

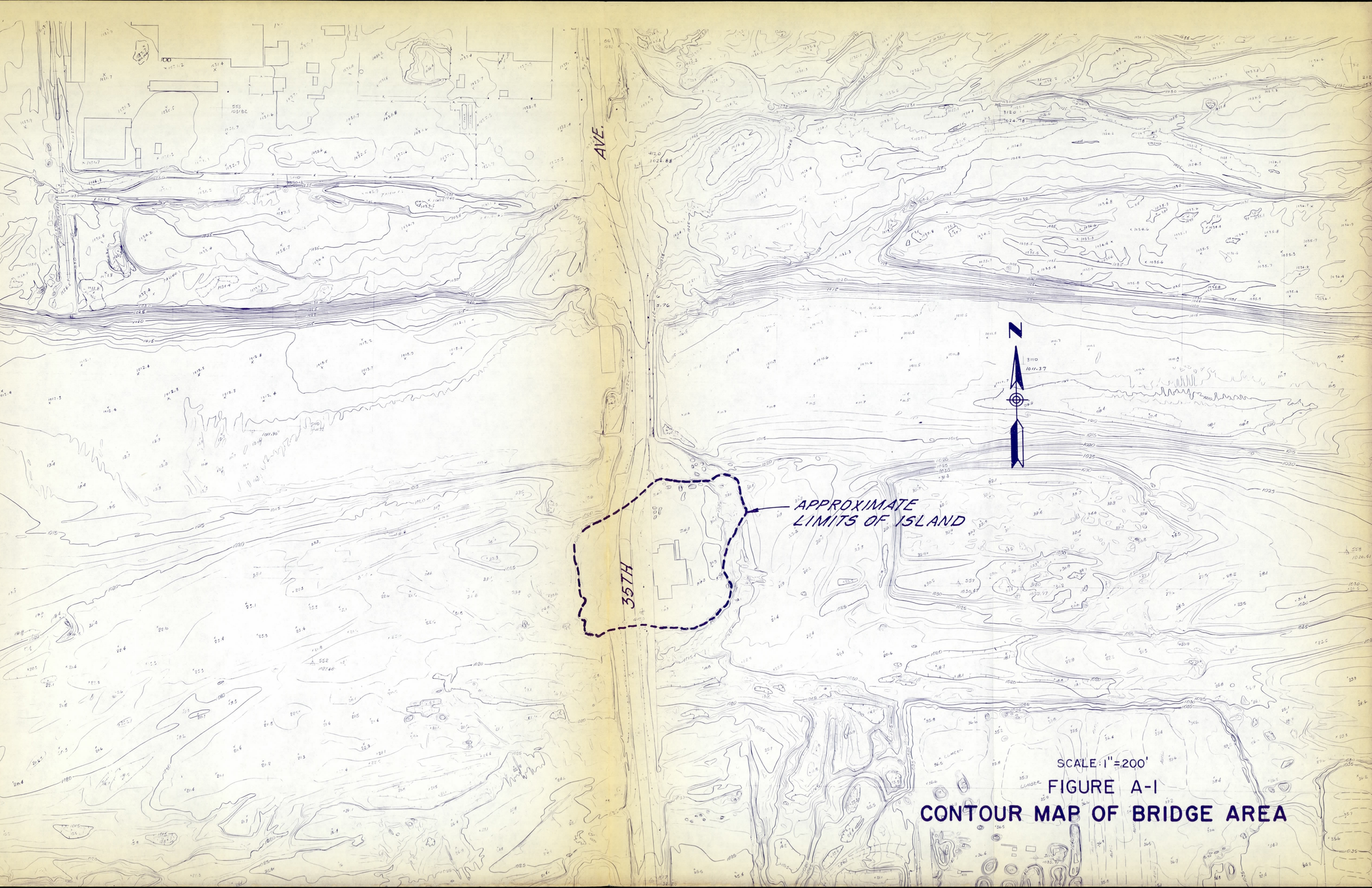



FIGURE A-1
CONTOUR MAP OF BRIDGE AREA

FIGURE A-2

**FLOOD OF DECEMBER 19, 1978 IN THE SALT RIVER AT 35TH AVENUE BRIDGE ($Q \simeq 105{,}000$ cfs)**

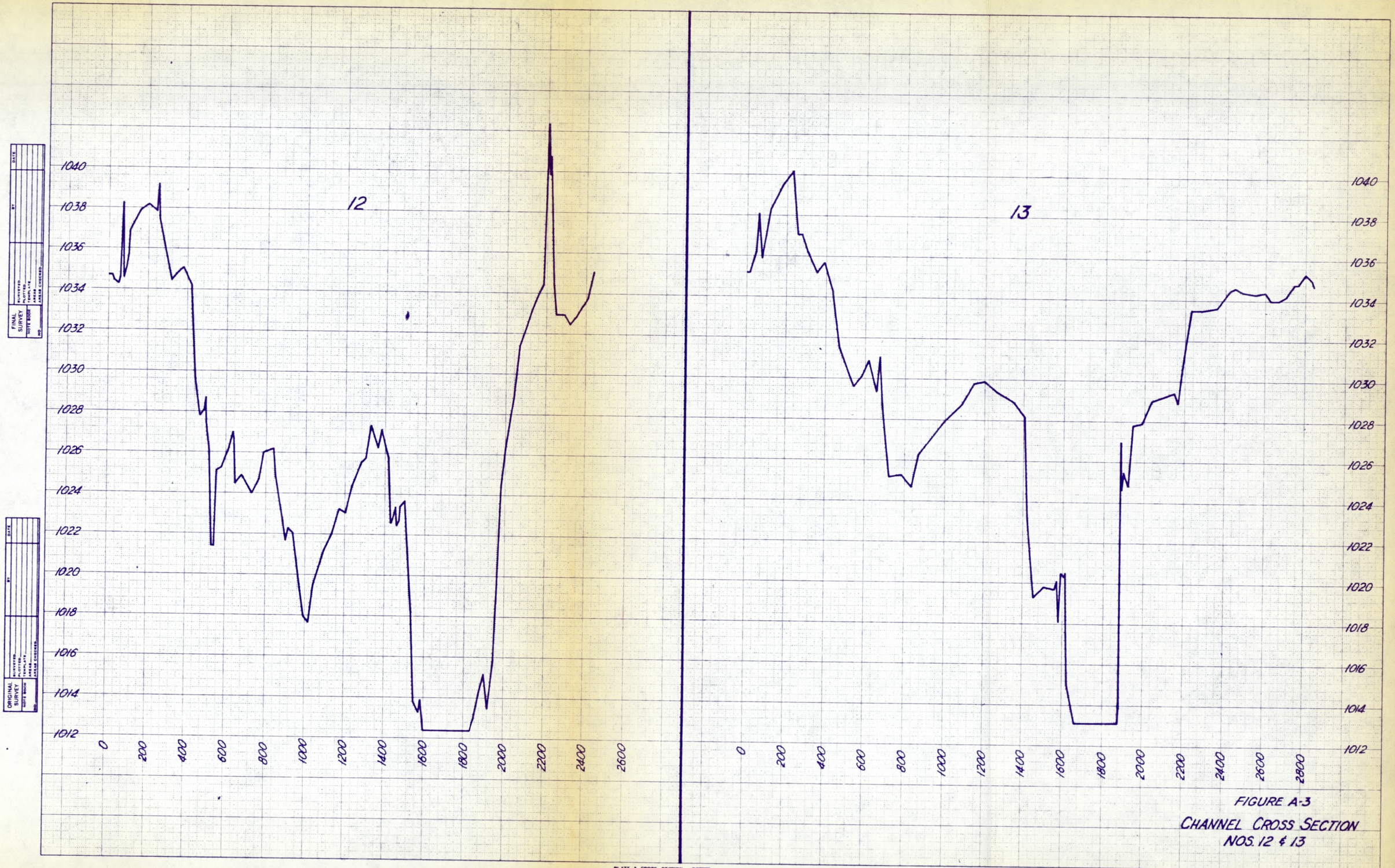



FIGURE A-3

CHANNEL CROSS SECTION
NOS. 12 & 13

PLATE 3 CROSS SECTION - BOTTED
CHARLES BRUNING COMPANY
MADE IN U.S.A.

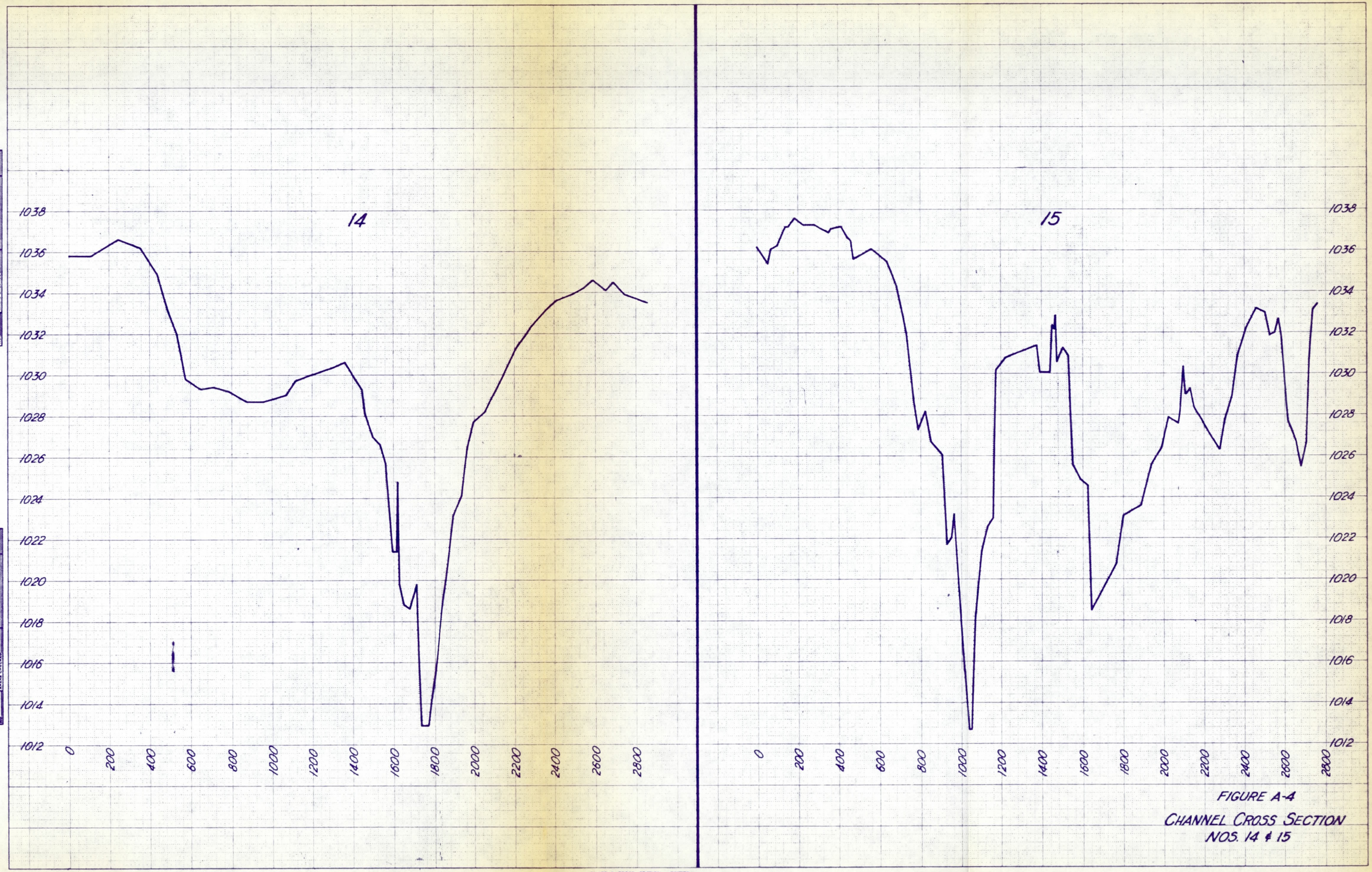



FIGURE A-4

CHANNEL CROSS SECTION
NOS. 14 & 15

PLATE 3 CROSS SECTION - DOTTED
CHARLES BRUNING COMPANY
MADE IN U.S.A.

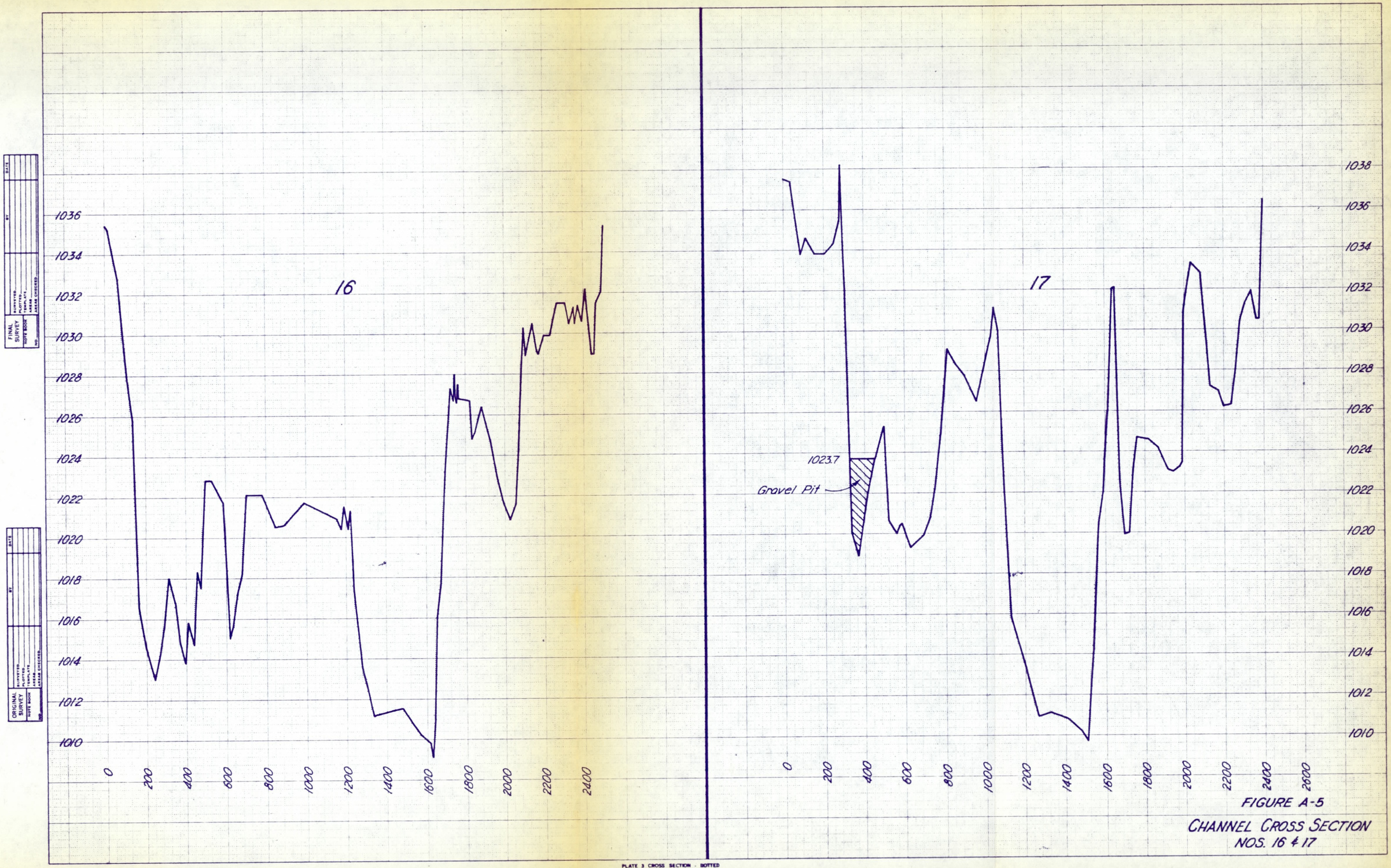



FIGURE A-5

CHANNEL CROSS SECTION
NOS. 16 & 17

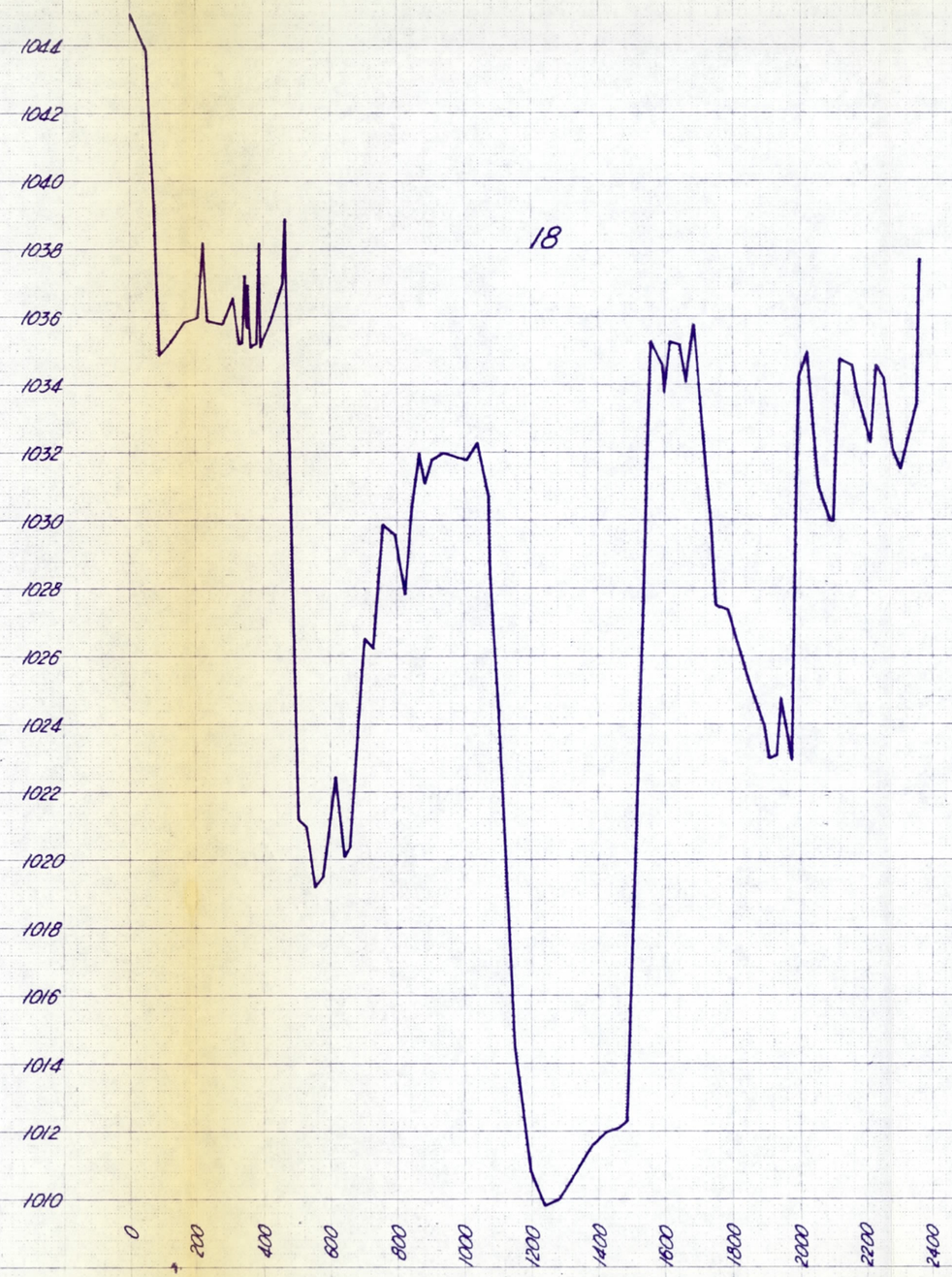



FIGURE A-6
CHANNEL CROSS SECTION
NO. 18

PLATE 3 CROSS SECTION - DOTTED
CHARLES BRUNING COMPANY
MADE IN U.S.A.

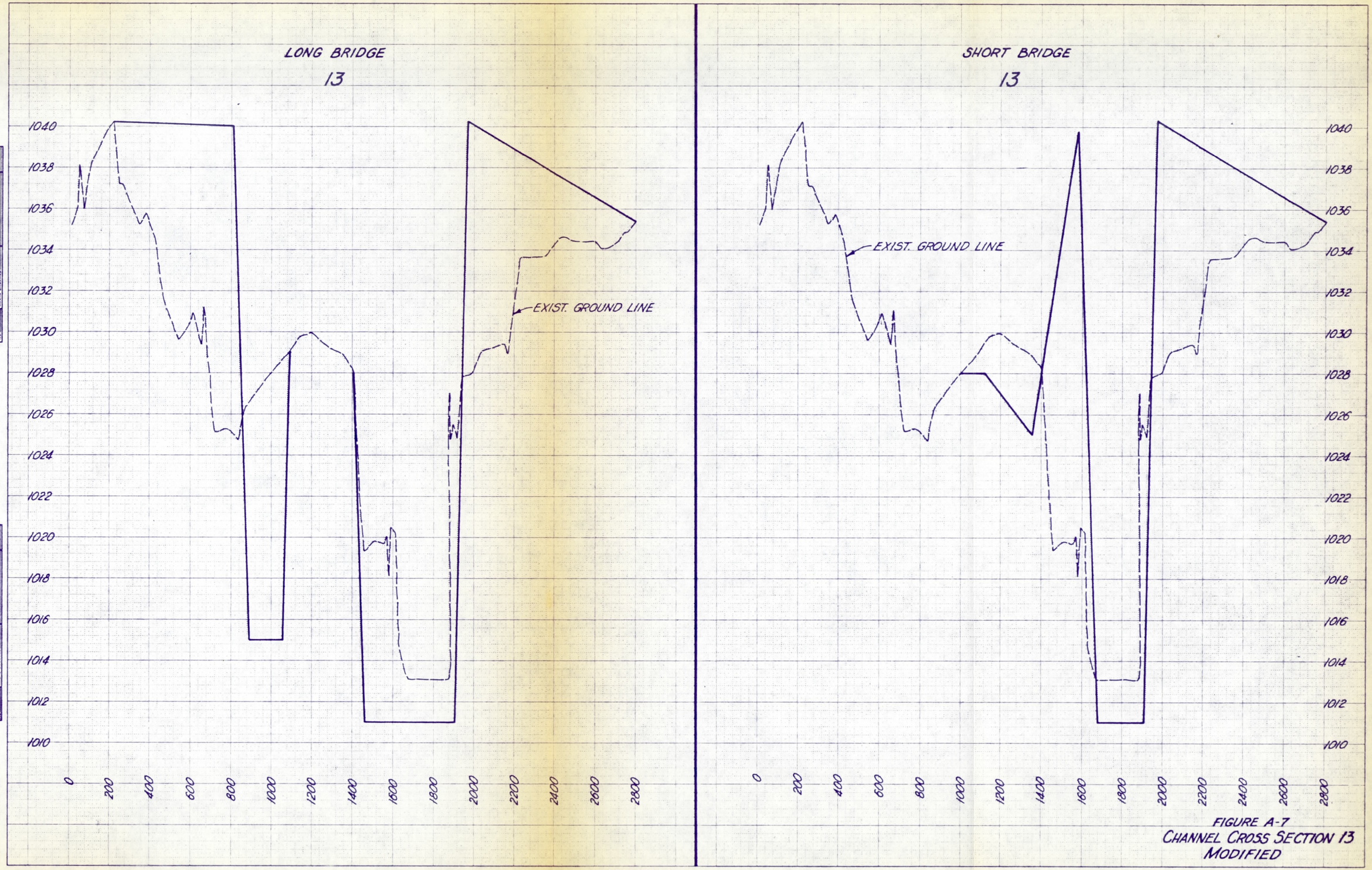



FIGURE A-7
CHANNEL CROSS SECTION 13
MODIFIED

PLATE 3 CROSS SECTION - DOTTED
CHARLES BRUNING COMPANY
MADE IN U.S.A.

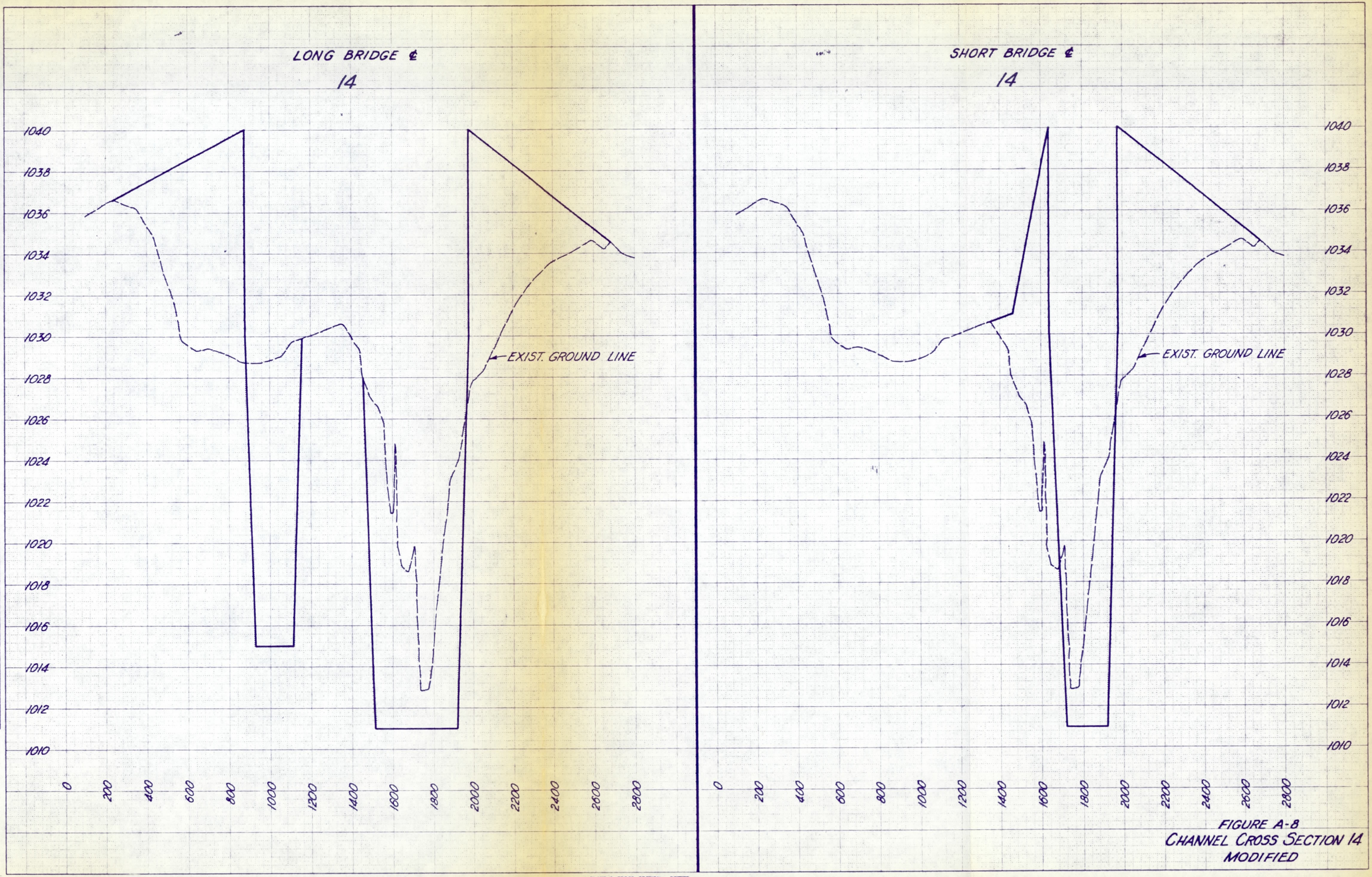



FIGURE A-8
CHANNEL CROSS SECTION 14
MODIFIED

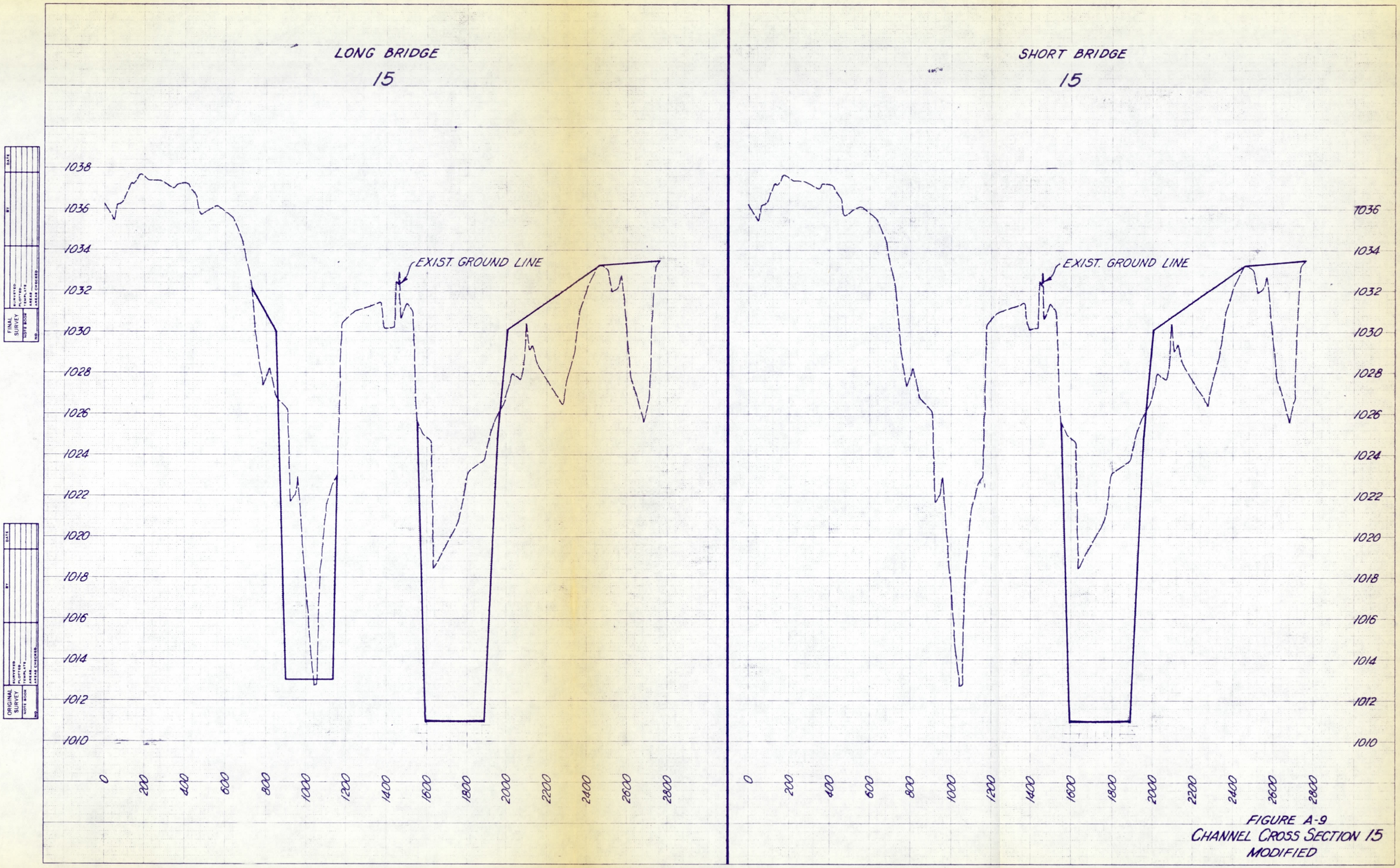
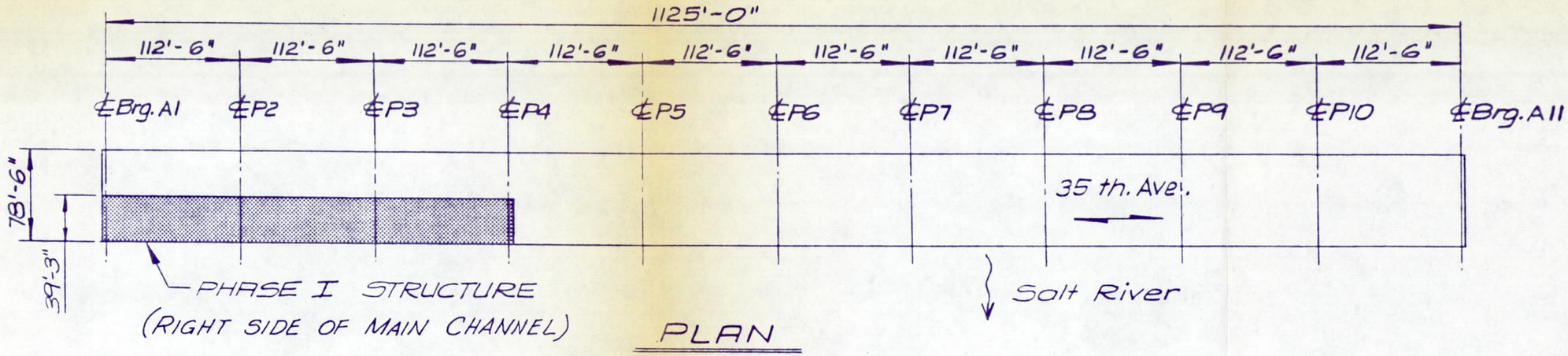



FIGURE A-9
CHANNEL CROSS SECTION 15
MODIFIED

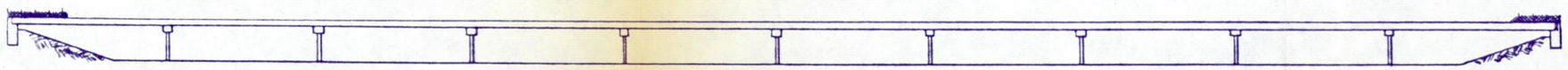
## BRIDGE DESIGN ALTERNATIVES


FIGURE

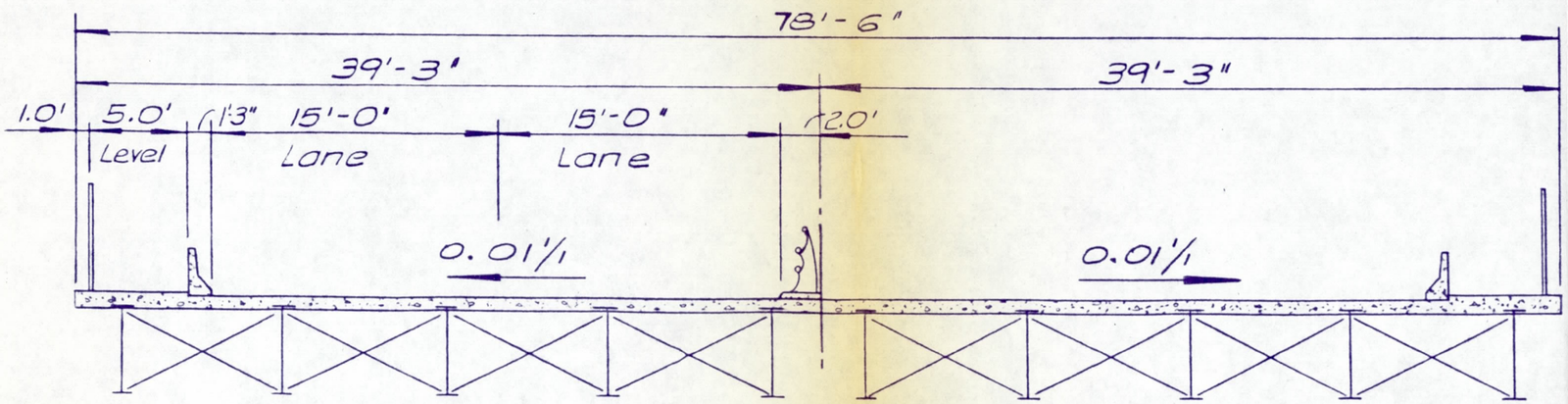
B-1 General Layout Showing Ultimate Structure
B-2 Design Data
B-3 Alternate Three-span Welded Composite Girder, Right Side Main Channel
B-4 Prestress Concrete Bridge Alternate, Right Side Main Channel
B-5 Cast-in-Place Box Girder Girder Alternate, Right Side Main Channel
B-6 Two-span Welded Composite Steel Girders, Right Side Main Channel
B-7 General Layout Showing Ultimate Structure, Left Side Main Channel
B-8 Alternate Three-span Welded Composite Girder, Left Side Main Channel
B-9 Prestress Concrete Bridge Alternate, Left Side Main Channel
B-10 Cast-in-Place Box Girder Alternate, Left Side Main Channel
B-11 Two-span Welded Composite Steel Girders, Left Side Main Channel




PLAN



ELEVATION




TYPICAL SECTION

GENERAL LAYOUT
SHOWING ULTIMATE STRUCTURE

INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

Fig. B-1

## DESIGN DATA

CURRENT AASHTO SPECIFICATIONS

LIVE LOAD: AASHTO HS-20-44 OR INTERSTATE ALTERNATE

DEAD LOAD: ASSUMES 25 LBS. PER SQ. FT. FOR FUTURE BITUMINOUS PAVEMENT.

STRUCTURAL CONCRETE:

| | | | |
|---|---|---|---|
| CLASS D | $F'_c$ | = | 3,000 PSI |
| | n | = | 9 |
| CLASS S | $F'_c$ | = | 4,500 PSI |
| | n | = | 7 |

REINFORCING STEEL:

| | | | |
|---|---|---|---|
| #4 BARS | $F_y$ | = | 40,000 PSI |
| #5 BARS AND LARGER | $F_y$ | = | 60,000 PSI |
| EXCEPT FOR TRANSVERSE DECK SLAB | $F_y$ | = | 40,000 PSI |

STRUCTURAL STEEL:

| | | | |
|---|---|---|---|
| AASHTO M-222 (ASTM A-588) | $F_y$ | = | 50,000 PSI |

LOAD FACTOR DESIGN WAS USED FOR THE PRELIMINARY DESIGN OF ALL MEMBERS EXCEPT THE TRANSVERSE SLAB DESIGN, WHICH WAS DESIGNED BY SERVICE LOAD DESIGN.

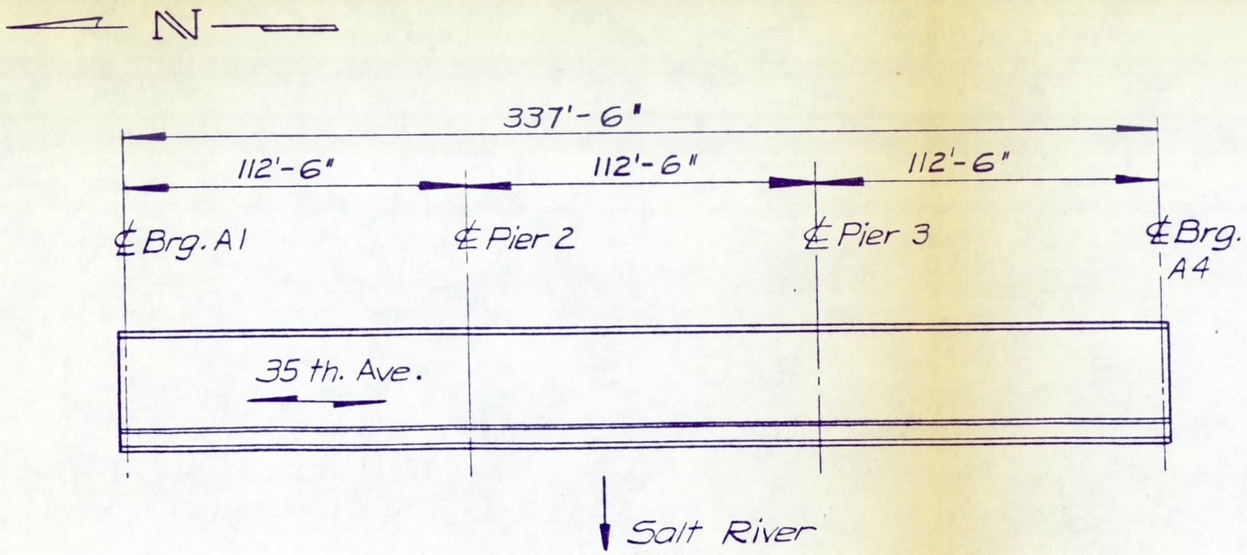
INDEX OF DRAWINGS

PRESTRESS CONCRETE ALTERNATE

CAST-IN-PLACE BOX GIRDER ALTERNATE

2-SPAN WELDED COMPOSITE STEEL GIRDER ALTERNATE

3-SPAN WELDED COMPOSITE STEEL GIRDER ALTERNATE

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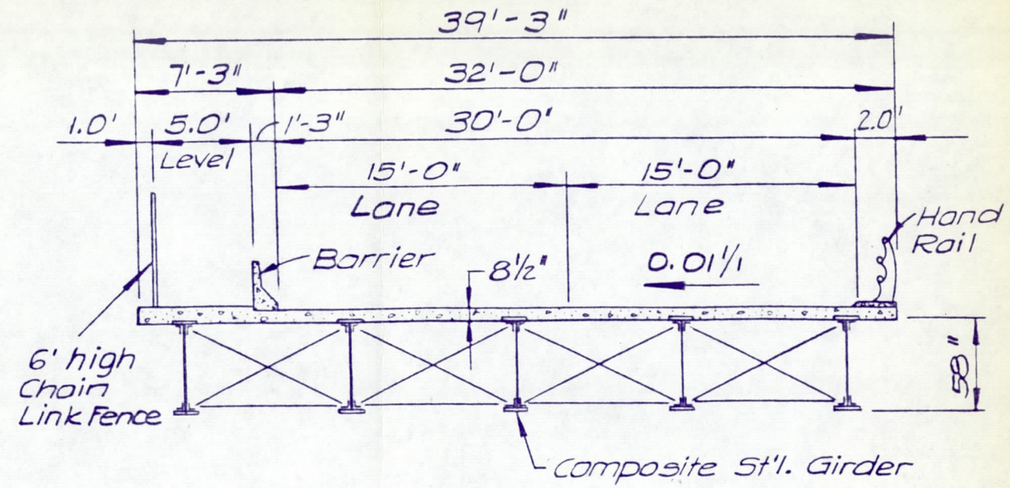


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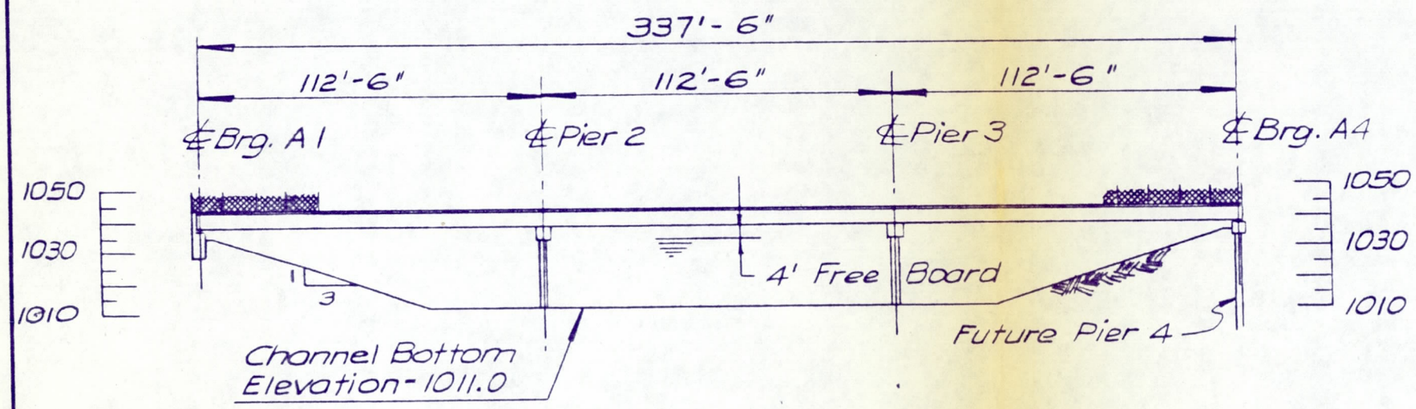



ELEVATION

High Water Elevation - 1033.5

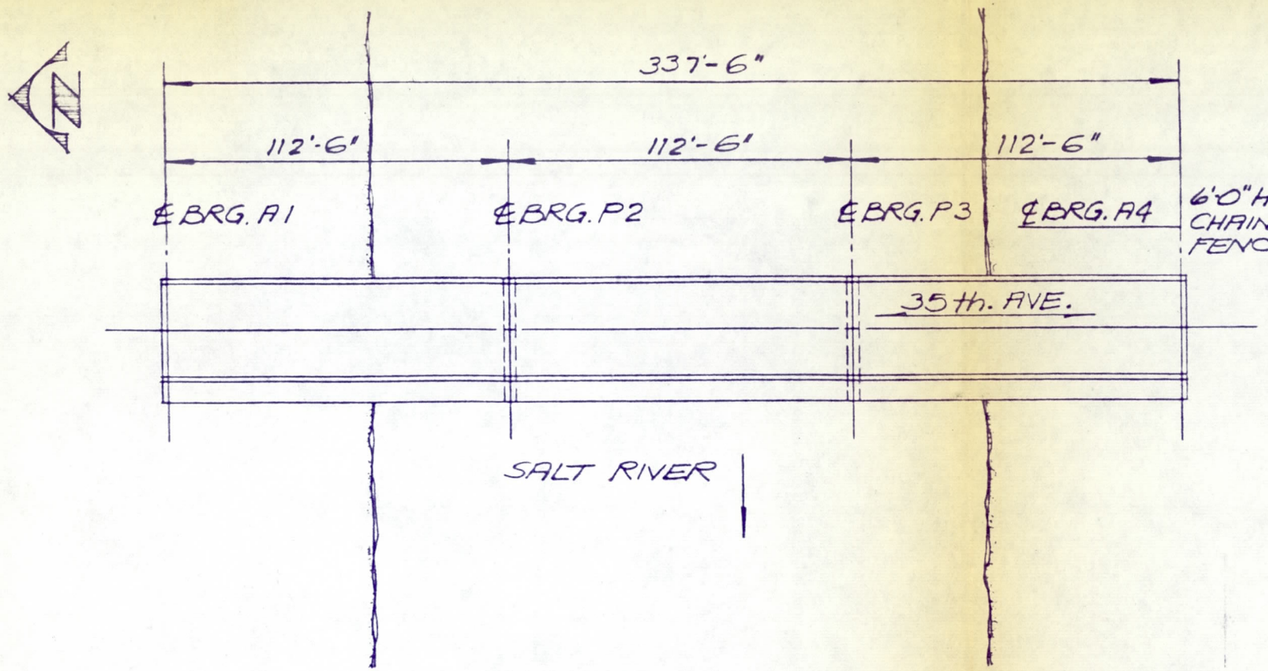
RIGHT SIDE OF MAIN CHANNEL

ALTERNATE
3 SPAN WELDED COMPOSITE GIRDER

INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

Fig. B-3

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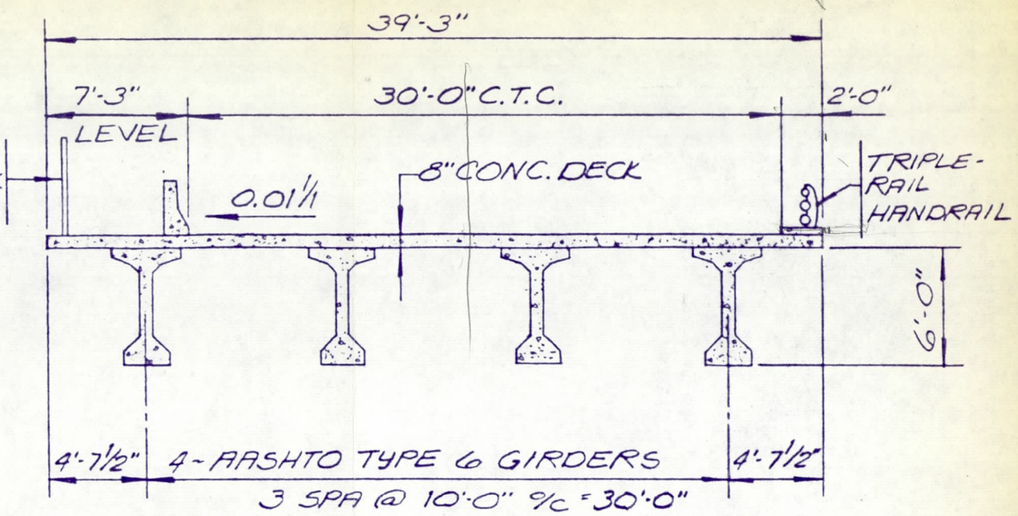
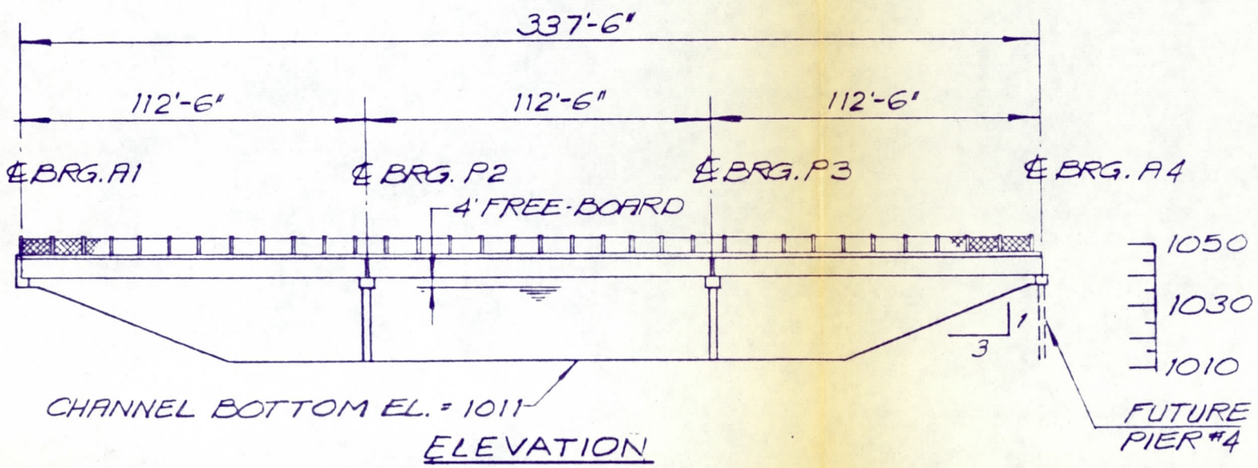



TYPICAL SECTION




ELEVATION

HIGH WATER ELEVATION = 1033.5

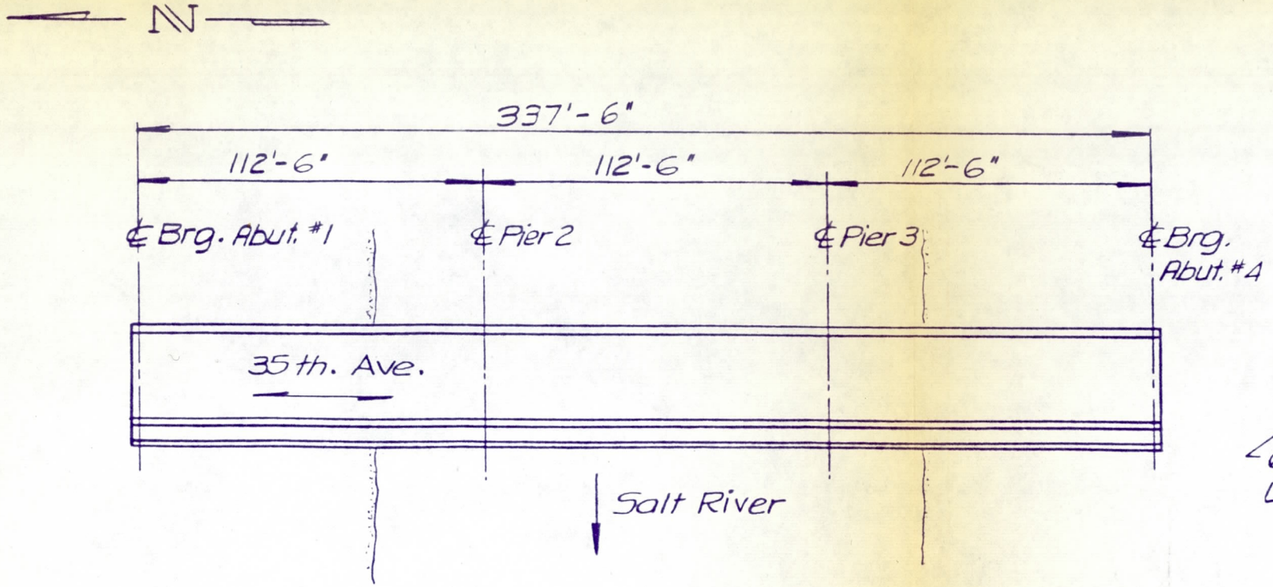
RIGHT SIDE OF MAIN CHANNEL

PRESTRESS CONCRETE BRIDGE ALTERNATE

INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

Fig. B-4

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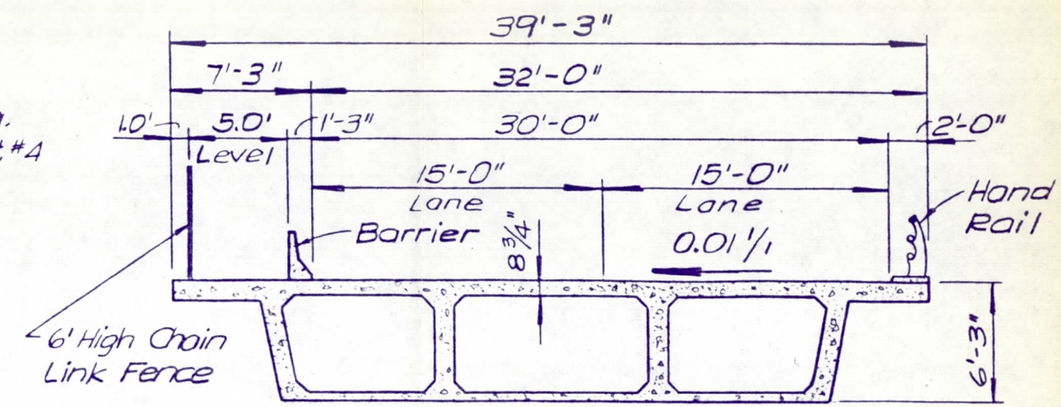


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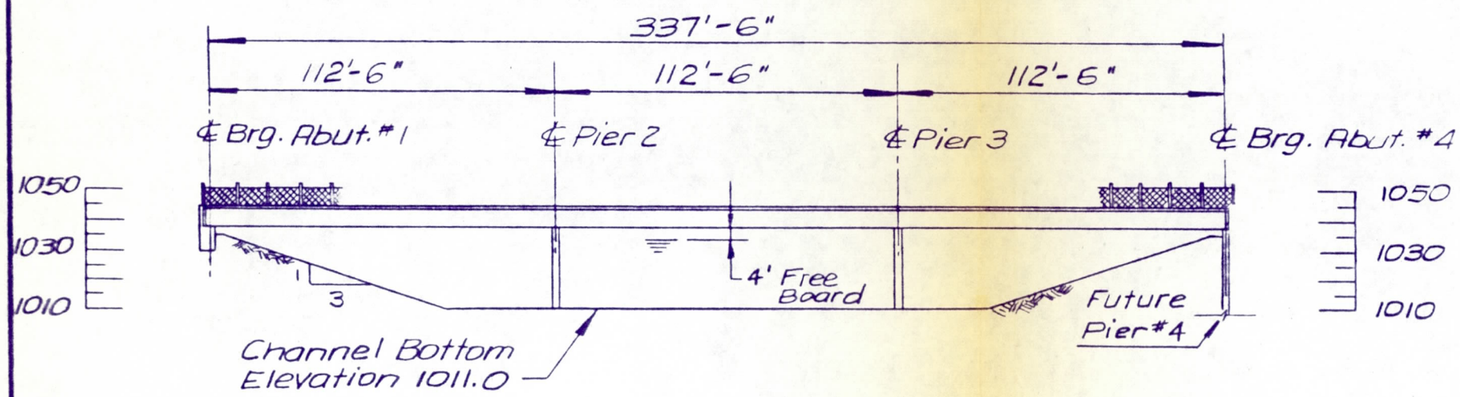



ELEVATION

High Water Elevation - 1033.5

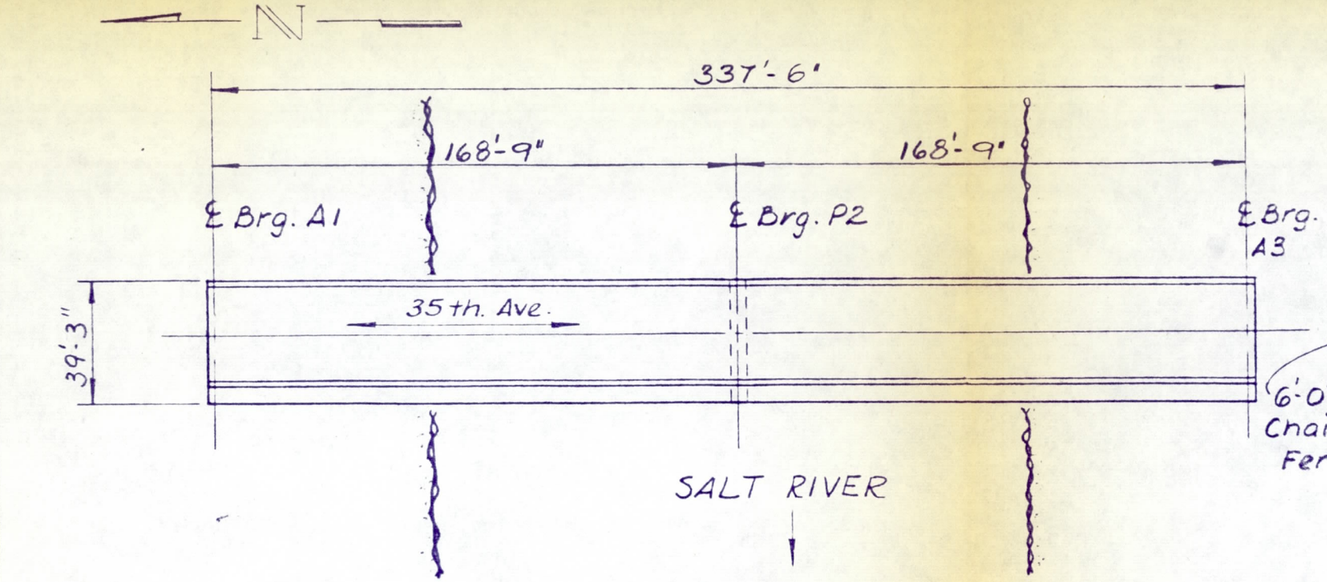
RIGHT SIDE OF MAIN CHANNEL

CAST-IN-PLACE BOX GIRDER ALTERNATE

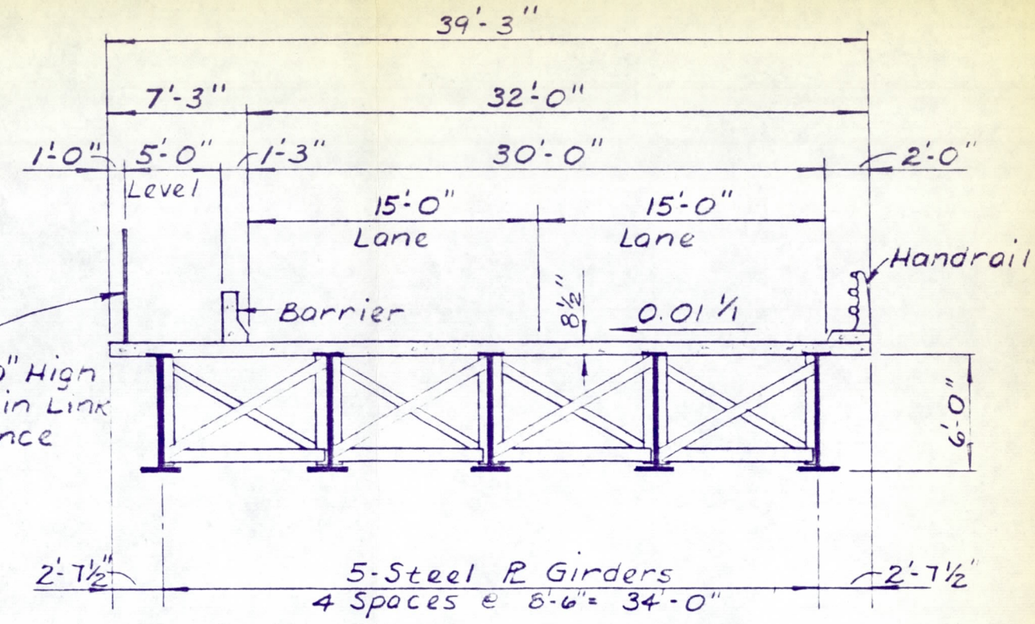
INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

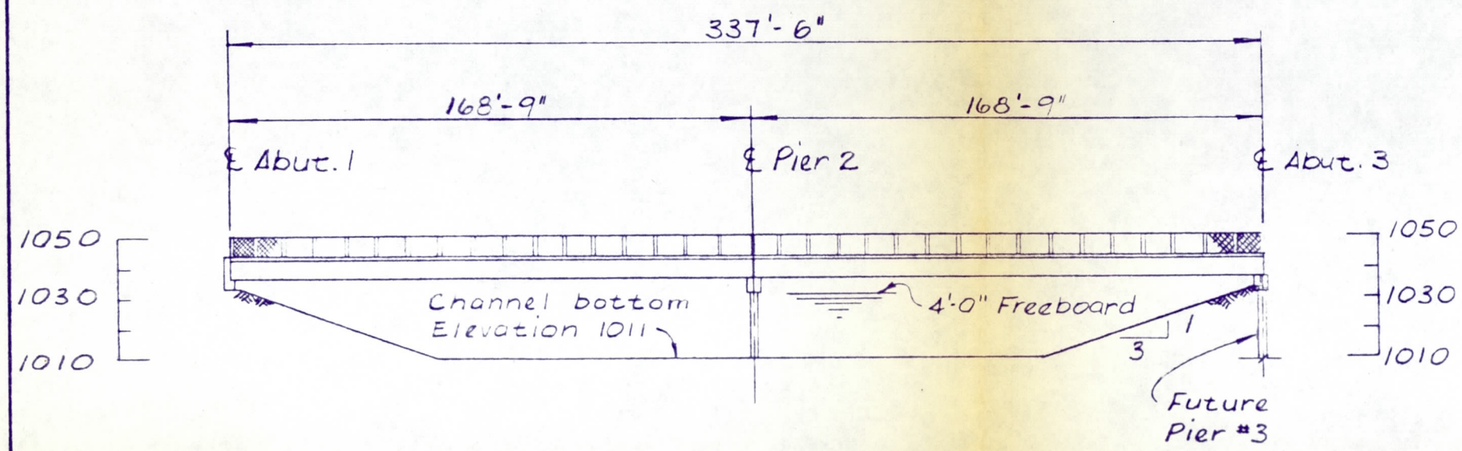
Fig. B-5




PLAN




TYPICAL SECTION




ELEVATION

High Water Elevation = 1033.5

RIGHT SIDE OF MAIN CHANNEL

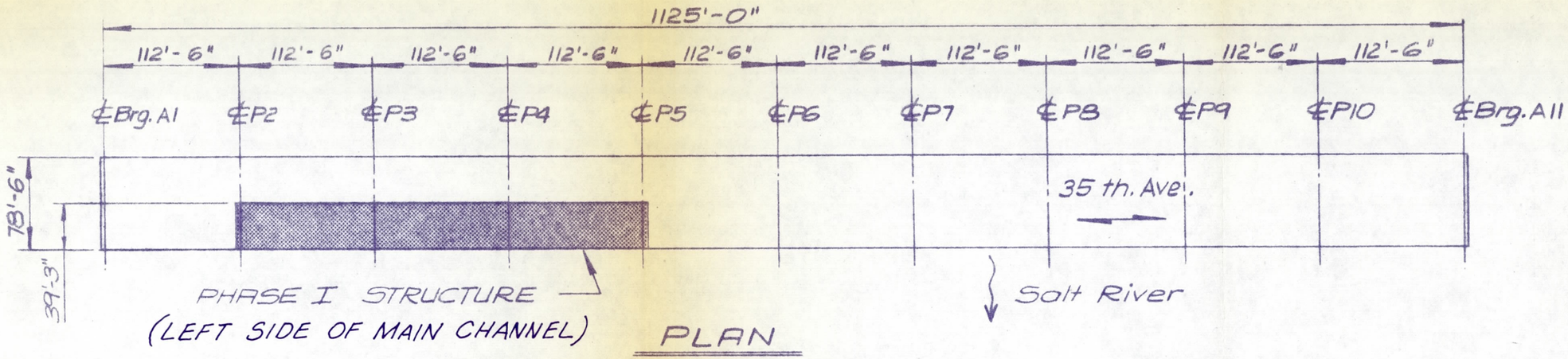
ALTERNATE

2 SPAN WELDED COMPOSITE STEEL GIRDERS

INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

Fig. B-6

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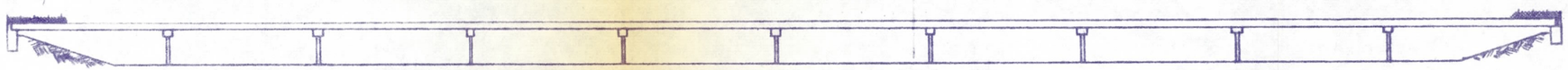
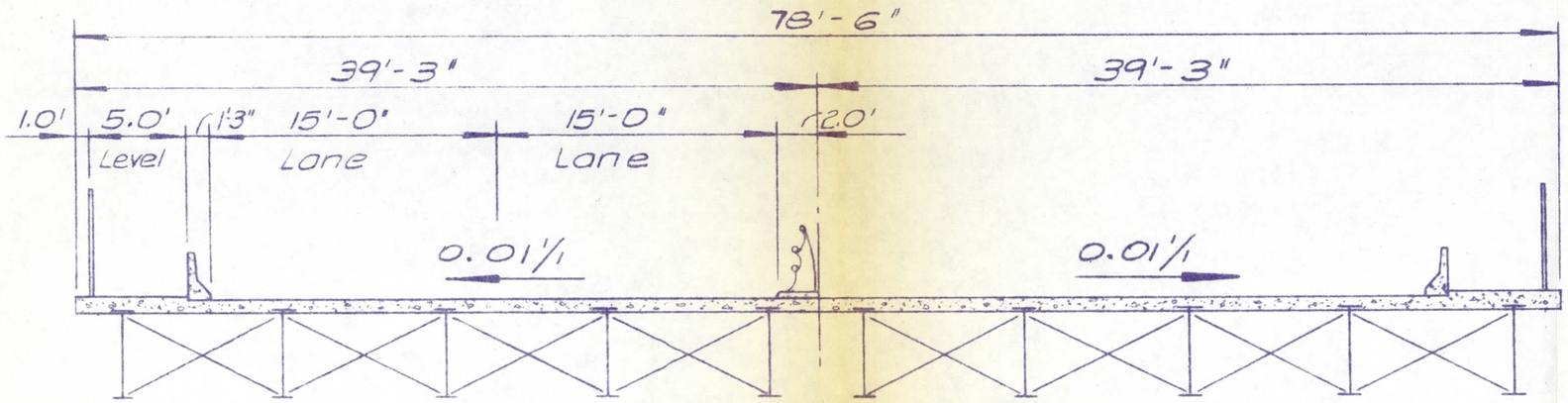


ELEVATION



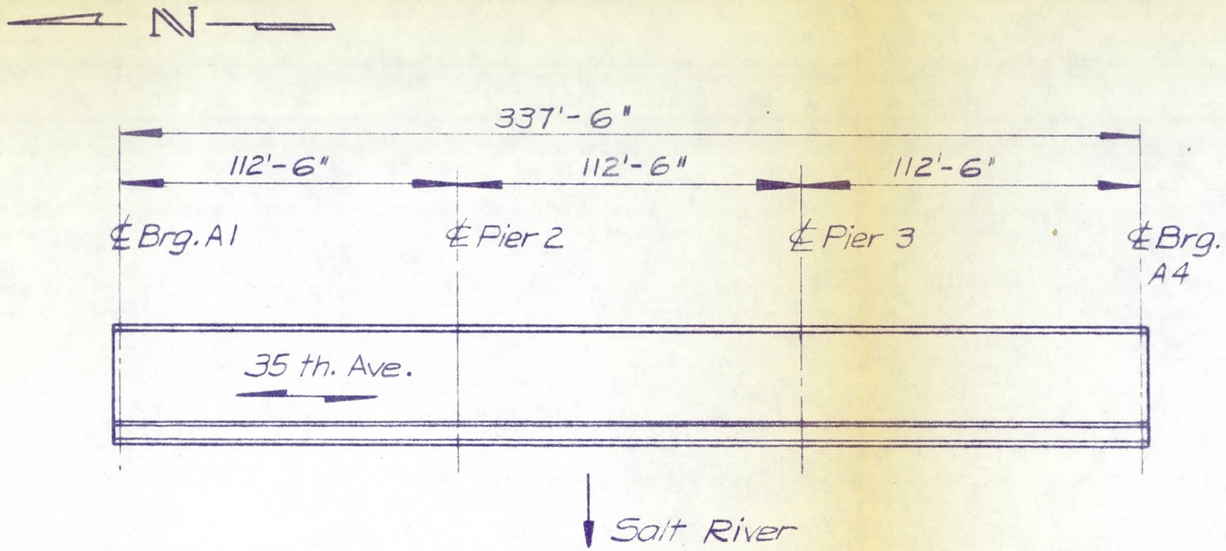

TYPICAL SECTION

GENERAL LAYOUT
SHOWING ULTIMATE STRUCTURE

INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

Fig. B-7

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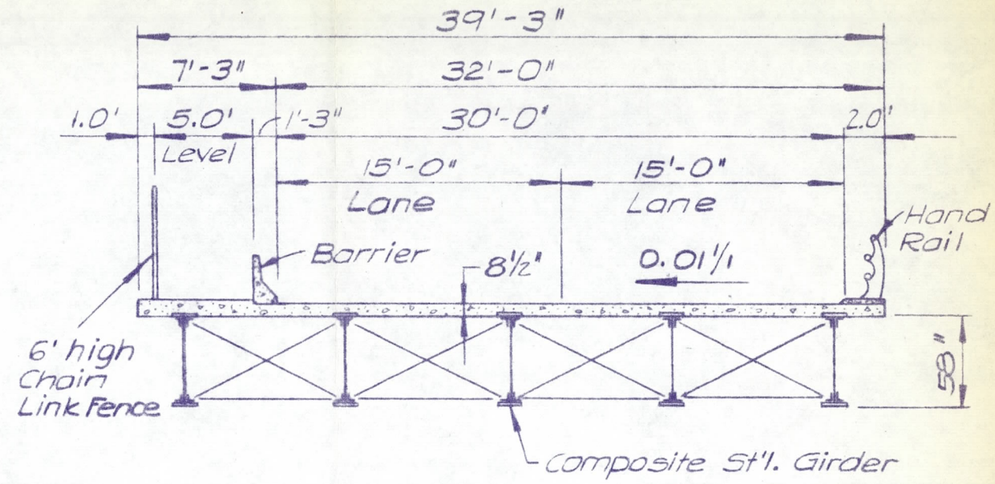


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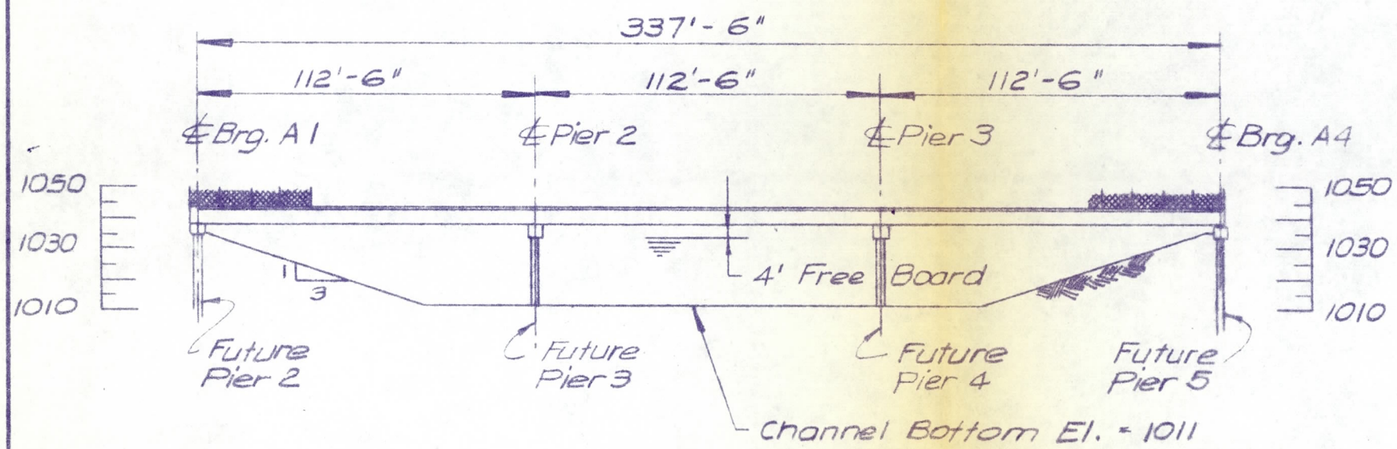



ELEVATION

High Water Elevation = 1033.5

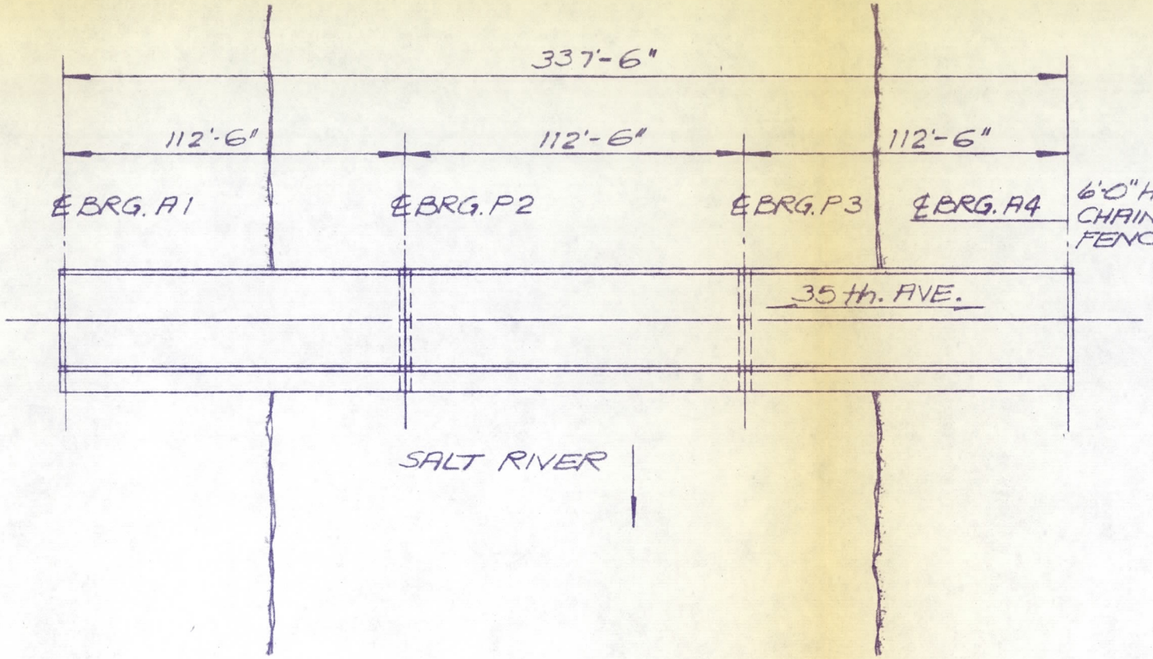
LEFT SIDE OF MAIN CHANNEL

ALTERNATE
3 SPAN WELDED COMPOSITE GIRDER

INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

Fig. B-8

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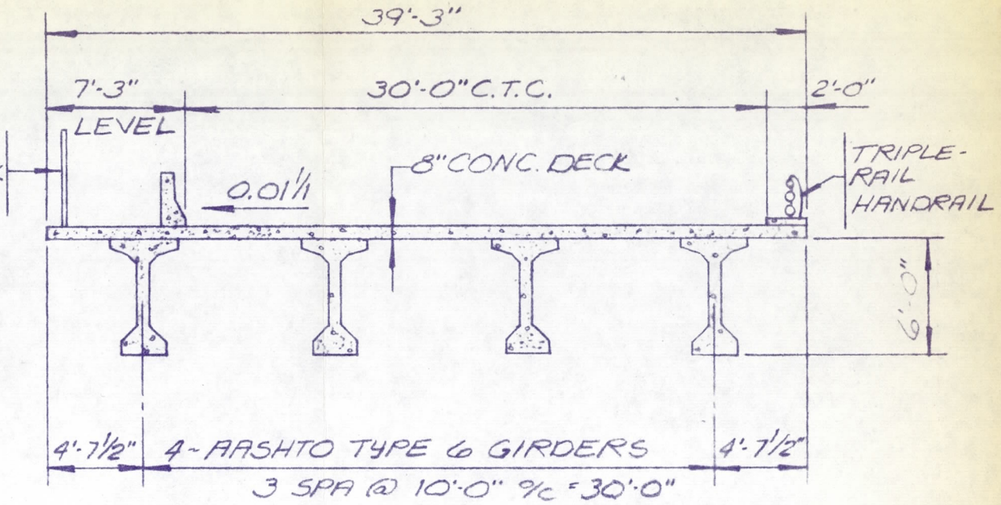


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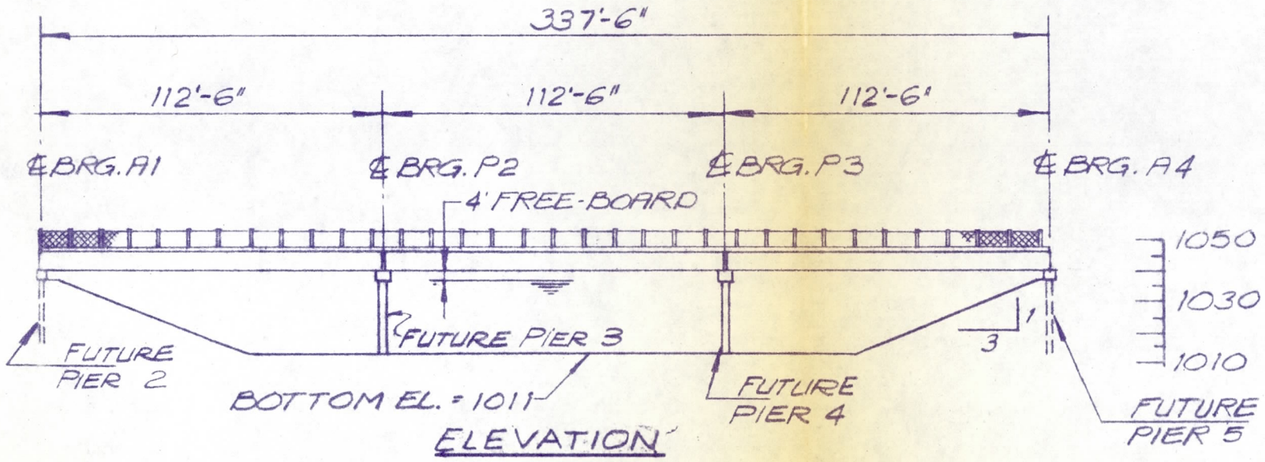



ELEVATION

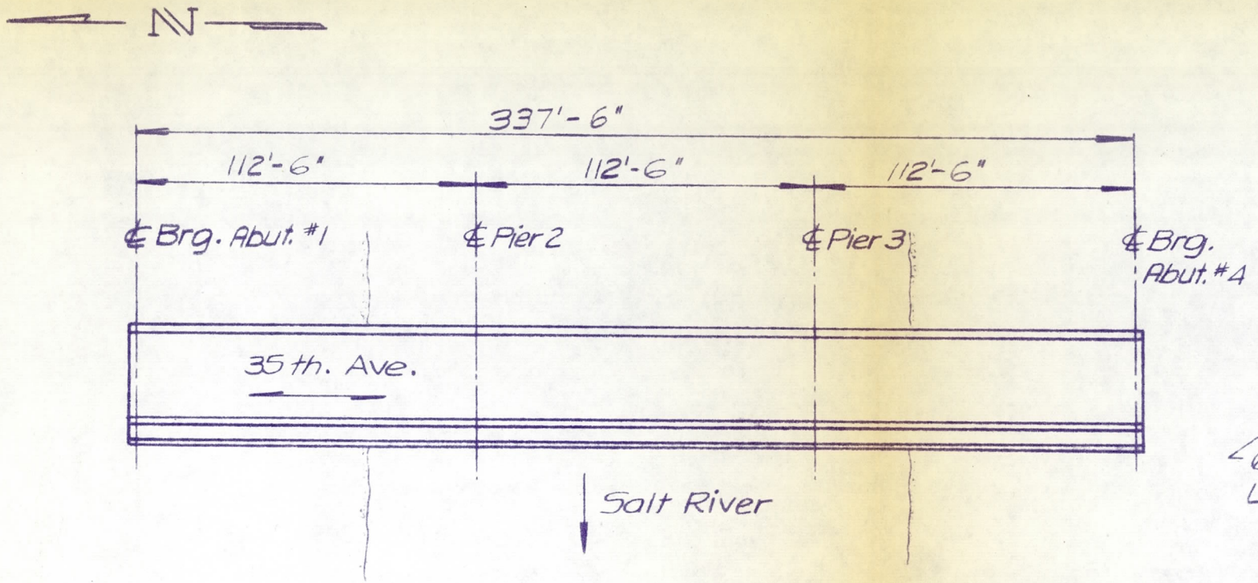
HIGH WATER ELEVATION = 1033.5

LEFT SIDE OF MAIN CHANNEL

PRESTRESS CONCRETE BRIDGE ALTERNATE

INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

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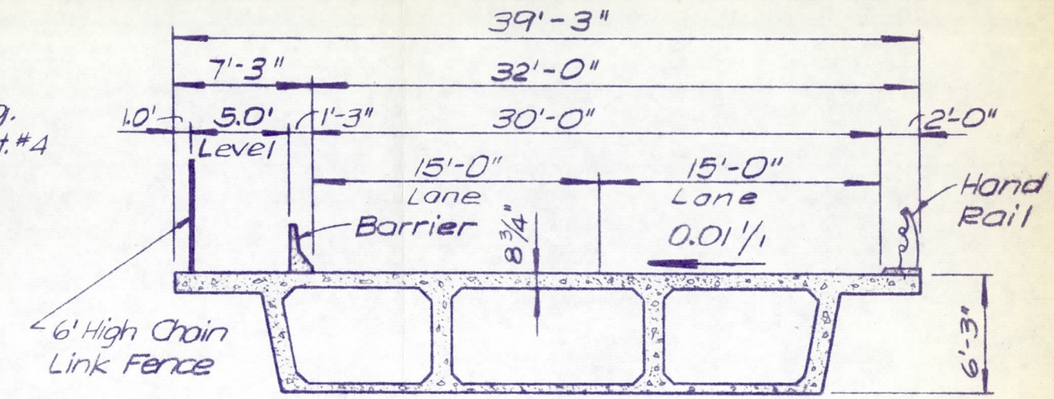


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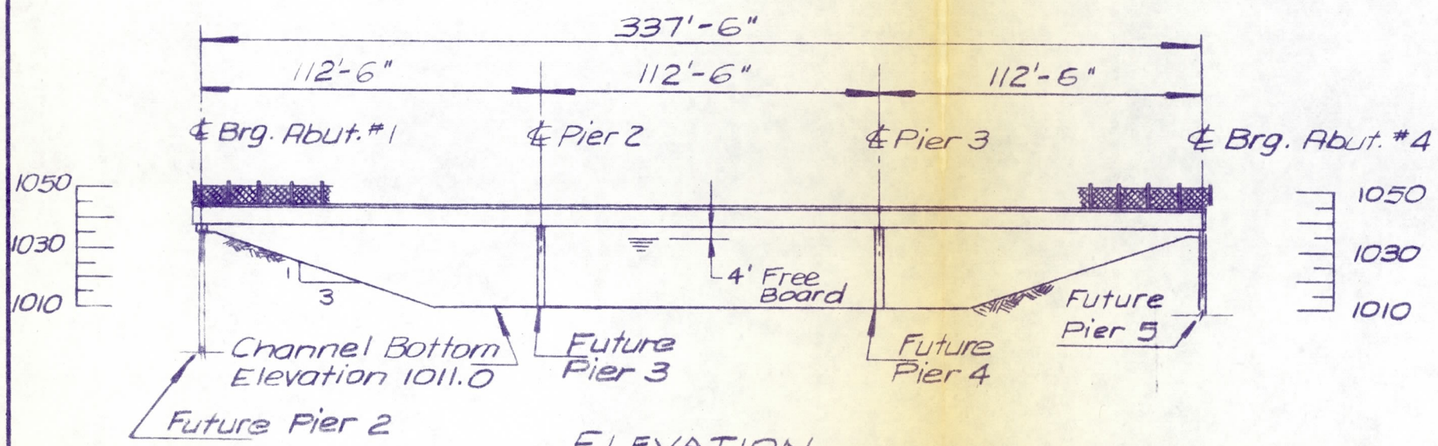



ELEVATION

High Water Elevation - 1033.5

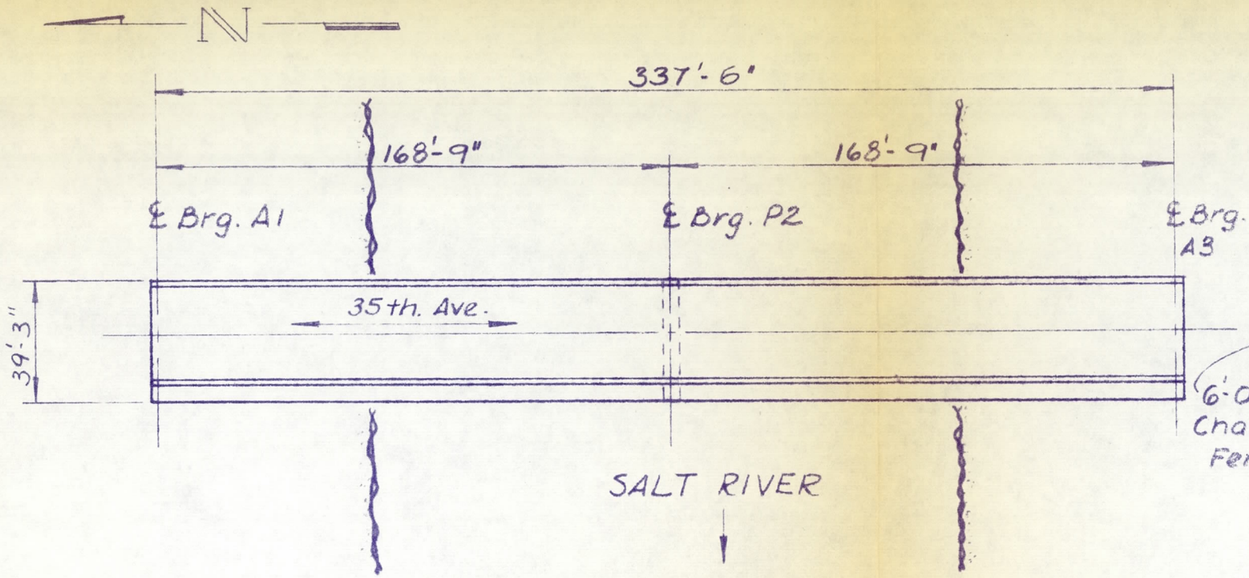
LEFT SIDE OF MAIN CHANNEL

CAST-IN-PLACE BOX GIRDER ALTERNATE

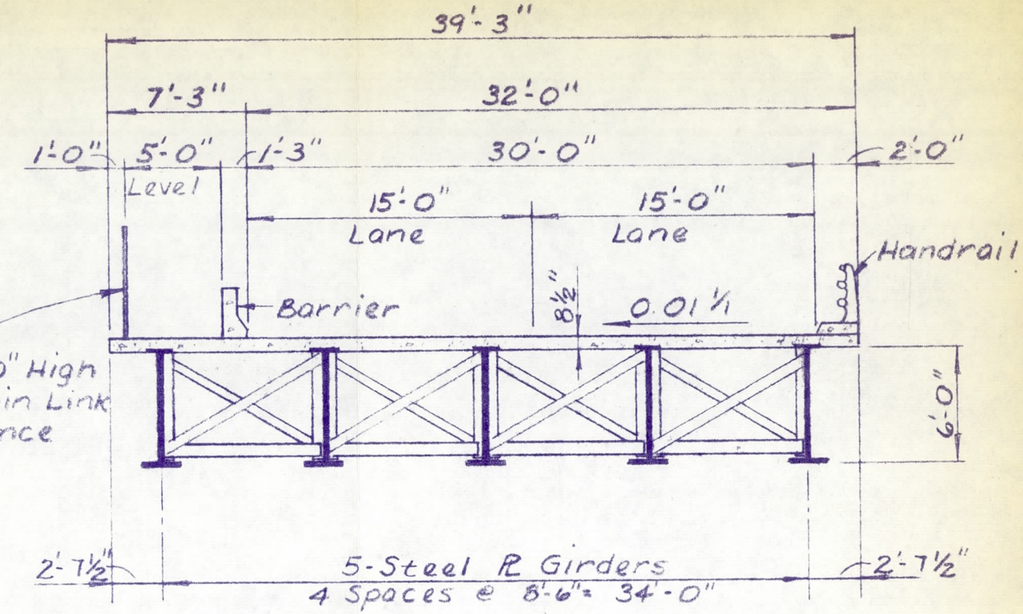
INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

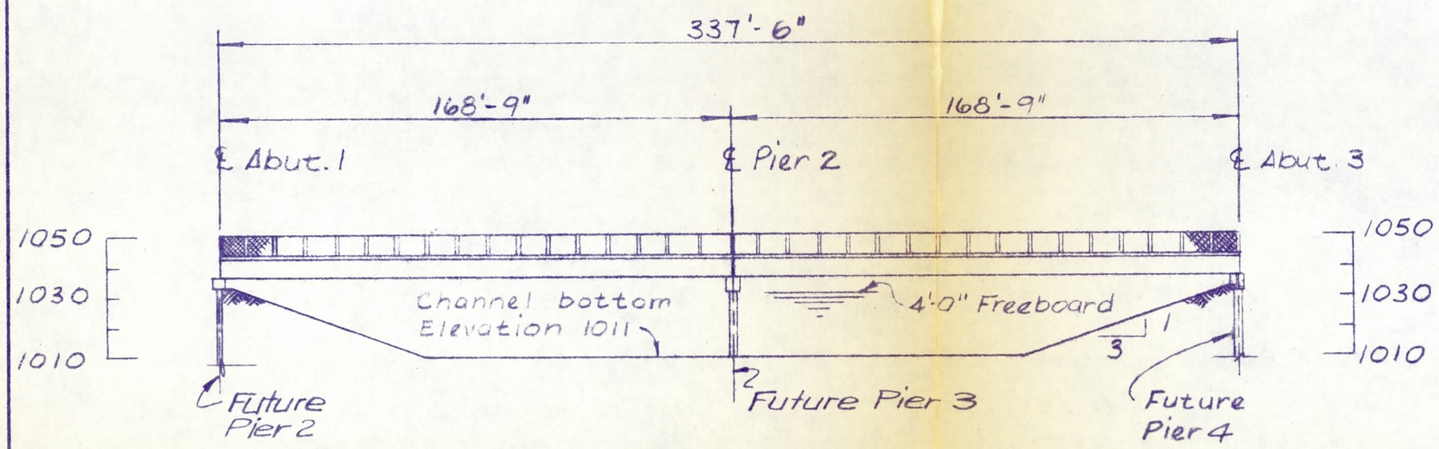
Fig. B-10




PLAN




TYPICAL SECTION




ELEVATION

High Water Elevation = 1033.5

LEFT SIDE OF MAIN CHANNEL

ALTERNATE

2 SPAN WELDED COMPOSITE STEEL GIRDERS

INTERNATIONAL ENGINEERING CO.
2966 W. CLARENDON AVE
PHOENIX, ARIZ.

PHOENIX
35th. AVENUE BRIDGE

Fig. B-11

FOUNDATION INVESTIGATION REPORT

# ATL Testing Laboratories

*A Division of R & D Engineering Associates, Inc.*

Engineers • Geologists

Boyd Smith, P.E. Donald E. Green, P.E.


ATL Job No.: F128054 January 29, 1981

REPORT OF

FOUNDATION SOIL INVESTIGATION

FOR

INTERNATIONAL ENGINEERING CO., INC

PROJECT: 35th Avenue Bridge
35th Avenue & the Salt River
Phoenix, Arizona
Maricopa County

Registered Professional Engineer
CERTIFICATE NO. 5817
BOYD SMITH
Date Signed 1/29/81
ARIZONA, U.S.A.


3130 North 27th Avenue • Phoenix, Arizona 85017 • Telephone (602) 252-3975

# ATL

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FIELD INVESTIGATION----------2

DISCUSSION AND RECOMMENDATIONS----------2

PART II PAVEMENT DESIGN

SITE PLAN

LOG OF BORINGS (1-3)

ON-SITE RESISTIVITY TESTS

Registered Professional Engineer
CERTIFICATE NO.
5217
LOYD
SMITH
Date Signed 1/29/81
ARIZONA, U.S.A.

ATL Testing Laboratories
A Division of R & D Engineering Associates, Inc.
Engineers • Geologists

Boyd Smith, P.E. Donald E. Green, P.E.

ATL Job No.: F128054 January 29, 1981

REPORT OF

FOUNDATION SOIL INVESTIGATION

FOR

INTERNATIONAL ENGINEERING CO., INC.

PROJECT: 35th Avenue Bridge
35th Avenue & the Salt River
Phoenix, Arizona
Maricopa County

PART I - FOUNDATIONS

SCOPE

This report presents the results of a foundation soil investigation performed by this firm at the site of the proposed structure designated above, and as shown on the enclosed Site Plan.

The investigation was undertaken to determine subsurface soil conditions at the site, and to develop criteria for the design of foundations for the proposed structure.

3130 North 27th Avenue • Phoenix, Arizona 85017 • Telephone (602) 252-3975

## FIELD INVESTIGATION

The site investigated is located at 35th Avenue and the Salt River, Phoenix, Arizona.

The area that was investigated spans the Salt River at 35th Avenue. The low flow channel is bordered by old backfilled pits in this general area. In the channel, itself, there is the remnant of the old bridge structure and a temporary crossing.

Three (3) borings were made to depths of from 10 to 66 feet by means of 36 and 48 inch diameter, flight augers, at the locations shown on the enclosed Site Plan.

For additional information, there in-place four terminal electrical resistivity tests were performed at the locations shown on the "Site Plan". The results of those tests are included herewith.

## DISCUSSION AND RECOMMENDATIONS

The electrical resistivity were analyzed for data trend in an attempt to furthur define the "scour line". The interpretation of the data indicates the "scour line" to vary from an elevation of 952 to 959.

The "scour line" has been established at elevations 952 to 958, approximately 55 feet below the stream bed. This material at this depth is described as a silty clayey sand gravel and cobbles with moderate calcareous cementation.

The cast-in-place pile system should be founded at an approximinate elevation of 947. The design contact pressure should be 12,500 pounds per square foot. Settlements are estimated to be 1 inch or less.

Casing will be required for concrete placement.

ATL Testing Laboratories
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Engineers • Geologists

Boyd Smith, P.E. Donald E. Green, P.E.

ATL Job No.: F128054 January 29, 1981

REPORT OF

FOUNDATION SOIL INVESTIGATION

FOR

INTERNATIONAL ENGINEERING CO., INC.

PROJECT: 35th Avenue Bridge
35th Avenue & the Salt River
Phoenix, Arizona
Maricopa County

PART II - PAVEMENT DESIGN

The pavement structure design is developed, based upon the assumption that adjacent river materials will be utilized to form the embarkment for the bridge approaches. Therefore, the minimum pavement stucture for "Major and Heavy Industiral" streets is recommended.

The pavement structure should consist of 4 inches of asphaltic concrete pavement and 10 inches of base material. The base material may consist of 6 inches of type A select material and 4 inches of aggregate base, both conforming to the requirements of Section 702.2 "crushed aggregate" of the M.A.G. Specification.

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# ATL

The asphaltic concrete should consist of type C-3/4.

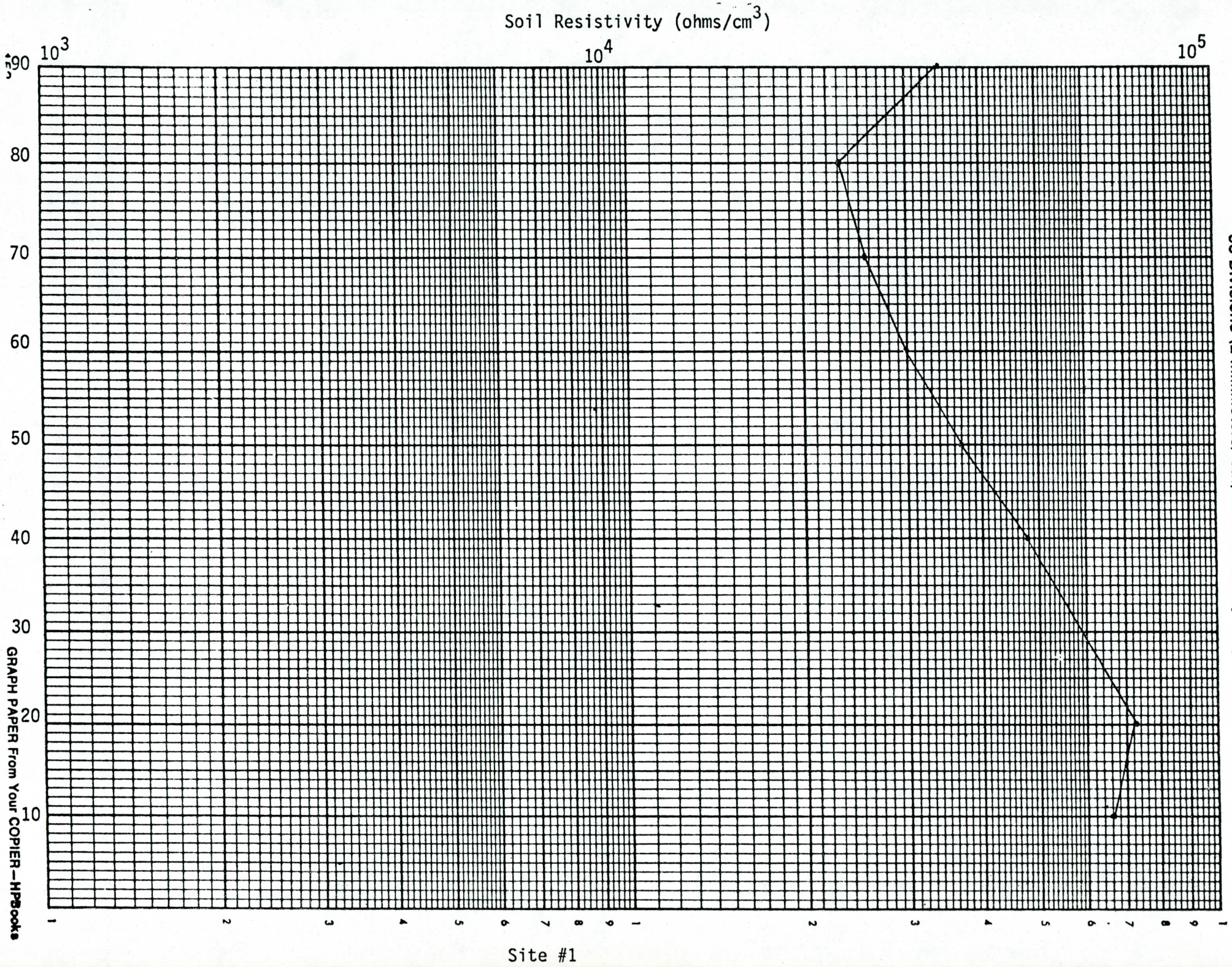
All construction and construction materials should comply with the Standard Specifications for Public Works Construction, sponsored by the Maricopa Association of Governments.

Respectfully Submitted,

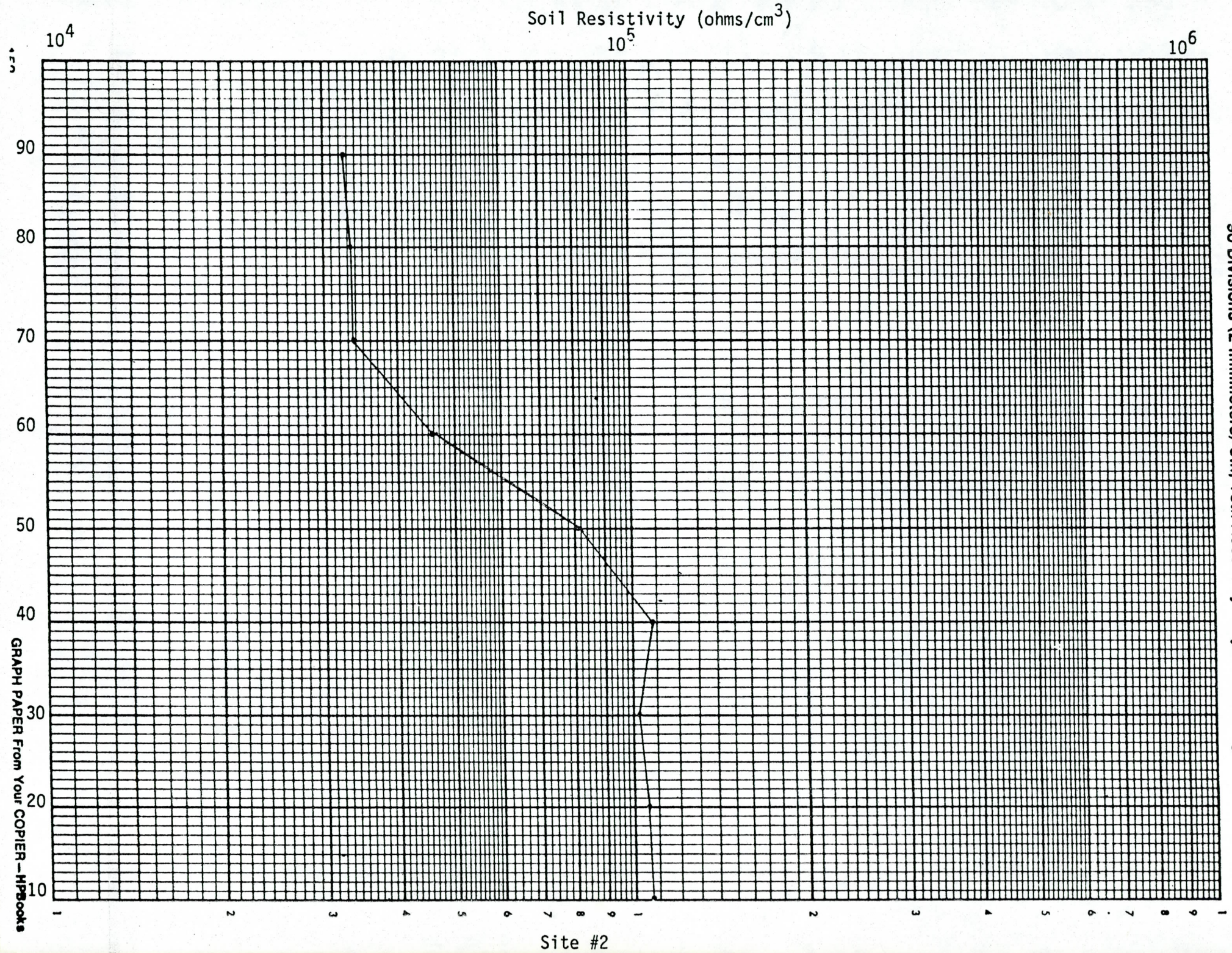
ATL TESTING LABORATORIES

Registered Professional Engineer (Civil)
CERTIFICATE NO. 5917
BOYD SMITH
Date Signed 1/24/91
ARIZONA, U.S.A.

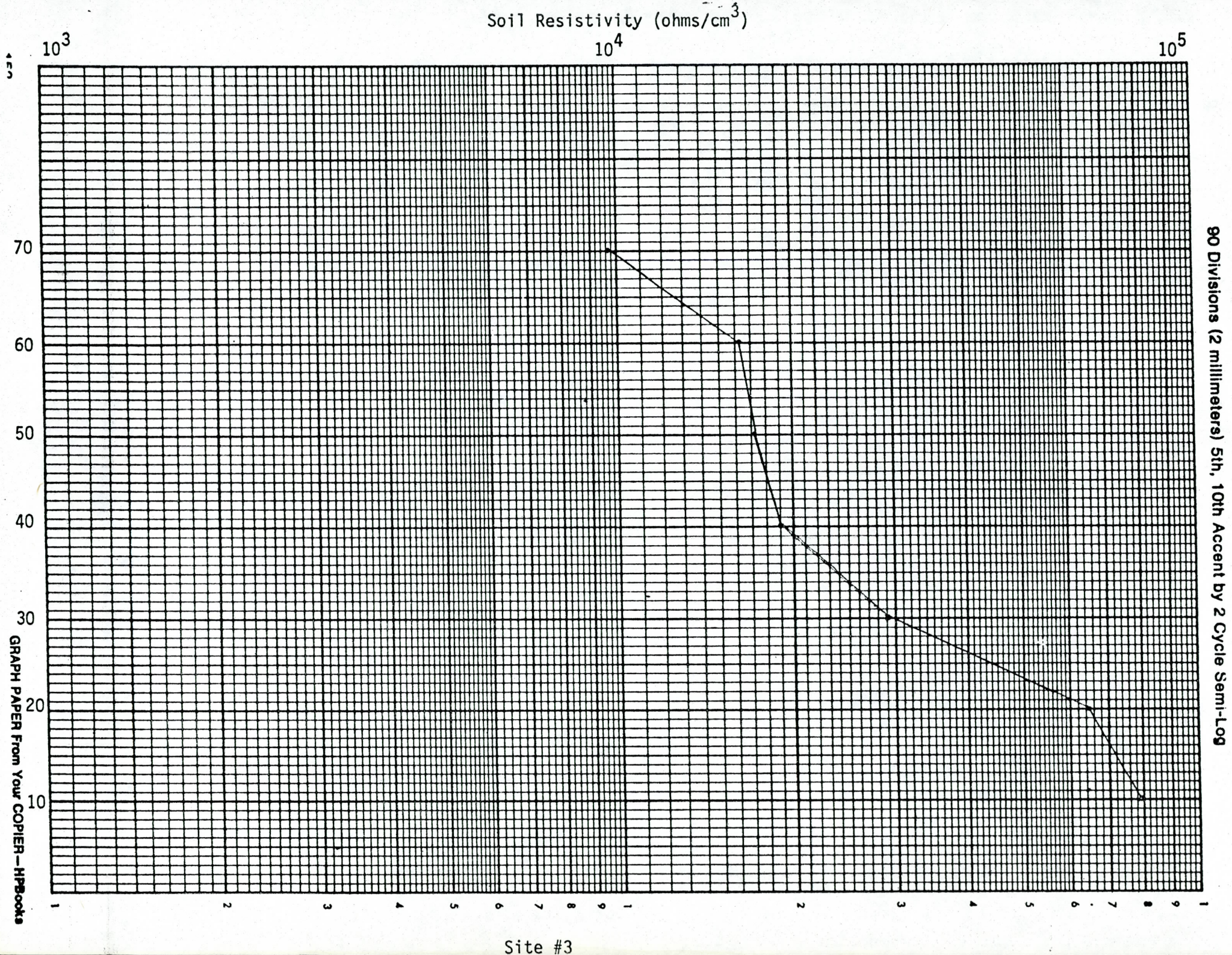
Boyd Smith, P.E.




90 Divisions (2 millimeters) 5th, 10th Accent by 2 Cycle Semi-Log
GRAPH PAPER From Your COPIER—HPBooks




90 Divisions (2 millimeters) 5th, 10th Accent by 2 Cycle Semi-Log
GRAPH PAPER From Your COPIER—HPBooks


Soil Resistivity (ohms/cm3)
10^3
10^4
10^5
70
60
50
40
30
20
10
Site #3
90 Divisions (2 millimeters) 5th, 10th Accent by 2 Cycle Semi-Log
GRAPH PAPER From Your COPIER—HPBooks

Site #2

el. 1027.2; 274.91' left of sta. 29+78.98

3+00 2+00 1+00

| Pin Spacing | Resistivity |
|---|---|
| 10 | 107,240 |
| 20 | 107,240 |
| 30 | 103,410 |
| 40 | 107,240 |
| 50 | 40,430 |
| 60 | 45,960 |
| 70 | 33,512.5 |
| 80 | 33,704 |
| 90 | 32,746.5 |

Bridge before flood

℄

N

| Pin Spacing | Resistivity |
|---|---|
| 10 | 63,195 |
| 20 | 72,770 |
| 30 | 86,175 |
| 40 | 47,492 |
| 50 | 37,342.5 |
| 60 | 29,874 |
| 70 | 25,461.5 |
| 80 | 22,980 |
| 90 | 34,470 |

Note:
Survey done from pin in ℄ on the north side of bridge.

Site #1

3+00 2+00 1+00 0+00

el. 1022.0; 176.35' left of sta. 25+34.30

Soil Resistivities using Vibrogroundex 4-point method

Bore holes

Elevations shown based on bridge deck elevation 1028.0

2+00

BH-3 el. 1012.65 — 152' right of sta 27+82.36

BH-2 el. 1014.10 — 143' right of sta. 27+35.11

1+00 el. 1013.7 146' right of sta. 27+22.40

BH-1 el. 1012.08 — 142' right of sta. 26+90.26

Site #3

0+00

| Pin Spacing | Resistivity |
|---|---|
| 10 | 78,515 |
| 20 | 65,110 |
| 30 | 28,725 |
| 40 | 19,150 |
| 50 | 17,235 |
| 60 | 16,086 |
| 70 | 9,651.6 |

SITE PLAN

ATL Testing Laboratory

1/28/81 | scale 1" = 60'

# ATL TESTING LABORATORIES
## LOG OF BORINGS

For: International Engineering
Date: 1/19/81 Job No. F128054
Project: 35th Ave. Bridge
Type of Boring: 36" Flight Auger
Location of Project: 35th Ave. & the Salt River
Field Party:

Boring No. 1
Location Same as Site Plan

| | | | |
|---|---|---|---|
| 1–2 | | | Silty sand with gravel to silty clayey sand with gravel<br>Light brown<br>Dry with rubble debris |
| 3–8 | | | Silty sand gravel cobbles (up to 8" diameter)<br>Brown<br>Damp with rubble and debris caving-(approx 35% + 3" material) |
| 9 | | | Same material except wetter and no debris & rubble |
| 10–19 | | | End of boring at 10' depth due to severe caving |
| 20–38 | | | |

ATL TESTING LABORATORIES
LOG OF BORINGS

For: _____ Date: _____ Job No. _____
Project: _____ Type of Boring: _____
Location of Project: _____ Field Party: _____

Boring No. 2 continued
Location _____

| | | | |
|---|---|---|---|
| 39 | | | Silty clayey sand gravel cobbles and small boulders (6" max) |
| 40 | | | Brown |
| | | | Slightly moist |
| 41 | | | |
| 42 | | | |
| 43 | | | |
| 44 | | | |
| 45 | | | |
| 46 | | | |
| 47 | | | |
| 48 | | | |
| 49 | | | |
| 50 | | | |
| 51 | | | |
| 52 | | | |
| 53 | | | |
| 54 | | | |
| 55 | | | |
| 56 | | | |
| 57 | | | |

| | | | |
|---|---|---|---|
| 58 | | | Silty clayey sand gravel and cobbles (4" max) |
| | | | Brown |
| 59 | | | Slightly moist |
| | | | Moderate calcareous cementation |
| 60 | | | |
| 61 | | | |
| 62 | | | |
| 63 | | | Silty clayey sand gravel and cobbles (4" max) |
| | | | Brown |
| 64 | | | Slightly moist |
| | | | Moderate calcareous cementation |
| 65 | | | |
| 66 | | | |
| | | | End of boring at 66' depth |
| 67 | | | |
| 68 | | | |
| 69 | | | |
| 70 | | | |
| 71 | | | |
| 72 | | | |
| 73 | | | |
| 74 | | | |
| 75 | | | |
| 76 | | | |

# ATL TESTING LABORATORIES
## LOG OF BORINGS

For: International Engineering
Date: 1/9/81 Job No. F128054
Project: 35th Ave. Bridge
Type of Boring: 36" Flight Auger
Location of Project: 35th Ave. & the Salt River
Field Party:

Boring No. 2
Location Same as Site Plan

| | |
|---|---|
| 1 | Silty sand gravel cobbles and boulders (10"-12" diameter)<br>Brown<br>Dry with rubble & debris |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | Silty sand gravel cobbles and boulders<br>Brown<br>Slightly moist |
| 21 | |
| 22 | Silty sand Gravel cobbles and boulders (10"-12" diameter)<br>Brown<br>Slightly moist<br>No debris |
| 23 | |
| 24 | |
| 25 | |
| 26 | |
| 27 | |
| 28 | Silty clayey to silty sand gravel cobbles (up to 8" diameter)<br>Brown<br>Slightly moist |
| 29 | |
| 30 | |
| 31 | |
| 32 | |
| 33 | |
| 34 | |
| 35 | |
| 36 | |
| 37 | |
| 38 | |

# ATL TESTING LABORATORIES
## LOG OF BORINGS

For: International Engineering
Date: 1/9/81 Job No. F128054
Project: 35th Ave. Bridge
Type of Boring: 36" Flight Auger
Location of Project: 35th Ave. & the Salt River
Field Party:

Boring No. 3
Location Same as Site Plan

| | |
|---|---|
| 1–2 | Silty sand with gravel to silty clayey sand with gravel<br>Light brown<br>Dry with rubble debris |
| 3–10 | Silty sand gravel cobbles and boulders<br>Brown<br>Damp with rubble debris<br><br>Same material except no rubble & debris |
| 11–19 | End of boring at center of 10' due to severe caving |

# ATL

Client International Engineering Co.

Address

Project

Location 35th Ave. & Salt River

Instruments Used Vibroground (4-point method)

Date January 26, 1981

Lab No.

Job No.

Date of Tests 1/26/81

Remarks West side of 35th Ave., south side of the Salt River channel. Silt

## ON-SITE RESISTIVITY TESTS

Elevation=1022.0

| Site No. | Station | Pin Spacing | Read | Constant | Soil Resistivity (ohms/CM) |
|---|---|---|---|---|---|
| #1 | See Site Plan | 10 | 33 | 1915 | 63,195 |
| | " " | 20 | 19 | 3830 | 72,770 |
| | " " | 30 | 15 | 5745 | 86,175 |
| | " " | 40 | 62 | .7660 | 47,492 |
| | " " | 50 | 3.9 | 9575 | 37,342.5 |
| | " " | 60 | 2.6 | 11,490 | 29,874 |
| | " " | 70 | 1.9 | 13,405 | 25,469.5 |
| | " " | 80 | 1.5 | 15,320 | 22,980 |
| | " " | 90 | 2.0 | 17,235 | 34,470 |
| | | | | | |
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# ATL

Client International Engineering Co.

Address

Project

Location 35th Ave. & Salt River

Instruments Used Vibroground (4-point method)

Date January 26, 1981

Lab No.

Job No.

Date of Tests 1/26/81

Remarks West side of 35th Ave., north side of the Salt River channel. River washed sand and gravel and silt

## ON-SITE RESISTIVITY TESTS

Elevation=1029.2

| Site No. | Station | Pin Spacing | Read | Constant | Soil Resistivity (ohms/CM) |
|---|---|---|---|---|---|
| #2 | See Site Plan | 10 | 56 | 1915 | 107,240 |
| | " " | 20 | 28 | 3830 | 107,240 |
| | " " | 30 | 18 | 5745 | 103,410 |
| | " " | 40 | 14 | 7660 | 107,240 |
| | " " | 50 | 8.4 | 9575 | 80,430 |
| | " " | 60 | 4.0 | 11,490 | 45,960 |
| | " " | 70 | 2.5 | 13,405 | 33,512.5 |
| | " " | 80 | 2.2 | 15,320 | 33,704 |
| | " " | 90 | 1.9 | 17,235 | 32,746.5 |
| | | | | | |
| | | | | | |
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| | | | | | |

ATL

Client International Engineering Co.

Address

Project

Location 35th Ave. & Salt River

Instruments Used Vibroground (4-point method)

Remarks East side of 35th Ave., in Salt River channel. Silt and some gravel

Date January 26, 1981

Lab No.

Job No.

Date of Tests 1/26/81

## ON-SITE RESISTIVITY TESTS

Elevation=1013.7

| Site No. | Station | Pin Spacing | Read | Constant | Soil Resistivity (ohms/CM) |
|---|---|---|---|---|---|
| #3 | See Site Plan | 10 | 41 | 1915 | 78,515 |
| | " " | 20 | 17 | 3830 | 65,110 |
| | " " | 30 | 5.0 | 5745 | 28,725 |
| | " " | 40 | 2.5 | 7660 | 19,150 |
| | " " | 50 | 1.8 | 9575 | 17,235 |
| | " " | 60 | 1.4 | 16490 | 16,086 |
| | " " | 70 | 0.72 | 13405 | 9,651.6 |
| | | | | | |
| | | | | | |
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