AQUA FRIA RIVER CHANNEL

REPORT

AGUA FRIA RIVER CHANNEL REPORT

(1971)

PROJECT NO. I-IG-10-2(37)

HIGHWAY EHERNBERG-PHOENIX

SECTION BULLARD AVE.-107th AVE.

Preliminary

PREPARED BY
DIBBLE & ASSOCIATES
PHOENIX, ARIZONA

February 23, 1971

Dibble & Associates, Consulting Engrs.
3625 North 16th Street
Phoenix, Arizona 85016

Gentlemen:

Re: Agua Fria River Channel Report

Some time ago you delivered to this office a copy of your preliminary report on the Agua Fria River Channel which is connected in with State Highway Project No. I-IG-10-2(37). This preliminary report covers a land excavation of the Agua Fria River Channel for two (2) purposes. (1) To protect the I-10 Project bridge to be constructed across the Agua Fria; and, (2) to provide material for highway construction.

This preliminary report as prepared has the approval of this office; particularly inasmuch as the channel to be constructed follows the U. S. Army Corps of Engineers' channel alignment. This preliminary report shows that this construction will start at or near Thomas Road running southward to where the Agua Fria River makes confluence with the Gila River Flood Plain.

Sincerely,

John C. Lowry
Chief Engineer & General Manager

JCL/jm

Carl

2/22 3:20 pm.

Ben Dibble—

How does Agnew Brin study code. He wanted like an comment before submitting it in final shape to the State.

Please call him

Tue
Noon

Carl —

Ben Sibble gave me this today and asked that I bring it down to the Office. It is a preliminary ~~dcp~~ R.O.W. copy. Note that FCD$_A$ is estimated to cost $400,000.

Lee

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FIGURES:

SUMMARY

From the information and discussion included herein, the following is a summary of the recommendations of this report:

1. That the Arizona Highway Department construct the Aqua Fria Channel north of the I-10 crossing on the Corps of Engineers alignment and acquire the necessary 800 feet right-of-way. This can be done at a less cost than to channelize the existing alignment.
2. That the Arizona Highway Department construct the Aqua Fria Channel south of the I-10 crossing on the Corps of Engineers alignment and acquire the necessary 600 feet right-of-way.
3. That the Maricopa County Flood Control District acquire the additional width for full 1,200 feet right-of-way throughout all of the channel construction. This will involve an estimated expenditure of approximately $400,000.

I. AUTHORIZATION

Dibble & Associates has been retained by the Arizona Highway Department to design and prepare construction plans for an Interstate Highway indentified by the following route designation:

Ehrenberg - Phoenix Highway
Bullard Road - 107th Avenue Section
Maricopa County
Project I-10-2 (37)

Included in this project and located at its approximate mid-point will be the Interstate crossing of the Aqua Fria River, hereafter referred to as I-10 Bridge.

The Aqua Fria River in this vicinity is the subject of considerable planning by the Corps of Engineers and the Maricopa County Flood Control District. Due to this planning a further study was authorized to accomplish basically the following items:

1. Comparison of channel locations upstream from I-10 Bridge.
2. Prepare proposed basis for County - State financial participation for upstream construction and right-of-way.
3. Prepare proposed basis for County - State financial participation for downstream construction and right-of-way costs.

II. SCOPE

It is the function of this study to analyze and compare the economics and other tangible features of the two alignments for Aqua Fria River Channel, that is Thomas Road to I-10 Bridge section, as they relate to existing geographical features, existing and proposed roadways and other improvements, downstream channel work, right-of-way acquisition, and general construction costs.

A comparison of the proposed alignments and the listing of the advantages and disadvantages for each along with the outlining of related downstream channel improvements will be made.

Further, the recommended financial participation of the various agencies involved will be made.

III. INTRODUCTION

A. Background

The Aqua Fria River rises about 7,000 feet above sea level in the mountains of Central Arizona and flows southwest 130± miles before emptying into the Gila River about 4 miles downstream from the mouth of the Salt River, at elevation 910 feet. The course of the stream is about equidistant between two parallel mountain ranges forming the east and west boundaries of the drainage area. Tributaries, except for New River, are generally short.

Two major floods, one in January, 1916 and another in November, 1919 are the largest of record. Each is estimated to have had a discharge of 105,000 cfs at Avondale. Since 1889, the records indicate five large floods within the 50,000 - 80,000 cfs range, four floods within the 30,000 - 50,000 cfs range, and three floods within the range from 10,000 to 30,000 cfs. During that period, eleven additional floods were reported, but without any indication of relative size.

Lake Pleasant Reservoir, a water-conservation reservoir with a capacity of 163,800 acre feet (1962), was built by the Maricopa County Municipal Water Conservation District No. 1 (Beardsley Project) in 1928. Since that date one spill has occurred on April 19, 1941, when 500 acre feet were discharged over the spillway.

The United States Corps of Engineers is in the planning

phase of various projects which would have downstream affects on the New River and Aqua Fria River. In reference to the "Interim Report on Survey for Flood Control, Phoenix, Arizona, and Vicinity (Including New River)" as prepared by the Los Angeles District, in conjunction with the Maricopa County Flood Control District, and dated January 15, 1964; these projects are outlined as: Cave Creek and Dreamy Draw Dams, Skunk Creek and New River Dams; Union Hills and the Arizona Canal diversion channels; and the Cave Creek, the Dreamy Draw, the Skunk Creek, the New River, and the Aqua Fria River channel improvements.

The Aqua Fria channel improvement as outlined in the U.S.C. of E. report comprises approximately 7½ miles, from the reconstructed mouth of the New River to a point about 2 miles downstream (south) of the U.S. Highway 80 Bridge. Design concepts and capabilities of this channel will be discussed later in this report.

Analysis of the growth patterns within the Phoenix Metropolitan area indicates that expansion of the Phoenix urban area into the Skunk Creek - New River - Aqua Fria River area has occurred in the past five years and this change from agricultural to urban usage will continue. It has been estimated in the U.S.C. of E. report mentioned herein that . . .

". . . the urban type developed areas in the overflow area will increase from roughly 4% in 1964 to 20% in 50 years."

This growth potential indicates urgency for construction of the proposed projects for not only economic and other tangible considerations, but also for the intangible ones of loss of life, environmental conditions (water contamination), adverse publicity attendant to flooding, and interruption to public services.

Upon inspection, it appears that sound preliminary investigation has been made by the U.S.C. of E. relative to analyzing the flood potentials, cost to benefit ratio, and design capacities for improvements proposed for the Aqua Fria drainage basin.

The cross-section dimensions, design depth, flow estimates, stream bed flow lines and gradients, right-of-way widths, and other criteria relative to the design of the "improved" Aqua Fria River channel were used from the U.S.C. of E. report to calculate construction quantities, right-of-way needs, highway protection devices, and bank protection. The costs generated by these factors helped formulate a cost comparison between the two alignments under consideration for the approach channel and in preparing a preliminary cost estimate for downstream channel improvement, predicated on and in adherence to the approved plan of the U.S.C. of E. for the said channel improvement.

B. Project Hydraulics

1. General: As illustrated on the Photo Plan Map attached (Figure 4) the flood plain of the Aqua Fria River in the subject area is generally 4,000 to 5,000 feet wide and approximately one mile wide at the I-10 crossing. In lieu of the tremendous cost of constructing bridges to span this area without constricting water passage through the highway area, the Arizona Highway Department, Bridge Division, has investigated the hydraulic capabilities of an improved channel corresponding to various structure lengths being studied, while attempting to hold channel flow lines and other geometrical features as generally outlined in the U.S.C. of E. master plan for the river channel improvement (1964).

Since the proposed 1,050 foot bottom width is only 20%± of the total flood plain width in the area, new grade lines (depth and gradients) and bank protection had to be developed to insure river capacity, retard bank erosion, and reduce to a minimum the possibility of constricting water-flow to such an extent as to cause water back-up which would contribute to flooding of adjacent land and cause potential erosion and other damage to the roadway of the proposed I-10 highway. Any such action would tend to make the highway fill act as a dam or a throttling devise which is directly opposite to the intent of such construction.

There is still another factor, however, to be considered

in developing a design depth and stream bed flow line to adequately handle the planned watershed. The planned drainage design of I-10 is such that it has a significant effect on the downstream channel design. A parallel channel constructed on the northerly side of I-10 has flow lines which will bring intercepted lateral drainage and run-off from 27th Avenue westward to the Aqua Fria and from Bullard Road eastward to the Aqua Fria.

For a 50-year storm, the design discharges have been estimated to be 3,000 cfs for each channel. Assuming the design times of concentration to coincide, the maximum design discharge for these two channels would be Q=6,000 cfs.

This intercepted flow follows a path more directly south at the present time and enters the Aqua Fria, Salt and Gila River channels at points downstream and considerably south of the I-10 alignment; therefore, these I-10 parallel channels will intercept, divert and eventually concentrate the water in the Aqua Fria River just upstream from the I-10 Bridge. Because this water is not native to currently proposed flow and because the Aqua Fria River is shallow, the downstream channel must be designed to insure that no damage can occur to private properties as a result of the 6,000 cfs discharge.

2. Design Q: In addition, the Arizona Highway Department, Bridge Division, initiated a request to the U.S. Army Engineer District, Los Angeles, Corps of Engineers for a

discharge value in the Aqua Fria River at McDowell Road. The Corps suggested a value of 60,000 cfs for a 50-year return period based on present conditions. Arizona Highway Department Hydrologists concur with this value and it is used throughout the study as the design discharge for establishing the recommended geometrical and vertical controls for the Aqua Fria River channel crossing.

3. Discussion: A 700 foot bottom channel with 3:1 side slopes was found to be sufficient to handle the design discharge of 60,000 cfs only if the stream bed was lowered and constructed to a gradient adequate to carry this flow or dykes constructed to such a height as to provide the necessary design depth for this volume of water. This recommendation to increase the channel depth is caused by the shallow nature of the existing channel. In order to prevent damage to surrounding properties and the I-10 roadway, the approach channel must contain the discharge flow within its banks. As previously discussed, high discharge overflows the existing river banks and calculations show that the approach channel depth must be about 11 feet, inclusive of freeboard, to contain the water.

Dykes however, have the disadvantage of being highly erodable and restricting local incoming drainage flow.

Lowering the channel is a more favorable solution because (1) the excavated material can be used as embankment for the I-10 roadway and (2) would be consistent with the

design features of the parallel channel of I-10 discussed herein.

The channel that parallels I-10 from 27th Avenue to the Aqua Fria River is a major elevation control point where it enters the approach channel. This channel design is critical because its grades are so flat that the required depth cannot be maintained without constructing dykes or establishing grade lines low enough to provide the design depth. The construction of dykes is objectionable because they interfere with both I-10 surface drainage and storm drainage from the north. Therefore, the elevation in the approach channel where the parallel channel enters must be set low enough to eliminate the need for dykes on the parallel channel from 119th Avenue to the Aqua Fria River.

Hence, a proposed flow line lower than the U.S.C. of E. grade is necessary (maximum of 1½ feet at I-10) and is proposed in the vicinity of the I-10 Bridge. Because of the 6 to 8 feet difference in the existing and proposed grade lines, transition grades have been laid in the vicinity of Thomas Road to meet the existing channel and grade. The downstream channel very nearly follows the proposed Corps alignment and grade and day-lites at the southerly terminus.

4. Erosion Protection: One of the high-cost items being considered in this study is bank protection. Its placement retards erosion of channel banks and secures the constructed channel limits. To generate design needs for the routes

considered herein, we have investigated reports on sedimentation and erosion in alluvial streams.

The following is an article from Carl B. Brown's "Sediment Transportation, Engineering Hydraulics", page 817.

> "21. Movement of Sediment in Alluvial Streams . . material is constantly eroded from the concave banks of bends and deposited to form shoals between bends or bars along the convex side of succeeding bends. The resulting tendency of an alluvial stream to meander is therefore not only one of its most essential characteristics but also one which cannot as yet be handled analytically. Existing knowledge of meander patterns stems almost entirely from field observation, with the exception of an extensive study conducted at model scale by the Waterways Experiment Station, Vicksburg, Mississippi (46). The conclusions reached during this study are essentially as follows:
>
> (1) Once a stream in an erodible bed deviates at any point from a linear course, the resulting unbalance of erosive power tends to increase the local deviation and to repeat it on alternate sides of the stream axis at successive downstream sections.

Each rate of flow has a meander pattern of its own, the radius and cross-sectional area of the average bend increasing with the discharge.

(2) The channel cross-sections are deeper in bends than in reaches above or below, because of the deflection of the flow along the concave banks and its increased erosive power in that part of the section.

Every phase of meandering thus depends upon the combined influence of three closely related factors:

(1) The discharge and hydraulic properties of the channel;

(2) the sediment load of the stream, and

(3) the relative erodibility of bed and banks.

Their interrelationship is very complex, because no single variable can be considered fully independent of the others."

"24. River Improvement for the Control of Floods . . Improvement of rivers for flood control is accomplished by (1) straightening and deepening the channel, (2) building levees to prevent or reduce overbank flooding, ... "

* * * * * * * *

From the above discussion it is seen that if a curved channel were improved by deepening it, the solution may be only temporary because the banks will tend to erode and deposit the material downstream. Therefore, slope protection should be provided for all improved channels which have relatively sharp curves.

When a stream bed and its banks are an alluvial material a temporary solution may result even in a straight channel if slope protection is not provided; however, it is less serious than that for curved channels and may be tolerable when velocities are less than 10 cfs.

For the channels of this study the following concepts are set forth for design purposes:

(1) If curves occur along its alignment, bank protection is required.

(2) Because the channel bed and banks are of alluvial material, velocities shall be computed and bank protection seriously considered for channels on straight alignment.

(3) That the 1,050 foot channel under the bridge shall be at an elevation slightly lower than that proposed by the U.S.C. of E.

(4) That the bridge length is established by the channel bottom width.

(5) That the approach channel shall have a minimum bottom width of 700 feet with 3:1 side slopes

with a flow capacity of 60,000 cfs.

(6) That the approach channel depth shall be 11 feet minimum, inclusive of freeboard.

(7) That the approach channel shall have bank protection where needed.

(8) That the downstream channel must be designed to carry a minimum of 6,000 cfs within its banks.

Hence, we will now proceed to discuss the primary aspects of the upstream channel portion of our study, ie . . .

(1) Approach channel alignments

(2) Approach channel erosion protection

(3) Treatment of cross-roads

(4) Private property affects

(5) Right-of-Way costs

(6) Approach channel construction costs

(7) Reconstructing of existing roads in conflict

(8) Approach channel interrelation with downstream channel and I-10 project

(9) County Flood Control District financial participation.

These items have been studied and the findings including comparative costs, conclusions, and recommendations are presented herein. It should be noted that the comparative costs figures shown in this report are for comparison purposes only and do not necessarily represent a total project cost as it is our primary objective to present sufficient information

to justify and recommend an approach channel alignment and to establish the geometrics thereof.

IV. APPROACH CHANNEL ALIGNMENTS

A. General

The two alignments under consideration in this study involve that portion of the Aqua Fria River from Thomas Road to I-10 Bridge, situated west of Phoenix in Section 35 and 36 Township 2 North and Section 1 and 2 Township 1 North, Gila and Salt River Meridian, Maricopa County, Arizona.

One proposal has as its intent following the general alignment of the existing river. This channel is generally located east of the City of Avondale and west of 115th Avenue; the flow direction being from north to south. The existing low flow channel follows a meandering path which can be seen in Figure 6. Beginning at Indian School Road, the low flow channel follows a relatively linear path until reaching a point about 1/2 mile south of Thomas Road; here the channel deviates from the linear path and enters into a complete reverse curve westerly, which terminates at a point about 1/4 mile south of McDowell Road. From here on to the south, the path is nearly linear, but with some gradual curves.

The other proposal as set forth by the Corps of Engineers tends to eliminate the reverse curve aspect of the river and straighten out an existing bend in the river while providing transition curves at each end for gentle flow through the curve areas. See Figure 7. This alignment is approximately 2,000 feet westerly of the existing river at its

maximum point and tapers back into the existing channel at each terminus, namely Thomas Road and I-10.

For purposes of this study and report and for easier reference thereto, the routes under discussion will be hereafter referred to as existing alignment and Corps alignment respectively.

B. Hydraulics

First inclinations tend to favor improving a river flow along its present course. There is an inherent hydraulic and legal danger in tampering with or altering the natural flow. Experience indicates that peak flows tend to flow in the original channel, subsequently inundating and destroying any improvement lying in the confines of the old stream.

There are some important characteristics to observe regarding flood patterns of the Aqua Fria in the subject area. As noted earlier and as also shown in Figure 4, the flood plain in this area is approximately 4,000 to 5,000 feet wide. Important characteristics to observe regarding this flood plain and the river are (1) that near Thomas Road the water spreads to the west when the low flow channel capacity is exceeded, and calculations by the Arizona Highway Department, Bridge Division indicate that about 2/3rds of a total flow of 60,000 cfs will lie within the plain west of the low flow channel; and (2) that for high flows, say about 20,000 cfs or more, at a point about 1/4 mile north of McDowell Road the water tends to overflow the east bank and continue in a

southerly direction while the river channel curves to the west. This overflow, if left unaltered, will cause damage to the new I-10 roadway because the water will continue southerly until it meets the I-10 roadway embankment. Subsequent erosion and/or washout damage would then occur as the roadway would have to divert this water to the west along and parallel to the I-10 facility. Even though we have outlined plans for a parallel channel in this area, it is not designed to handle this flow, thus subsequent damage would also occur to this channel, its dykes or other attendent features. Hence, this flow must be contained in an approach channel sufficient to accommodate and direct it to the waterway opening at the I-10 Bridge. The above information adds a great deal of insight into the flow characteristics and flood pattern of the river in this area and shows that although the low flow channel has a meandering pattern, that peak discharges show the desired direction of flow and indicates the advisability of considering a channel change to accommodate these needs and tends to accent the desireability of a straight channel as it is most consistent with the areas of inundation during peak flows and eliminates the adverse affects of the reverse curves of the existing alignment. These hydraulic and economic features will be discussed in subsequent paragraphs.

C. Discussion

1. General: Our study involved cost determination for both alignments on these basic items; (1) right-of-way, (2) earthwork, (3) bank protection, (4) treatment of cross-roads, (5) utility adjustments and (6) reconstructing existing roads.

We will discuss these items individually outlining scope, content and findings. A detailed listing and comparative cost summaries are shown in Plates 1 and 2.

2. Cost Comparison Items:

a. Right-of-Way: Our study was inclusive of, but not limited to, the calculating of preliminary right-of-way taking areas and residual areas for all parcels north of I-10, based on a 700 feet bottom channel, 3:1 side slopes and 800 feet width right-of-way for both alignments and for 1,200 feet width right-of-way for the Corps alignment only. See Figure 5 - Right-of-Way Map.

All right-of-way costs, inclusive of severance damages and/or allowances, for residual areas have been estimated by the Arizona Highway Department and are shown in Plate 5.

The 800 feet width right-of-way is sufficient to permit the construction of the 700 feet bottom channel at the grades and side slopes set forth herein. The estimated costs for this 800 foot right-of-way inclusive of severence and/or residual allowances is $214,500 for the existing alignment and $515,200 for the Corps alignment. The estimated right-of-

way cost of 1,200 foot width for Corps alignment is $613,000.

Although the cost is greater for the basic 800 foot right-of-way in the Corps alignment, we have shown hydraulic advantages in this proposal and will further show economical off-sets in actual construction items. In addition, the $97,800 needed to acquire the extra 400 feet of right-of-way for the Corps alignment would appropriately be a Maricopa Flood Control District cost.

b. Earthwork: The cross-sectional dimensions used to calculate earthwork quantities for these alignments were the established 700 foot bottom, 3:1 side slopes and to the depth accommodating the design discharge of 60,000 cfs and the desired freeboard.

Less excavation is required to construct the channel along the existing alignment of course, as the existing stream has an approximate depth of 5 feet. The projected quantity of excavation for this alignment is 1,925,000 c.y. at an estimated cost of $1,347,500.

The Corps alignment is generally through property now under cultivation except for the transition sections at each end. We estimate an excavation quantity of 2,411,000 c.y. at an estimated cost of $1,687,700.

Whereas we outlined in Section II, Scope, we would analyze any affects of these two proposals on the I-10 project, the following items of clarification are set forth:

(1) That these above costs are only for the quantity

anticipated to be removed for the channel construction, and do not reflect related costs to the I-10 construction project.

(2) That shallow dykes are required on each alignment to provide the desired freeboard and that this embankment is 46,000 c.y. on the existing alignment and 10,000 c.y. on the Corps alignment.

(3) That 531,000 c.y. of additional excavation can be obtained from the Corps alignment and is a net total after dyke embankment and its compaction allowance and can be designated as borrow material for I-10 roadway embankment.

(4) That the close proximity of the channel excavation would not increase the unit cost of the excavated material as this material would have to be hauled away and wasted if not used for I-10 embankment.

(5) That the large volume of embankment needed for the I-10 job (1.5 million c.y. for the above captioned project and 2 million c.y. for the westerly contigous section) will actually be reduced if the river excavation is designated a borrow source for the I-10 project.

(6) That, based on additional haul, site acquisition and/or royalties, this same 531,000 c.y. of excavation is estimated to cost approximately $0.95 per c.y. if another source is needed for

it. Even if a source is available, it is estimated that it would take approximately 80 acres of land excavated to a depth of 40 feet to provide the same amount of material.

(7) That this estimated replacement cost is real and must be considered to be a liability inherent in the existing alignment proposal and is an anticipated cost thereto and must be included in the formulation of the total construction cost for that proposal.

(8) That this estimated replacement cost is $504,450 and is shown in Plate 1.

c. Bank Protection: We define "Bank Protection" to be the placing of a rock blanket on the slopes along with the necessary excavation and other allied work and as detailed in Arizona Highway Department Standard C-17.01. We are using rock bank protection as we found this to be less expensive than concrete lined slopes. If concrete lined slopes are constructed, the increase in construction costs for this item on the existing alignment will be directly proportional to the incremental difference in the two types of bank protection.

It was established in Section III, B.4, Erosion Protection; that for channels in alluvial material, bank protection is required at curves. Hence, bank protection is required throughout the total reach of the existing alignment as it is curvelinear throughout. This requires

approximately 10,200 linear feet of bank protection at a total estimated cost of $387,600. $38/lin. Ft

As indicated earlier, the Corps alignment eliminates the undesireable reverse curve aspect of the existing alignment and is generally a straight alignment except for the transition sections on each end.

The decision whether to require bank protection at this time, throughout this straight section is marginal and although this material is highly alluvial, we do not recomment it for the following reasons:

(1) 1,200 feet of right-of-way is available to this alignment thus providing a 200 foot wide sacrificial bank on both sides of the channel, hence some bank erosion is acceptable.

(2) When the County Flood Control District improves the channel they will follow the same alignment but will widen the channel, hence a bank protection built by the Arizona Highway Department would have to be removed at that time.

(3) The alignment follows a generally straight line thus erosive energy due to bends is eliminated.

For these reasons only 3,000 linear feet of bank protection is needed and this is required at the transition near Thomas Road. The estimated cost for bank protection for the Corps alignment is $114,000.

d. Treatment of Cross-Roads: We have considered two treatments for carrying water flow through the

McDowell Road crossing; (1) concrete ford and (2) bridge. For the design discharge set forth and considering the skew angles which the two alignments intersect McDowell Road, we find need for 2,560 linear feet of concrete ford for the existing alignment at an estimated cost of $256,000, and for 2,150 linear feet on the Corps alignment at an estimated cost of $215,000. This difference is even more pronounced when considering bridge crossings. We estimate $1,518,000 for the existing alignment and $998,000 for the Corps alignment. See Plate 4 for a compilation of estimated costs.

We find that the construction of concrete fords will provide sufficient protection for the design flow set forth and is less expensive for the Corps alignment as it is more normal to the cross-road. For economic reasons we recommend concrete ford installation for a dip crossing, hence, these construction costs are used for the costs comparison listing of Plates 1 and 2.

e. Utility Adjustments: There are two overhead powerline facilities in the subject area, both crossing each alignment. The Salt River Project (SRP) has steel structures on four concrete columns, each structure on approximate 1,000 feet centers. The Bureau of Reclamation (BR) has twin wood pole structures on approximate 650 foot centers.

Depending on the span and sag, allowances and the establishing of individual tolerances by each utility, we have determined the relocation costs for only the structures

in physical conflict with the two alignments. It could well be that additional structures will have to be relocated, even though these structures are outside the physical and right-of-way limits of the considered alignment to conform to the tolerances mentioned above.

It is also possible that the existing structures will be reinforced in place by lowering concrete column footing elevations, as practical, but for this study our costs are predicated on relocation.

We find the existing alignment will require relocation of two SRP structures and two BR structures while the Corps alignment will require relocation of one of each. It is possible that more structures will need relocating in adherence to span-sag tolerances, but the net cost savings between the two alignments will remain the same ($20,000). The estimated unit cost of relocating these structures is $15,000 and $5,000 respectively.

f. Reconstructing Existing Roads: We have estimated that it will be necessary to relocate and reconstruct approximately 0.3 miles of El Mirage Road to keep the intersection at McDowell Road out of the channel and ford on the existing alignment while no such relocation is needed on the Corps alignment.

Both alignments require some reconstruction of McDowell Road at each end of the ford installation and construction

under either alignment is considered similar.

Hence, the estimated road reconstruction costs are $35,000 for the existing alignment and $3,500 for the Corps alignment inclusive of excavation, base rock and asphaltic concrete surfacing, and other allied work but does not include right-of-way costs if relocated outside channel or other existing right-of-way.

V. DOWNSTREAM CHANNEL

A. General

In addition to the cost comparative study just discussed and as stipulated earlier in Section II, SCOPE, we were to determine right-of-way taking costs and preliminary earthwork quantities for the downstream channel, from I-10 to 1/3 mile south of lower Buckeye Road (approximately 3.6 miles). In addition, upon receipt of right-of-way costs on these takings and allowances for the severances and residual areas as compliled by the Arizona Highway Department, we were to prepare a preliminary cost estimate for the downstream channel construction inclusive of the excavation, bank protection, treatment of cross streets and utility adjustment.

The termination of the downstream channel is as illustrated with the profile grade predicated on a continuation of the channel grade line established through the I-10 section to day-lite with the existing channel bottom at the downstream end which lies in the Salt and Gila River flood plain. See grade detail in Figure 8.

B. Hydraulics

Because of the concentration of the 6,000 cfs from the I-10 project and the necessity to do enough grade work downstream to provide a smooth transition from the lowered channel upstream as outlined herein, it is proposed that the Arizona Highway Department perform the necessary work to improve the downstream section of river channel to prevent damage to

private properties and their I-10 roadway.

To accomplish this a 450 foot bottom channel with 3:1 slopes is proposed from Van Buren Street to the end with a transition section from the 1,050 foot channel at I-10 into this 450 foot wide channel at Van Buren Street.

No attempt has been made to design this channel so that it will contain flood waters within its banks, and for the 60,000 cfs design discharge, the banks will overflow. See the curves in Figure 3 for relationship between depth of flow, velocities and channel capacity. The primary objective of the channel work is to insure that there is adequate capacity to carry the 6,000 cfs from the I-10 parallel channels within its banks. As illustrated in Figure 3 this channel can accommodate the anticipated flow with a design depth slightly in excess of 3 feet. The improved channel will be sufficiently deep except for some irregularities in the existing channel bottom where the construction grade line day-lites the southerly end. This flow can spread as it did before channelization because this terminal point is in the Gila and Salt River flood plain.

The transition section from I-10 to Van Buren Street reduces the channel width from 1,050 feet to 450 feet which will cause a backwater curve of the water surface. The hydraulic requirements for this water surface stipulate that it shall not rise above what it was before the channel improvements are made, and it must be at an elevation which

does not interfere with the I-10 Bridge and Roadway.

The Arizona Highway Department has performed the necessary hydraulics calculations and as indicated in Figure 10, the water surface is well below the limits established above.

C. Discussion

The construction alignment adheres to the future U.S.C. of E. alignment and is generally that of the existing river. This alignment is economically advantageous because it utilizes the existing and proposed bridge crossings at Southern Pacific railroad and U.S. Highway 80 respectively.

As-built plans of the Southern Pacific railroad bridge, which is located adjacent to the U.S. 80 bridge, show that its footings are about 20 feet beneath the existing river flowline. No work is required for this bridge when the downstream channel improvements are made.

Similar conditions exist at the U.S. 80 bridge site as the Arizona Highway Department is currently designing a new bridge crossing for the Aqua Fria with its footings and span(s) designed to meet the needs of the planned improvements. Hence, no additional cost will be incurred at this crossing when the downstream channel is built.

This proposed channel is at a lower elevation than the existing channel; therefore, a concrete ford crossing is required at Van Buren Street. On-site inspection of the existing ford crossing of W.P.A. vintage, indicates fords have worked very well in the past and are recommended for

the new crossing. Cost comparisons for bridges vs fords are shown in Plate 4.

Based on the established dimensions for this channel, we estimate approximately 1,949,000 c.y. of excavation can be expected. This material can be used for roadway fill on the I-10 project, and should be made a mandatory borrow site.

VI. COST ESTIMATE SUMMARIES

A. Comments

Having studied the comparative cost items for the suggested upstream channel alignment and the downstream channel, we have compiled cost estimate summaries which are illustrated in Plates 1 through 5.

It should be noted that the comparative cost figures, individual summaries, or other estimates shown in these subsequent pages are for comparison and informational purposes only and do not represent a total project cost.

Comparative cost summaries for the existing alignment and Corps alignment are shown in Plates 1 and 2 respectively. All major cost items are shown, however, some of the utility costs, crossing protection costs, overhaul or other such costs that are the same or similar for either alignment are not included. Note the inclusion of Item #8 of Plate 1 as outlined in Section IV, C.2.b. Earthwork. The cost summary for the downstream channel is shown in Plate 3.

CONSTRUCTION COST

EXISTING Channel Alignment
Aqua Fria River
From Thomas Road to I-10 Bridge

ITEM NO.	DESCRIPTION	UNIT COST	QUANTITY	ITEM COST
1	Excavation	$ 0.70	1,925,000 C.Y.	$1,347,500.
3	Bank Protection	38.00	10,200 L.F.	387,600.
4	Concrete Fords	100.00	2,560 L.F.	256,000.
5	Reconstruct Exist Streets	14.00	2,500 L.F.	35,000.
6	Right-of-Way Acquisition Width = 800 Ft.		Lump Sum	214,500.
7	Utility Adjustment		Lump Sum	40,000.
8	*Replacement Borrow	0.95	531,000	504,450.
			TOTAL	$2,785,050.

*See Section IV, C.2.b.

Plate 1

CONSTRUCTION COST

CORPS of Engineers Alignment
Aqua Fria River
From Thomas Road to I-10 Bridge

ITEM NO.	DESCRIPTION	UNIT COST	QUANTITY	ITEM COST
1	Excavation	$ 0.70	2,411,000 C.Y.	$1,687,700.
3	Bank Protection	38.00	3,000 L.F.	114,000.
4	Concrete Fords	100.00	2,150 L.F.	215,000.
5	Reconstruct Exist. Streets	14.00	250 L.F.	3,500.
6	Right-of-Way Acquisition Width=800 Ft.		Lump Sum	515,200.*
7	Utility Adjustments		Lump Sum	20,000.
			TOTAL	$2,555,400.

*Item 6 1,200 ft. right-of-way = $613,000.

Plate 2

CONSTRUCTION COST

Aqua Fria River
Downstream
From I-10 Bridge to End

ITEM NO.	DESCRIPTION	UNIT COST	QUANTITY	ITEM COST
1	Excavation	$ 0.70	1,949,000 C.Y.	$1,364,300.
3	Bank Protection	38.00	3,000 L.F.	114,000.
4	Concrete Fords	100.00	1,800 L.F.	180,000.
5	Reconstruct Exist. Streets	14.00	200 L.F.	2,800.
6	Right-of-Way Acquisition Width=600 Ft.		Lump Sum	120,900.
			TOTAL	$1,782,000.

Plate 3

COST COMPARISON

Aqua Fria River
Concrete Ford Versus Bridge

	COST
CORPS OF ENGINEERS ALIGNMENT	
McDowell Road Bridge	$ 998,000.
McDowell Road Concrete Ford	215,000.
EXISTING CHANNEL ALIGNMENT	
McDowell Road Bridge	1,518,000.
McDowell Road Concrete Ford	256,000.
DOWNSTREAM CHANNEL	
Van Buren Street Bridge	477,000.
Van Buren Street Concrete Ford	180,000.

Plate 4

RIGHT-OF-WAY COST

Aqua Fria River

	COST
APPROACH CHANNEL	
A. Corps of Engineers Alignment:	
800 foot wide right-of-way	$ 515,200.
1200 foot wide right-of-way	613,000.
B. Existing Channel Alignment:	
800 foot wide right-of-way	214,500.
DOWNSTREAM CHANNEL	
600 foot wide right-of-way	120,900.
1200 foot minimum right-of-way	391,550.

VII. CONCLUSIONS

A. Approach Channel

Upon review of the Discussion, Section IV, and Cost Comparison Study, Section VI, we find it quite apparent that the Corps of Engineers alignment for the approach channel is the most desirable of the two considered. Its advantages are:

(1) That it adheres to the future plan for ultimate improvement.

(2) That it is generally straight with gentle curves, thus minimizing erosive energy due to bends and making it possible to eliminate bank protection except at linear transition areas thus saving $273,000.

(3) That it has 531,000± c.y. more excavation available for the I-10 roadway job.

(4) That although this may appear to be a liability initially, upon a replacement evaluation it actually remits a net savings of approximately $132,750.

(5) That it has 400 feet of additional right-of-way width at no extra cost to the Arizona Highway Department, if the cost of this additional right-of-way can appropriately be borne by the County Flood Control District.

(6) That this extra 400 foot width provides a sacrificial bank which makes some erosion tolerable, thus eliminating the need for placing expensive bank protection which would have to be removed when the County Flood Control District widens the channel in the future.

(7) That it intersects McDowell Road at nearly right angles thus requiring a shorter concrete ford or bridge crossing.

(8) That it directs the water so that the channel curve length under the I-10 Bridge is minimized thus reducing possible damage to abutment and roadway.

(9) That it more nearly follows the meander pattern of peak flows.

(10) That it eliminates the need for relocating existing adjacent roads.

(11) That the total net savings for this alignment is estimated to be approximately $229,650.

Its only apparent disadvantage is:

(1) That the right-of-way for this alignment is approximately $300,000 more expensive than the similar 800 foot width for the existing alignment.

These costs are more than offset however, by the savings in overall construction costs, such as bank protection and

treatment of cross-roads.

Hence, the advantage of having additional borrow for the I-10 project is obtained at no cost.

B. Downstream Channel

Upon review of Section V, we conclude:

(1) That the channel will not have a bottom width of less than 450 feet with 3:1 side slopes.

(2) That the channel be constructed in adherence to future alignment plans.

(3) That the channel will carry the estimated 6,000 cfs from the I-10 parallel channels within its banks with a design depth of slightly in excess of 3 feet.

(4) That it is not required that this channel carry the Aqua Fria River design discharge of 60,000 cfs.

(5) That the channel be constructed to the grades established herein accommodating both river flow and lateral flow.

(6) That in accordance with the channel grade, Van Buren Street be lowered or bridge crossing installed to insure hydraulic requirement of eliminating backwater affect on I-10 Bridge and Roadway.

(7) That the 6,000 cfs from the lateral channels will incur no damage on either I-10 or private property.

(8) That the excavated material can be used as borrow for I-10 roadway.

(9) That there is not any adverse affect on either the existing Southern Pacific railroad bridge or the proposed Buckeye Road (U.S. 80) bridge.

(10) That the minimum right-of-way for 450 foot bottom channel is 600 feet and that alternate right-of-way (1,200 foot minimum) has been determined for and in accordance with future widening plans.

(11) That the southerly grade point will day-lite with the existing channel bottom.

(12) That the total construction costs will be borne by the Arizona Highway Department, exclusive of right-of-way excess of originally proposed 600 feet.

(13) Any dyking or channelization below the southerly terminus point of this project, will be provided by the County Flood Control District or by private property owners to prevent any damage to the surrounding properties.

(14) The maintenance of the entire channel (upstream and downstream of I-10 Bridge) will be the responsibility of the County Flood Control District.

VIII. RECOMMENDATIONS

Upon analyzing the merits, weighing disadvantages and with reference to the discussion, compilations and summations presented herein, we find that the Corps of Engineers alignment is far superior in all phases of concern.

It also provides opportunity for two governmental agencies, namely the Arizona Highway Department and the Maricopa Flood Control District to benefit from work and monies expended by each other in fulfilling their respective needs and in achieving much more realization of the entire project at this time, than otherwise possible, thereby benefiting the entire area and the public as a whole.

We therefore recommend:

(1) That the Corps of Engineers alignment for the approach channel be selected for further design and construction.

(2) That the approach channel bottom width be a minimum of 700 feet, with 3:1 side slopes.

(3) That both the approach channel and downstream channel be constructed to the depths shown by the profile grade of Figure 8.

(4) That bank protection be placed at the northerly linear transition to retard bank erosion and to protect dyke across throat of existing channel.

(5) That concrete ford crossings and related items

be installed at cross-roads where possible and practical instead of bridges in lieu of tremendous cost differential.

(6) That the net excavation from this alignment be used as borrow for the I-10 roadway.

(7) That the Arizona Highway Department be asked to coparticipate with the Maricopa Flood Control District in acquistion of right-of-way for this alignment instead of the 800 feet originally planned and that 1,200 feet be acquired.

(8) That the apportionment of these right-of-way costs be obtained by the Arizona Highway Department acquiring the 800 feet initally proposed for this alignment construction and the costs for the additional 400 feet of the right-of-way be borne by the County Flood Control District.

And we further recommend:

(9) That the downstream channel be constructed on the Corps of Engineers alignment.

(10) That the downstream channel bottom will be a minimum of 450 feet wide with 3:1 side slopes.

(11) That the downstream channel terminate at a point south of Lower Buckeye Road at the grade day-lite point in the Salt and Gila River flood plain.

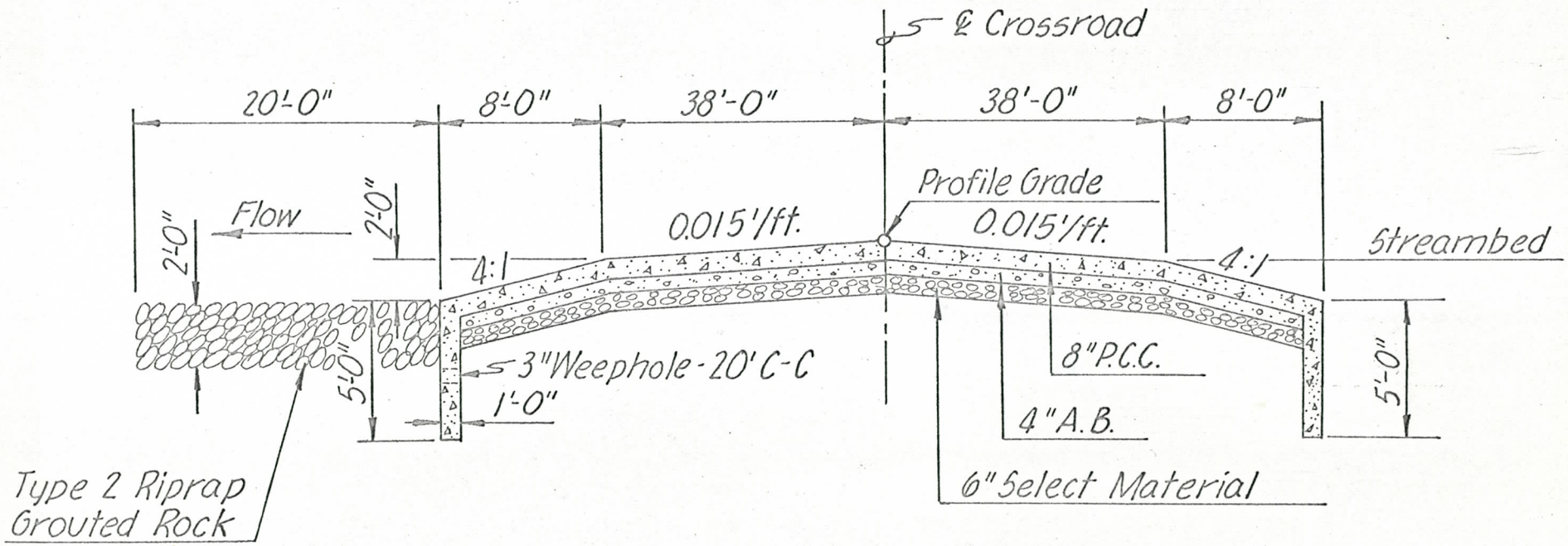
(12) That the downstream channel shall have a bottom width transition from 1,050 feet at I-10 to a

minimum of 450 feet at Van Buren Street.

(13) That in lieu of proposed improvement of the downstream channel and the State expenditure therein, the County Flood Control District increase the right-of-way acquisition to a minimum width of 1,200 feet to accommodate future widening.

(14) That the two agencies coordinate their right-of-way acquisition of both sections of channel and the County Flood Control District acquire its right-of-way simultaneously with the Arizona Highway Department to eliminate the necessity of negotiating with property owners more than once.

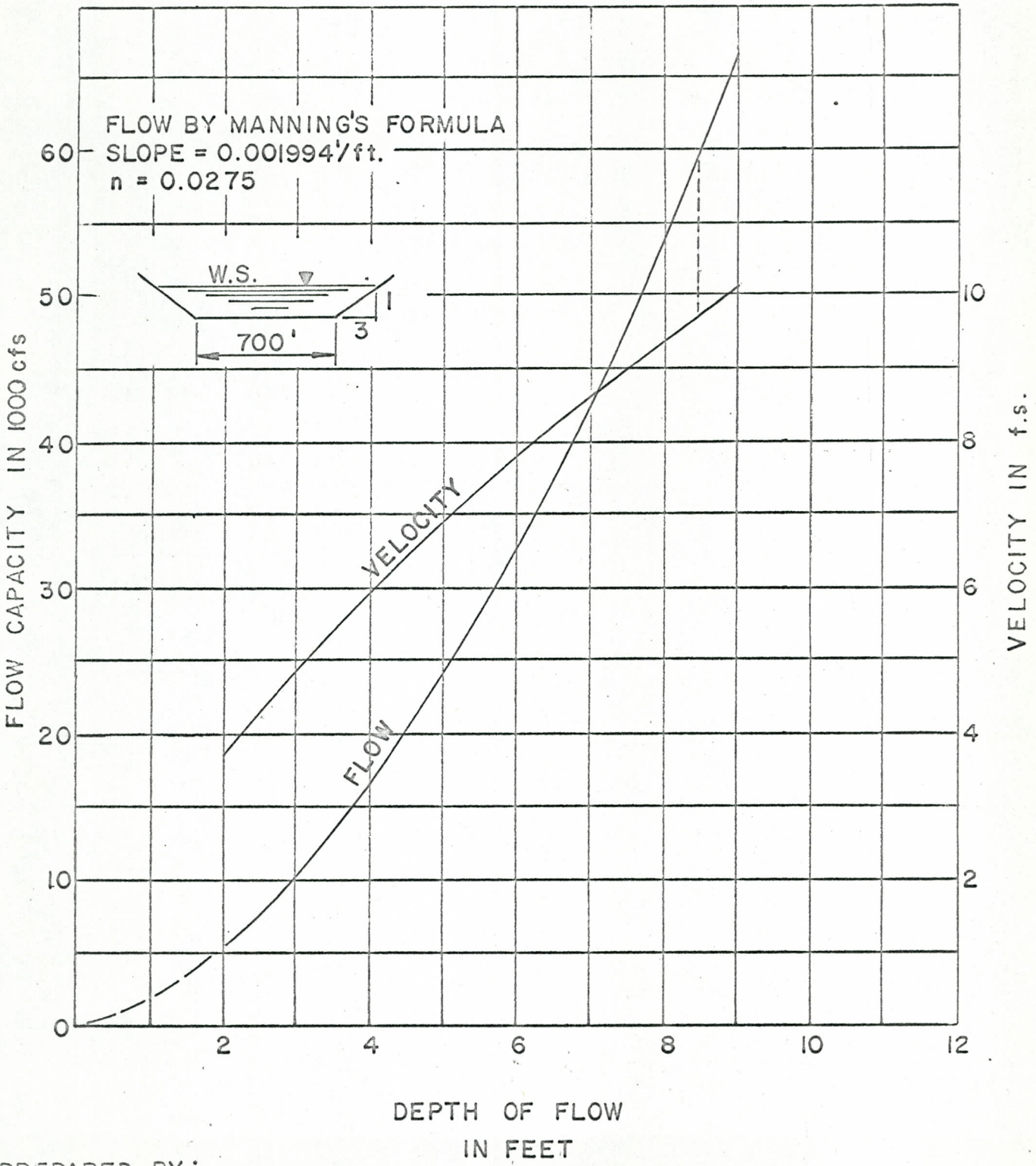
FIGURES



SPECIAL CONCRETE FORD DETAIL

FIGURE 1

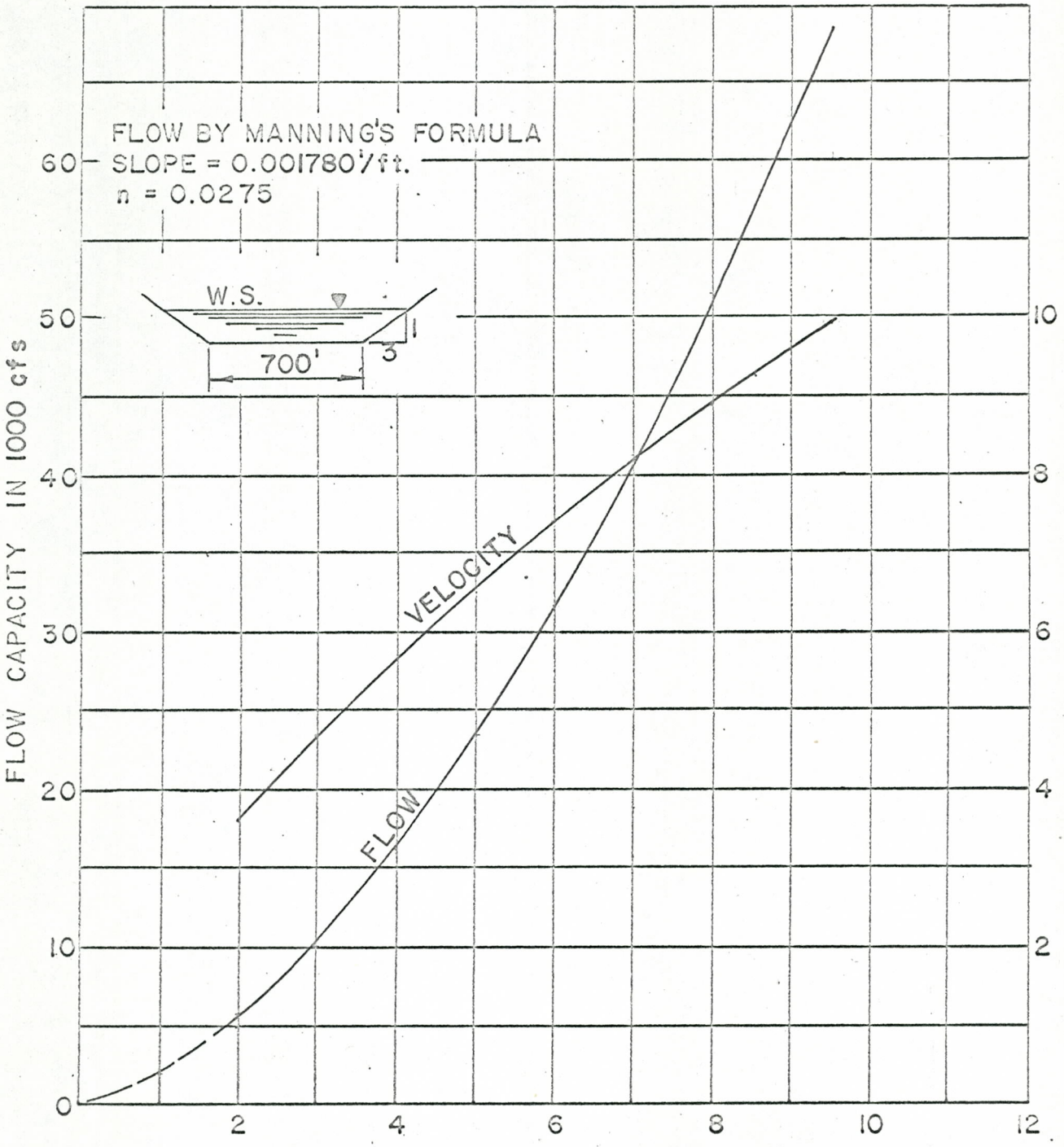
AGUA FRIA RIVER CHANNEL
700 FT. BOTTOM
CORP ALIGNMENT



PREPARED BY:
DIBBLE & ASSOCIATES
CONSULTING ENGINEERS

FIGURE 2

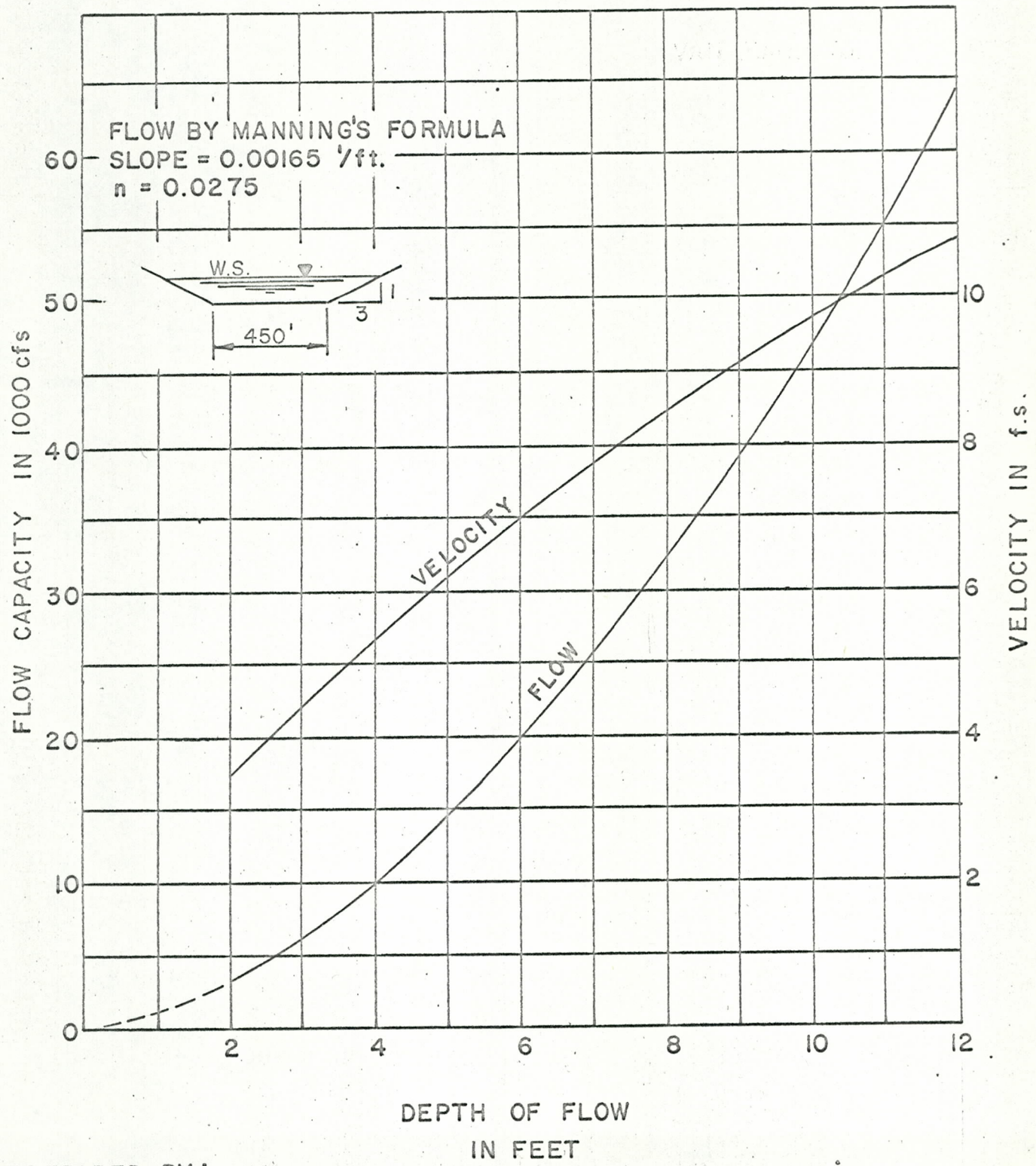
AGUA FRIA RIVER CHANNEL
700 FT. BOTTOM
EXISTING ALIGNMENT



PREPARED BY:
DIBBLE & ASSOCIATES
CONSULTING ENGINEERS

FIGURE 2

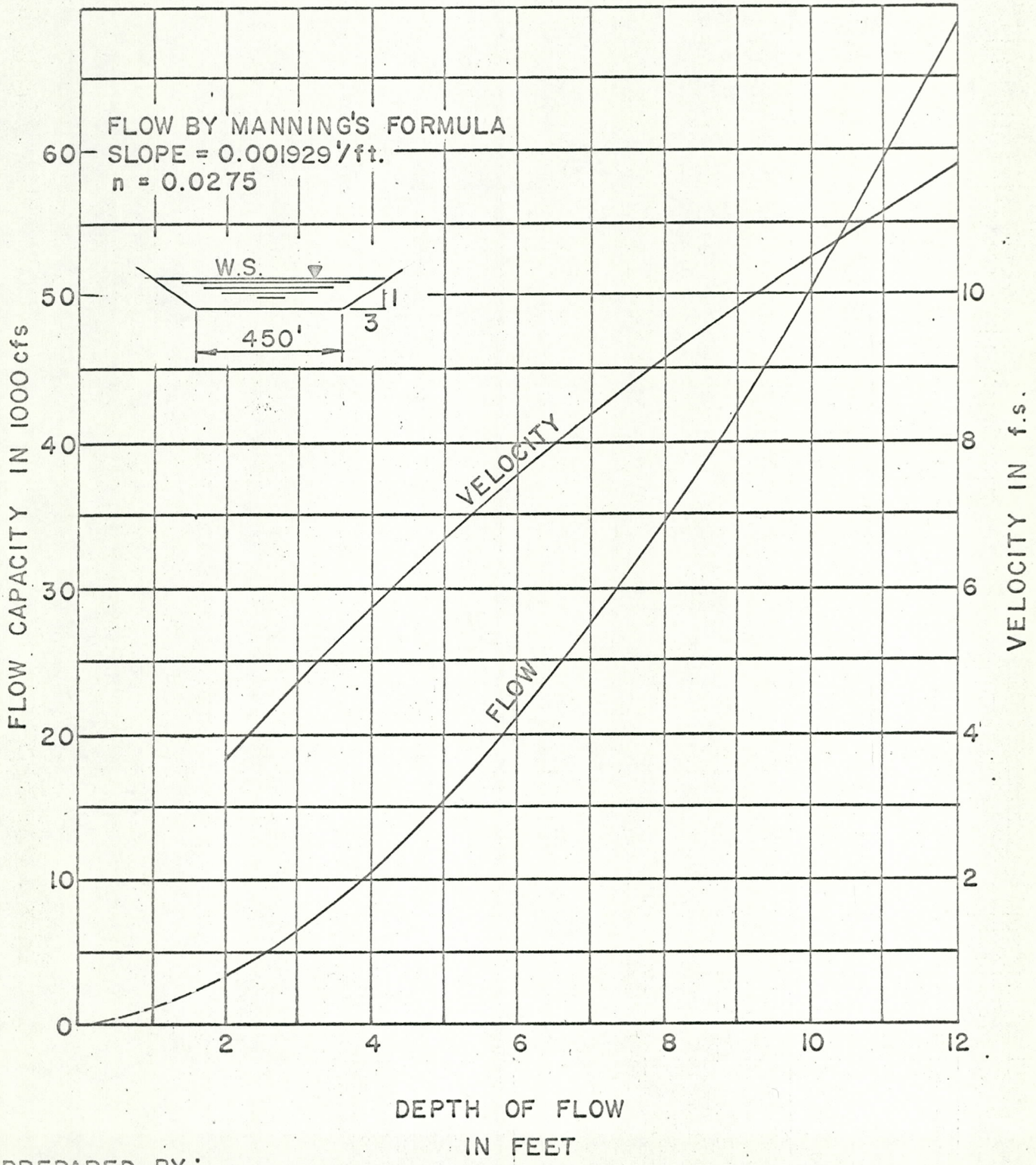
AGUA FRIA RIVER CHANNEL
450 FT. BOTTOM



PREPARED BY:
DIBBLE & ASSOCIATES
CONSULTING ENGINEERS

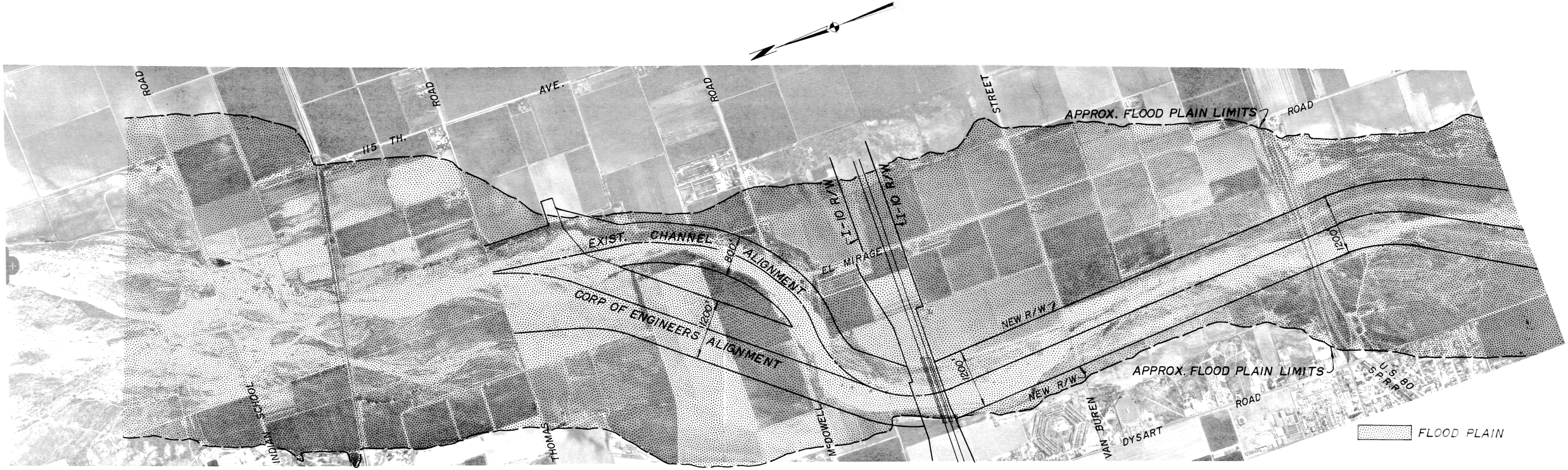
FIGURE 3

AGUA FRIA RIVER CHANNEL
450 FT. BOTTOM



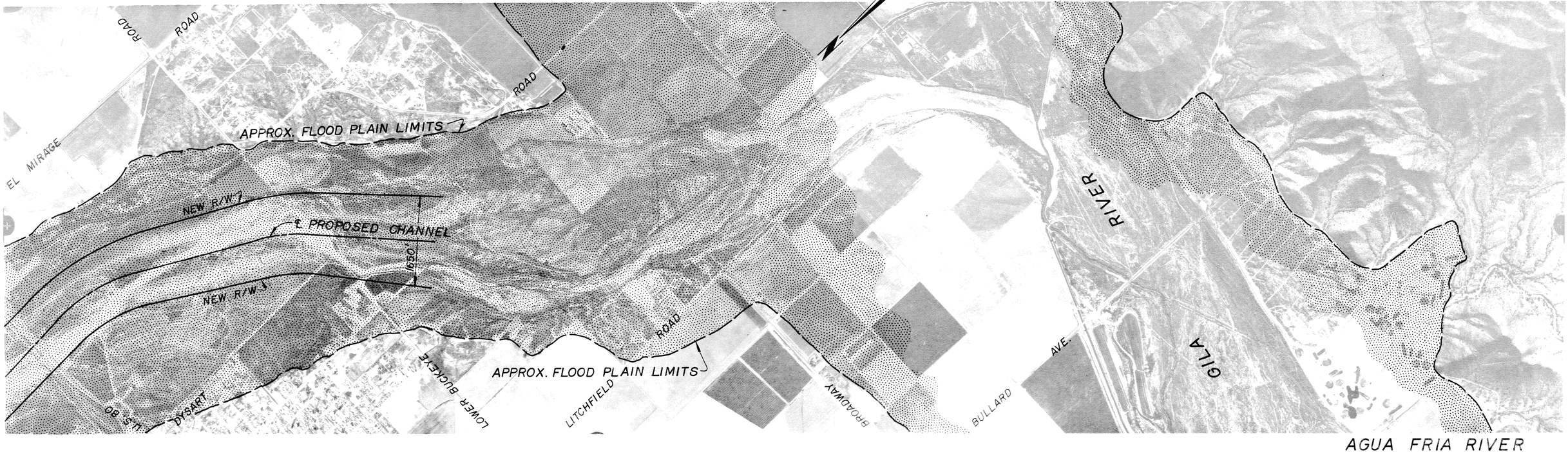
PREPARED BY:
DIBBLE & ASSOCIATES
CONSULTING ENGINEERS

FIGURE 3



AGUA FRIA RIVER PHOTO PLAN MAP

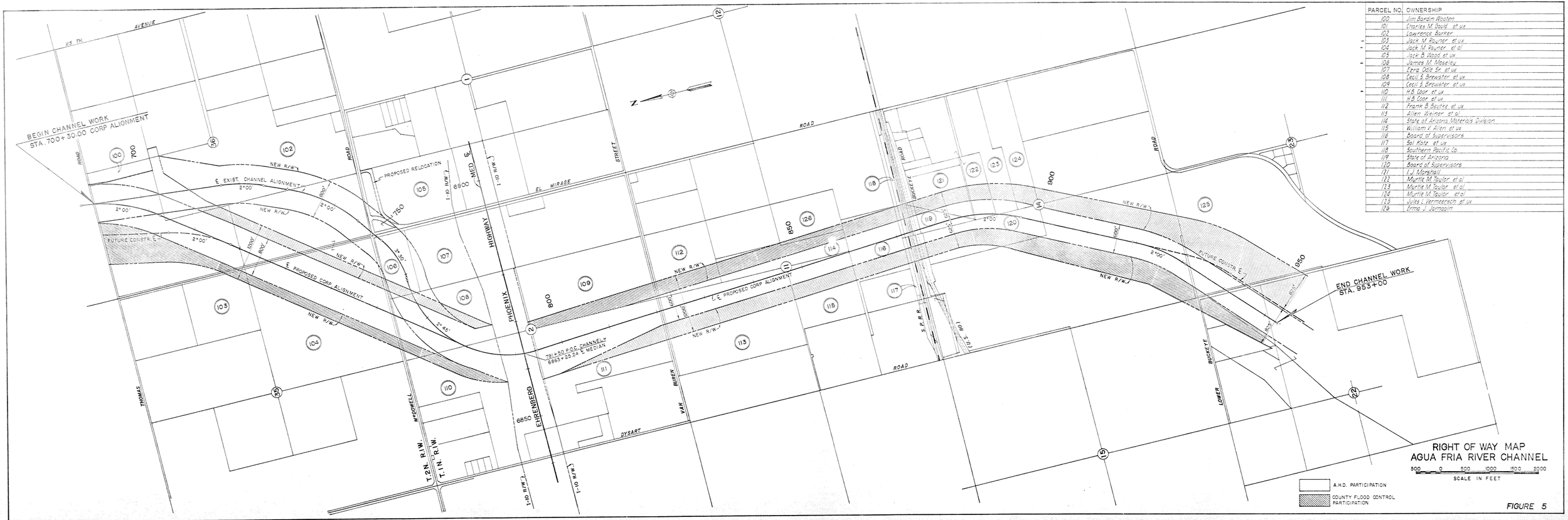
FIGURE 4 SHEET 1 OF 2



0 500 1000 2000
SCALE IN FT.

AGUA FRIA RIVER
PHOTO PLAN MAP

FIGURE 4 SHEET 2 OF 2

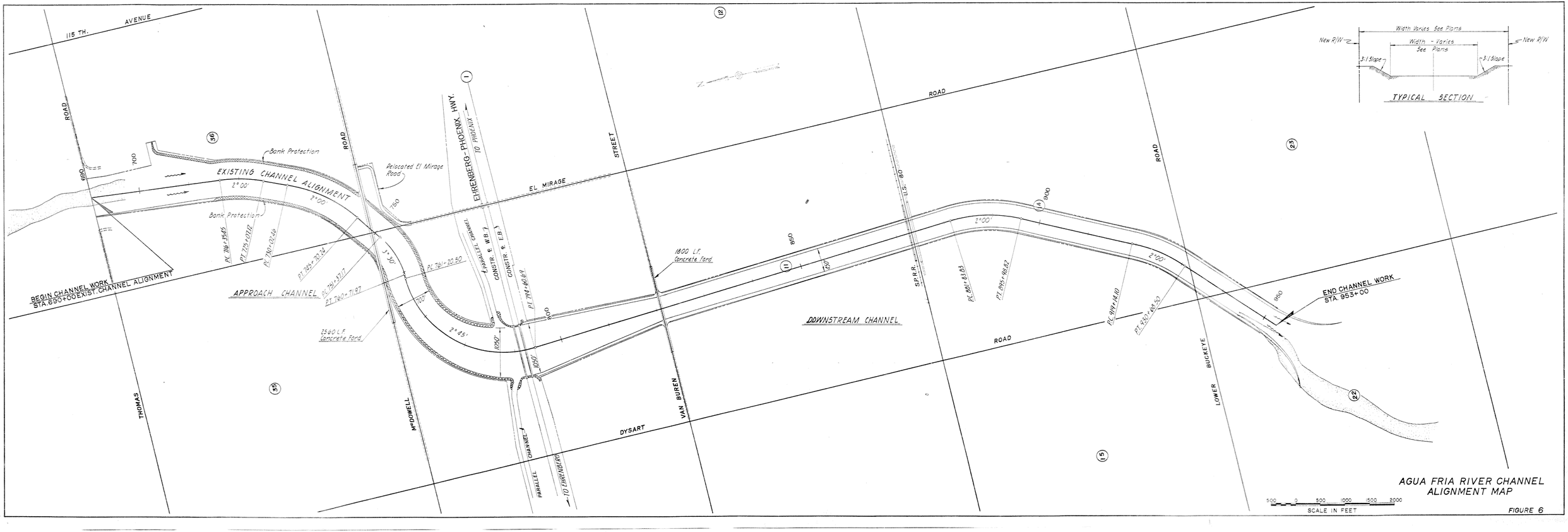


PARCEL NO.	OWNERSHIP
100	Jim Bardin Wooten
101	Charles M. Dowd et ux
102	Lawrence Barker
103	Jack M. Rayner et ux
104	Jack M. Rayner et al
105	Jack B. Hood et ux
106	James M. Moseley
107	Ezra Dale Sr. et ux
108	Cecil S. Brewster et ux
109	Cecil S. Brewster et ux
110	H.B. Coor et ux
111	H.B. Coor et ux
112	Frank B. Burke et ux
113	Allen Weiner et al
114	State of Arizona Materials Division
115	William V. Allen et ux
116	Board of Supervisors
117	Bel Katz et ux
118	Southern Pacific Co.
119	State of Arizona
120	Board of Supervisors
121	I.J. Marshall
122	Myrtle M. Taylor et al
123	Myrtle M. Taylor et al
124	Myrtle M. Taylor et al
125	Willis L. Vermersch et ux
126	Erma J. Jarnagin

RIGHT OF WAY MAP
AGUA FRIA RIVER CHANNEL

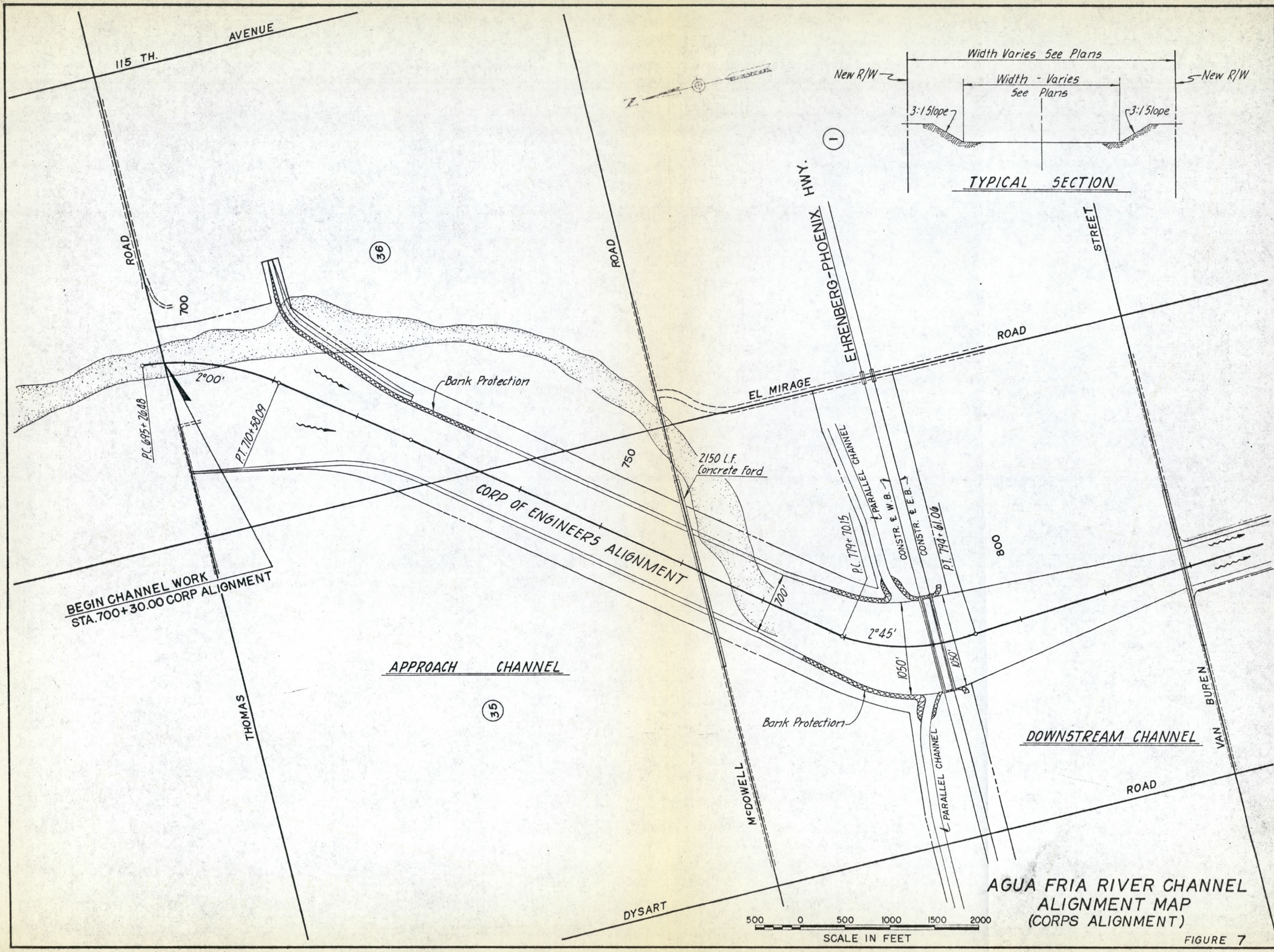
500 0 500 1000 1500 2000
SCALE IN FEET

FIGURE 5



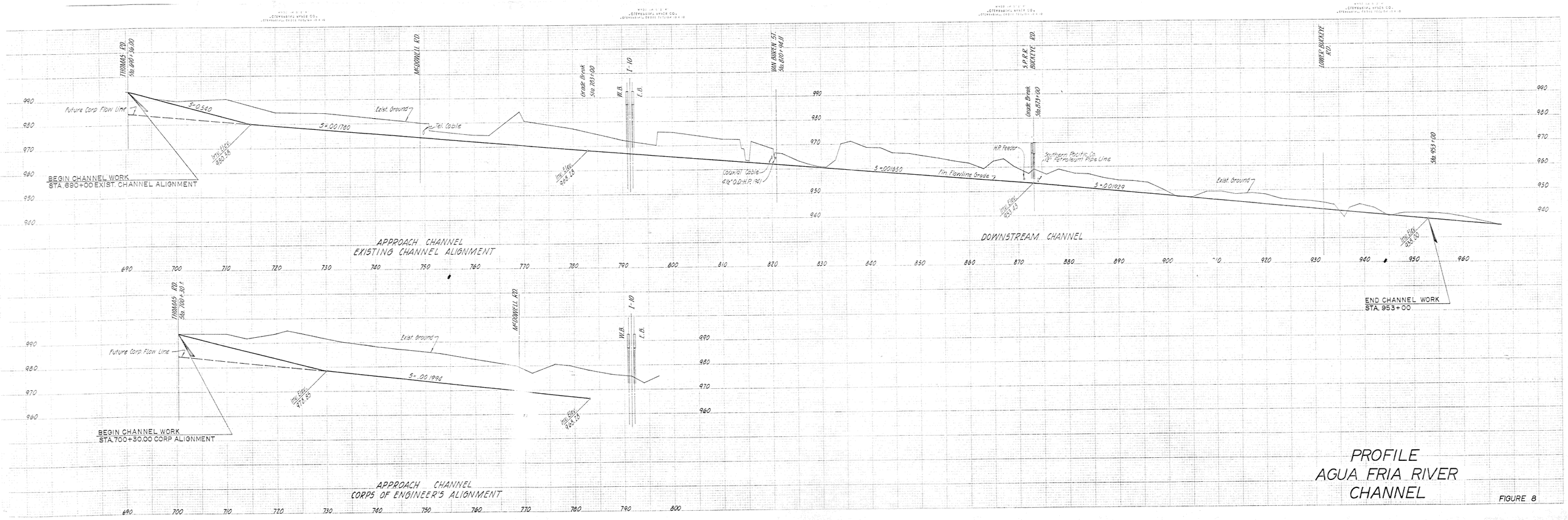
AGUA FRIA RIVER CHANNEL ALIGNMENT MAP

FIGURE 6



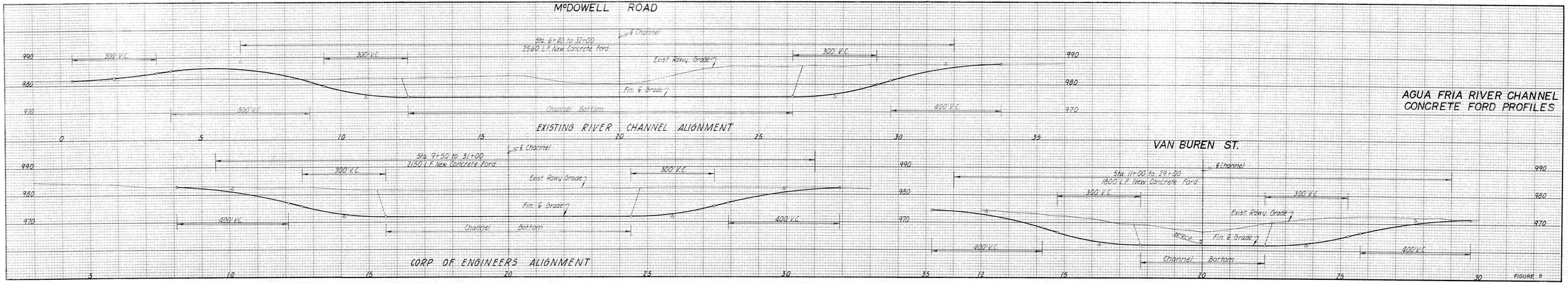
AGUA FRIA RIVER CHANNEL ALIGNMENT MAP (CORPS ALIGNMENT)

FIGURE 7



PROFILE
AGUA FRIA RIVER CHANNEL

FIGURE 8


McDOWELL ROAD
Sta. 6+40 to 32+00
2560 L.F. New Concrete Ford
℄ Channel
Exist. Rdwy. Grade
Fin. ℄ Grade
Channel Bottom
300' V.C.
300' V.C.
300' V.C.
500' V.C.
400' V.C.
990
980
970
0
5
10
15
20
25
30
35
EXISTING RIVER CHANNEL ALIGNMENT
Sta. 9+50 to 31+00
2150 L.F. New Concrete Ford
℄ Channel
Exist. Rdwy. Grade
Fin. ℄ Grade
Channel Bottom
300' V.C.
300' V.C.
400' V.C.
400' V.C.
990
980
970
5
10
15
20
25
30
CORP OF ENGINEERS ALIGNMENT
VAN BUREN ST.
Sta. 11+00 to 29+00
1800 L.F. New Concrete Ford
℄ Channel
Exist. Rdwy. Grade
Fin. ℄ Grade
Channel Bottom
300' V.C.
300' V.C.
400' V.C.
400' V.C.
990
980
970
35
12
15
20
25
30
AGUA FRIA RIVER CHANNEL
CONCRETE FORD PROFILES
FIGURE 9

MARICOPA COUNTY DEPARTMENT OF CIVIL DEFENSE AND EMERGENCY SERVICES
2035 N 52nd St, Phoenix, Arizona 85008

SUBJECT: WATER SITUATION REPORT
TO: See Distribution

Compiled by: Maria Lawson
~~Bess Levinson~~
273-1411

Date: August 29, 1980
Time: 1035 hours

Salt: 236,837
Verde: 183,568
Total available storage Salt & Verde Systems: 420,405 Acre Feet (A/F)

Salt Reservoir Capacities (A/F)		Inflow (cfs)		Release (cfs)		Diversions
* Roosevelt	1,381,580	Salt	768			Az Canal 1,584
Contents	1,164,841					So Canal 1,242
Available	216,739					2,826
Apache (Horse Mesa)	245,138	Tonto	334			
	237,031					
Contents	8,107					
Available						
Canyon (Mormon Flat)	57,852					
	53,322					
Contents	4,530					
Available						
Saguaro (Stewart Mtn)	69,765					
	62,304					
Contents	7,461					
Available						

FLOOD CONTROL DISTRICT
RECEIVED
SEP 2 '80

2	CH ENG	3	HYDRO
1			LMgt
	ADMIN		SUSP
	C & O		FILE
	ENGR		DESTROY
REMARKS			

1,775

Verde Reservoir Capacities (A/F)		Verde	169
			1,271
* Horseshoe	131,427		
Contents	10		
Available	131,417		
			999
Bartlett	178,186		2,774
Contents	126,035		
Available	52,151		

GRANITE REEF -0-

Gain ~~xxxxxxx~~ in available storage since 8/22/80
Salt 13,996 + (A/F)
Verde 10,939 + (A/F)
Total 24,935 + (A/F)

TOTAL CONTENTS: 1,643,543
TOTAL SALT AND VERDE LAKES CAPACITIES 2,063,948 79.63 % FILLED

Lake Pleasant 157,200
Contents 113,760
Available 43,440

Agua Fria
. . . Releasing 2,507.85

Gain ~~xxxxxx~~ in available storage since 8/22/80 1,650 +

* Storage available in Roosevelt & Horseshoe Lakes at head of Salt & Verde System: 348,156

DISTRIBUTION: State Emergency Services, Highway, Flood Control, Sheriff, Parks & Recreation, American Red Cross.

CD Form 20

Nov 1979

STA 783+00 Elev 968.28 994.0 968.3

STA 690+36 Elev 994 25.7'

92+64

$$\frac{25.7}{9264} = 0.00277$$