VALENCIA WASH
BASIN MANAGEMENT STUDY

PHASE II - FLOOD CONTROL ALTERNATIVES

Prepared for:

Pima County Flood Control District
201 N. Stone Avenue
Tucson, AZ 85701
Contract No. 07-04-A-115511-1191

Prepared by:

Alpha Engineering
3131 E. Second Street
Tucson, AZ 85716
Tel: (602) 795-8600
A.E. Job No. 12091

September, 1992

Registered Professional Engineer (Civil)
CERTIFICATE NO.
14833
DINKAR
GANGWAL
3/8/93

Alpha Engineering
Consulting Civil Engineers & Surveyors

3131 E. Second Street, Tucson, AZ 85716 Tel.: (602) 795-8600 Fax: (602) 795-7047

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Registered Professional Engineer (Civil)
CERTIFICATE NO. 14833
DINKAR GANGWAL
Date Signed 3/8/93
ARIZONA, U.S.A.

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Registered Professional Engineer (Civil)
CERTIFICATE NO.
14833
DINKAR
GANGWAL
Date Signed 3/8/93
ARIZONA, U.S.A.

1. INTRODUCTION

Alpha Engineering was awarded a contract by the Pima County Flood Control District to perform the Valencia Wash Basin Management Study. The study is comprised of the following two phases:

Phase I: Analysis of existing drainage conditions.

Phase II: Analysis and evaluation of flood control alternatives.

Phase I of the study was submitted to the District on July 15, 1992. This report presents the results of Phase II of the Valencia Wash Basin Management Plan.

Scope of work for Phase II is described below:

<u>Task 1:</u> <u>Structural and Non-Structural Flood Control Alternatives</u>

Item A: Formulate Structural Solutions

1. Based on the information from Phase I, formulate solutions to the identified flood hazards through the use of structural means such as channelization, levees, bank stabilization and/or stormwater detention/retention.

2. For the reach between Valencia Road to Westover Avenue, evaluate the effectiveness, advantages, and disadvantages of two or more structural solutions. This shall include an analysis of depth versus flood damage and determination of flood frequency versus depth. Evaluation criteria shall include social and environmental factors.

3. Prepare a cost estimate for each structural alternatives, evaluated.

Item B: Formulate Non-Structural Solutions

1. Identify floodprone property within the project limit using Phase 1 flood delineations.
2. Determine costs associated with the acquisition of identified floodprone properties on a per property basis.
3. Develop floodplain management policies that would reduce or restrict further development in identified flood hazard areas.
4. Determine and evaluate the advantages, disadvantages and effectiveness of two or more non-structural alternatives.

<u>Task 2:</u> <u>Recommendations</u>

Select and rank recommendations based on the detailed evaluation of structural and non-structural alternatives for mitigating flood hazards at various locations. Use a matrix rating system to document the recommendation procedure. Recommended solutions may be combinations of structural and non-structural solutions.

<u>Task 3:</u> <u>Final Report</u>

1. Prepare a final report encompassing the results and assumptions determined for both phases of the project.
2. The report shall include a detailed discussion of the selected recommendation(s) as determined in Phase II, Task 2.
3. Submit two (2) copies of the final report for review and approval.

4. Submit a total of six (6) copies of the final approved report including reproducible copies of all maps, figures and a IBM compatible diskette of computer input data if applicable.

2. BASIN MANAGEMENT ALTERNATIVES

Several preliminary basin management alternatives were discussed with the project manager at a meeting held on August 7, 1992 and it was decided to address the following items in the Phase II basin management alternatives.

A. Structural Solutions

A-1: Improvement of Valencia Wash channel between Westover Avenue and Valencia Road including considerations of levees for two different conditions i.e i) with grading for outfall in the Indian Reservation land and ii) without any grading in the Reservation land.

A-2: Detention facility upstream of Valencia Road to control flow in the downstream reach of the Valencia Wash.

B. Non-Structural Solutions

B-1: Acquisition of the floodprone properties.

B-2: Detention facility within the downstream reach of the Valencia Wash.

3. STRUCTURAL SOLUTIONS

3.1 Channelization of Valencia Wash

Valencia Wash between Westover Avenue and Valencia Road is an earthen channel approximately 30' wide with flat slope and shallow banks of 3' to 4' height. The channel has 64' right-of-way for drainage with 16' and 20' alley on the west and east side respectively. Existing concrete box culvert (7 - 10' x 6') under the Valencia Road carries most of the 100-year discharge of 5,130 CFS. However the channel downstream has capacity between 601 and 923 CFS, which is less than a 5-year frequency discharge in the channel. This very low capacity of the channel causes a wide floodplain up to 700' wide.

Another reason for a wide floodplain in this area is a lack of an outlet at Westover Avenue. Land immediately east of Westover Avenue lies within the San Xavier Indian Reservation. The outlet at Westover Avenue is blocked by vegetation and debris. It was mentioned by the District staff that the Pima County is not permitted to perform grading work within the Reservation land. The natural channel downstream of Westover Avenue is not maintained by the County or the Owner. This study includes alternatives to improve the channel with and without any grading work and convey a 100-year frequency discharge through the problem area in the Reservation Land.

Three types of channels are considered in this reach. Type 'A' is an earthen channel with 3:1 side slope. Type 'B' is a concrete lined slope with earthen floor and type 'C' a fully lined concrete channel. Type 'B' and 'C' has 1:1 side slope.

Appendix "A" contains calculations deriving various channel cross-sections to contain the 100-year discharge of 5,310 CFS without doing any grading work within the Reservation land, and is designated as option "A". Table 1 is a summary of the calculations for this option.

Appendix "B" contains calculations, designated as option "B", for various channel cross-sections with an assumption that grading within the Reservation land can be performed which will provide a steeper and/or deeper channel and a proper outlet. Table 2 is a summary of the calculations for this option.

TABLE 1

ALTERNATIVE CHANNEL SECTIONS: OPTION "A"
(WITH NO GRADING IN RESERVATION LAND)

Section No.	Channel Type*	Bottom Width Feet	Top Width Feet	Normal Depth Feet	Velocity FPS
A-1	Type 1	80	125	7.4	7.0
A-2	Type 1	100	140	6.6	6.7
A-3	Type 1	180	209	4.8	5.7
A-4	Type 1	200	227	4.5	5.5
A-5	Type 1	225	250	4.2	5.3
A-6	Type 2	80	93	6.5	9.5
A-7	Type 2	100	111	5.7	8.9
A-8	Type 2	120	130	5.1	8.4
A-9	Type 2	140	149	4.6	7.9
A-10	Type 3	36	52	8.0	15.1
A-11	Type 3	40	55	7.5	14.8
A-12	Type 3	60	72	5.9	13.6
A-13	Type 3	80	90	5.0	12.5

* Type 1: Earthen channel
Type 2: Concrete lined slopes with earthen bottom
Type 3: Concrete lined channel

TABLE 2

ALTERNATIVE CHANNEL SECTIONS: OPTION "B"
(WITH GRADING IN RESERVATION LAND)

Section No.	Channel Type*	Bottom Width Feet	Top Width Feet	Normal Depth Feet	Velocity FPS	Remarks
B-1	Type 1	80	117	6.2	8.7	
B-2	Type 1	100	133	5.5	8.2	
B-3	Type 1	140	168	4.6	7.5	
B-4	Type 1	160	185	4.2	7.2	
B-5	Type 2	80	91	5.4	11.6	
B-6	Type 2	100	109	4.7	10.8	
B-7	Type 2	120	128	4.2	10.1	
B-8	Type 3	34	48	6.9	18.9	
B-9	Type 3	40	52	6.3	18.3	
B-10	Type 3	60	70	4.9	16.6	

* Type 1: Earthen channel
Type 2: Concrete lined slopes with earthen bottom
Type 3: Concrete lined channel

3.2 Detention/Retention

Since most of the flooding problem within the watershed lies near the downstream reach of the basin and north of Valencia Road, feasibility for upstream detention/retention can not be overlooked.

Upstream detention/retention facilities will benefit the lower reach of the Valencia Wash watershed. Many factors will need to be considered during selection of future sites. Economics, land availability, site location, engineering feasibility, aesthetics and public opinion will all impact selection of the facility locations. Preliminary qualifications for detention/retention facilities include a location which will be: 1) significantly upstream from flooding, 2) in a low area where ponding would naturally occur and significant runoff would be able to be accumulated, and 3) where there would be a potential for recharge away from the known pollution sources, such as landfills.

Geologic factors that must be considered when choosing a site for a potential detention/retention facility include: 1) soil permeability, 2) depth to bedrock, 3) depth to water table, and, 4) presence of impervious/impermeable strata.

An exercise is undertaken for a feasibility of detention/retention basin for a single subbasin and for a combination of several subbasins. The study includes four possible detention/retention facilities of various sizes at various locations.

Calculations for detention basins volume are based upon discharge values of combined hydrographs of subbasins involved. Area of the detention basins is calculated assuming a 5' average depth for each basin.

Detention Basin No. 1

This basin will control discharge from the largest tributary, i.e. subbasin no. 1 with an area of 437.1 acres, to the Valencia Wash. The subbasin is located northwest of Valencia Road and Camino De La Tierra contributing peak discharge of 1671 CFS. If outflow is limited to approximately 20% of the inflow, the required detention basin volume will be 72 acre-feet requiring 14.4 acre land. The detention basin can be located as an on-line basin between section 1.1 and 1.3 shown in the hydrology map. The basin will reduce the peak discharge by approximately 1,341 CFS but will not provide adequate relief to flooding problem areas of the Wash near Westover Avenue/Valencia Road. Therefore this option is not further investigated.

Detention Basin No. 2

This basin will control discharge from the subbasin no. 1A, 2, 3, 4, 5, and 6 containing 623 acres. Point of concentration is at the west side of Camino De La Tierra, 600 feet south of Valencia Road with a peak discharge of 3,114 CFS. If outflow is limited to 600 CFS, the detention basin volume will be 105 acre-feet requiring 21 acres of land. The basin can be located directly west of Camino De La Tierra as an on-line basin within the subbasin no. 5 and 6. This detention basin will be reduce peak discharge by approximately 2,514 CFS, which is still not adequate relief to flooding problems at Westover Avenue. Considering limited benefits, this option is also not further investigated.

Detention Basin No. 3

This basin will control discharge from subbasins no. 1, 1A, 2, 3, 4, 5, and 6, containing 1,060 acres. Point of concentration will be approximately 800 feet east of Camino De La Tierra and south of Valencia Road with a combined peak discharge of 4,061 CFS. If the outflow is limited to 800 CFS, the detention basin volume will be 177 acre-feet requiring 36 acres of land. The basin can be situated southeast of the Valencia Road/Camino De La Tierra intersection within subbasin no. 8. This detention basin will reduce the peak discharge by approximately 3,261 CFS, which can be considered a significant reduction. However cost of 36 acres land at a major intersection can be prohibitive. Considering an average price of $2.00 per s.f., the land cost alone will be $ 3,136,320.00. Moreover, the basin will still require some improvements of the Valencia Wash at Westover Avenue. Therefore this option is considered to be nonfeasible.

Detention Basin No. 4

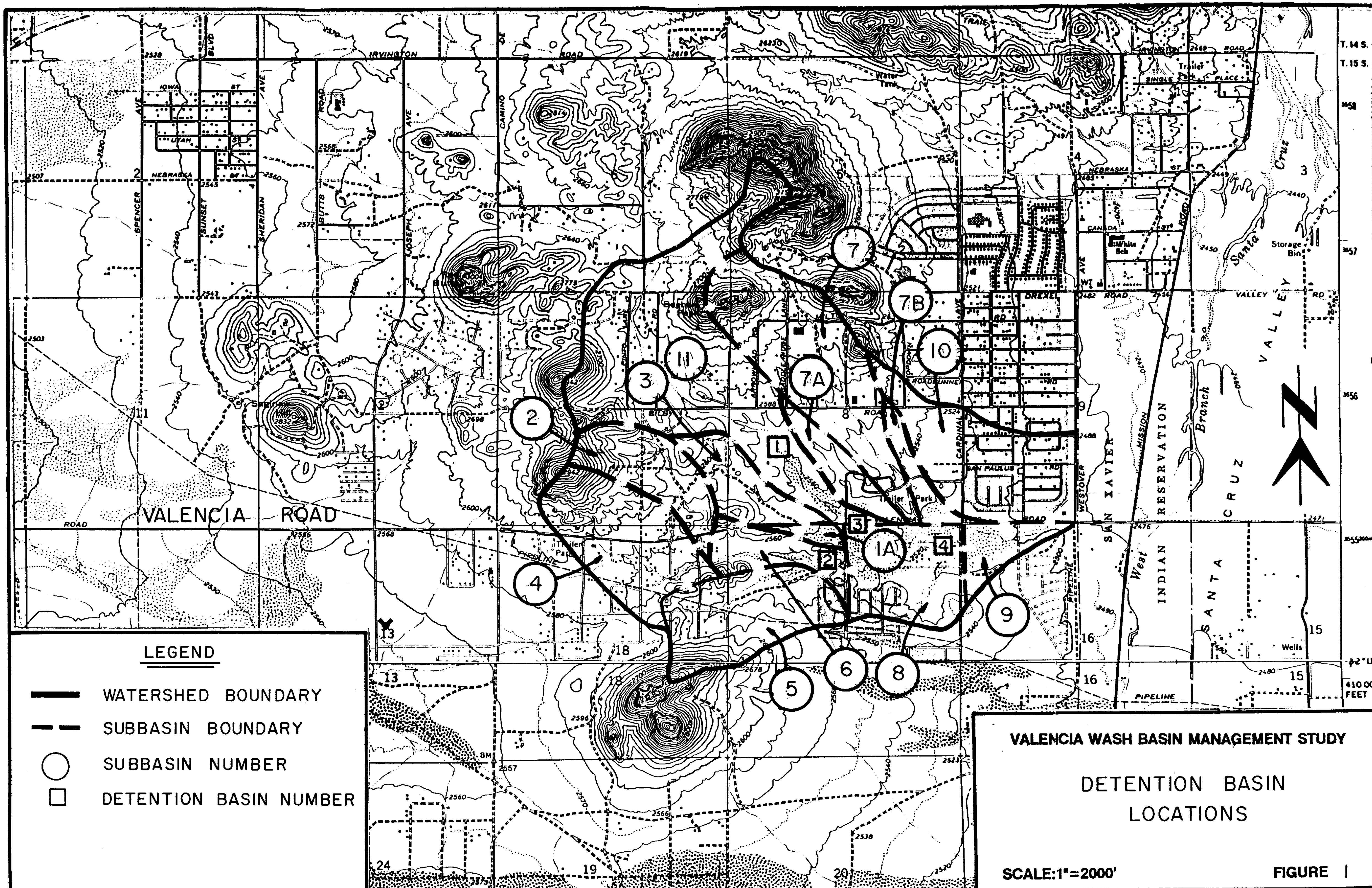
This basin will control discharge from subbasin 1 thur 8 containing 1,380 acres. Point of concentration is at Cardinal Avenue, approximately 400 feet south of Valencia Road, with a peak discharge of 5,000 CFS. If the outflow from the basin is limited to 1,000 CFS, the detention basin volume will be 230 acre-feet requiring 46 acres of land. Even though this detention basin will provide significant relief for area downstream of Valencia Road, the land acquisition cost of approximately 4 million dollars will be the prohibitive factor, making this option unacceptable.

Table 3 is a summary of the detention basin alternatives discussed above. Figure 1 depicts the detention basin location on a watershed map.

TABLE 3

DETENTION BASIN ALTERNATIVES

Det. Basin No.	Subbasin Number	Total Area AC.	100-year 1 hour Rainfall Inch	Weighted Runoff to Rainfall Ratio	100-year Peak Discharge CFS	Outflow CFS	Det. Basin Vol. AC-FT.
1	1	437.1	3.13	0.79	1670.9	330	72
2	1A + 2 + 3 + 4 + 5 + 6	623.0	3.13	0.80	3113.8	600	105
3	1 + 1A + 2 + 3 + 4 + 5 + 6	1060.1	3.13	0.796	4061.0	800	177
4	1 thru 8 (1 + 2 + 3 + 4 + 5 + 6 + 1A + 7 + 7A + 8)	1379.60	3.13	0.80	5000.0	1000	230



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4. NON-STRUCTURAL SOLUTIONS

4.1 General

Non-structural solutions include land use restrictions, purchase of flood prone property or on-site retention/detention, or a combination thereof.

A land use restrictions solution is not applicable since the flood prone area is developed to its fullest extent. Retention/detention alternative is also not feasible due to high peak flow of 5,310 CFS and limited area available for retention/detention. However the basin area can be designated as a critical basin in the County's critical and balanced basins map, which would provide some restriction for development of open areas. The non-structural solutions will focus on acquisition of the flood prone property.

4.2 Property Acquisition

4.2.1 Flood Prone Property

The 100-year floodplain delineation map for the downstream reach of the Valencia Wash, between Cardinal Avenue and Westover Avenue, was developed using HEC-2 model incorporating cross sections from field survey and 1" = 200' scale topographic map, provided by the District. Figure 9 of the Phase I report depicts the floodplain delineation.

Following is a list of properties lying within the 100-year floodplain, between Valencia Road and Westover Avenue.

I. Mission Terrace No. 3

A. Block 11; Lots No. 9, 10, an 11

B. Block 12; Lots No. 7 thur 18

II. Mission Terrace No. 2

Block 12; Lots 5 and 6

The above parcels lies south and east of Oriole Circle and borders along the westerly bank of the Valencia Wash.

III. Three lots along Valencia Road situated immediately west of the box culvert are also affected.

IV. A parcel, containing 1.03 acres, developed as a convenient store, (Circle K, now closed for business), and located northeast of the culvert.

V. A strip of land 165' wide, just west and parallel to Westover Avenue, owned by El Paso Natural Gas Company for their high pressure gas line running parallel to Westover Avenue.

If the Valencia Wash channel within this reach is not improved, all the above properties, except the El Paso Natural Gas parcel, may have to be acquired in order to provide total flood protection to the property owners.

4.2.2 Acquisition Cost

Estimate for acquisition cost of the floodprone property is based upon the maximum value shown on the current record of the Pima County Assessor. A factor of the 1.33, suggested by the District staff, is applied to the assessed value to arrive at the acquisition cost estimate.

Detail acquisition cost is as follows:

No.	Parcel Description	Tax Code	Assessed Value
1	M.T. No. 2, Blk 12; Lot 5	137-26-0410	$ 54,719.00
2	M.T. No. 2, Blk 12; Lot 6	137-26-0420	$ 10,500.00
3	M.T. No. 3, Blk 12; Lot 7	137-26-0600	$ 47,578.00
4	M.T. No. 3, Blk 12; Lot 8	137-26-0610	$ 10,500.00
5	M.T. No. 3, Blk 12; Lot 9	137-26-0620	$ 55,663.00
6	M.T. No. 3, Blk 12; Lot 10	137-26-0630	$ 44,758.00
7	M.T. No. 3, Blk 12; Lot 11	137-26-0640	$ 44,508.00
8	M.T. No. 3, Blk 12; Lot 12	137-26-0650	$ 63,542.00
9	M.T. No. 3, Blk 12; Lot 13	137-26-0660	$ 10,500.00
10	M.T. No. 3, Blk 12; Lot 14	137-26-0670	$ 10,500.00
11	M.T. No. 3, Blk 12; Lot 15	137-26-0680	$ 52,083.00
12	M.T. No. 3, Blk 12; Lot 16	137-26-0690	$ 10,500.00
13	M.T. No. 3, Blk 12; Lot 17	137-26-070	$ 34,306.00
14	M.T. No. 3, Blk 12; Lot 18	137-26-071	$ 42,810.00
15	M.T. No. 3, Blk. 11; Lot 9	137-26-051	$ 56,850.00
16	M.T. No. 3, Blk. 11; Lot 10	137-26-052	$ 46,264.00
17	M.T. No. 3, Blk. 11; Lot 11	137-26-053	$ 51,557.00
18	2600 W. Valencia Road	137-23-004H	$ 8,105.00
19	2610 W. Valencia Road	137-23-0046	$ 2,818.00
20	Circle K parcel	137-23-0030	$ 96,807.00
	Total Assessed Value		$ 754,868.00

Acquisition cost = $ 754,868 x 1.33 = $ 1,003,974.00

This is the estimate for acquisition of all property within the 100-year floodplain, situated between Westover Avenue and Valencia Road. Even minor improvement to the channel will decrease the floodplain area and consequently reduce the number of properties within floodplain and hence the acquisition cost.

5. EVALUATIONS OF ALTERNATIVES

As discussed in Section 3.2, the detention/retention alternative is very cost prohibitive and may not be accepted by the general public because of its size and proximity to major streets.

The property acquisition cost estimate of $ 1,003,974.00, as detailed in Section 4.2.2, also seems unacceptable from a cost point of view as well acceptance by the general public.

This leaves channelization of the wash between Valencia Road and Westover Avenue, along with the other relevant improvements, as a most preferable alternative.

<u>Channel Improvements</u>

The following three types of trapezoidal shape channel improvements are considered. For each type of improvement, alternative cross sections of different channel widths are calculated, using Manning's Equation.

Type 1: Earthen channel with 3:1 side slope and a Manning's "n" value of 0.028.

Type 2: Concrete lined banks with 1:1 side slope, with earthen bottom and a Manning's "n" value of 0.020.

Type 3: Concrete lined channel (banks and bottom) with 1:1 side slope and a Manning's "n" value of 0.013.

For each type of channel, the required cross-sections are calculated for two options for the channel slope: <u>OPTION "A"</u>: Existing channel slope of 0.16% and no grading in the Indian Reservation Land and OPTION "B": Channel with slope of 0.30%, which will be available by doing grading in the Reservation Land for approximately 200' east of Westover Avenue.

Appendix "A" contains calculations and sketches of various cross sections for option "A." Table 1 is a summary of alternative cross sections for this option.

Appendix "B" contains calculations and sketches of various cross sections for option "B." Table 2 is a summary of alternative cross sections for this option.

Review of Table 1 and 2 indicates that the required channel section will not fit within the existing 64' wide drainageway. Another criteria for the channel selection is the feasible height of the bank considering existing channel depth of only 4' near the drainageway from Oriole Circle.

If height of levee is limited to 2', the total depth of the channel should be under 6'. Considering 1' of free board, the selected channel should have normal depth under 6', for option "A" and under 5' for option "B". Under these criteria, selected sections would be A-3, A-8, or A-13 for option "A" and B-3, B-6, or B-10 for option "B". All of these options will require additional right-of-way which can be available by acquiring the Circle K property located along the east bank of the wash. Both options will require approximately 900' of channel between Valencia Road and Westover Avenue and reconstruction of the existing dip section at Westover Avenue, and other relevant improvements.

Selected cross sections for an earthen channel will require a bottom width of 180' and a top width of over 220' for option A and a 140' bottom width with over 180' top width for option B. Since there is no available space for channel expansion along the westerly bank, a very wide channel width required for this alternative will utilize most of the Circle K property. Moreover, it will require a significant improvement for outlet transition near the downstream end of the Valencia Road box culvert. It will also require removal of a significant amount of vegetation and a longer dip section in Westover Avenue as well as frequent maintenance of the earthen channel. Considering all these facts, this alternative is eliminated for further considerations.

This leaves type 2 and type 3 channel configuration for the final evaluation and recommendation.

Construction cost estimates for the above two alternatives are presented below. Land acquisition costs for the Circle K property are not included in the estimates. The estimated earthwork for the channel improvements is based upon the topographic map at a 1" = 200' scale. The use of topographic maps at this scale precludes a high degree of accuracy when estimating earthwork. A more accurate estimate can only be made using larger scale drawings, prepared for design purposes during the design phase of the project.

Construction Cost Estimates

I. Option "A" - Section A-8 (concrete lined slope with earth bottom)

Earthwork	10,000 c.y. @ $5/c.y.	$ 50,000
Concrete lining	480 c.y. @ $180/c.y.	86,400
Westover Ave.	400 l.f. @ $40/l.f.	16,000
	Subtotal	152,400
	Administration (15%)	22,860
	Engineering (10%)	15,240
	Misc Contingency (20%)	30,480
	TOTAL COST	**$ 220,980**

II. Option "A" - Section A-13 (fully lined concrete channel)

Earthwork	5,000 c.y. @ $5/c.y.	$ 25,000
Concrete lining	1,750 c.y. @ $180/c.y.	315,000
Westover Ave.	400 l.f. @ $40/l.f.	16,000
	Subtotal	356,000
	Administration (15%)	53,400
	Engineering (10%)	35,600
	Misc Contingency (20%)	71,200
	TOTAL COST	**$ 516,200**

III. Option "B" - Section B-6 (concrete lined slope with earth bottom)

Earthwork	12,000 c.y. @ $5/c.y.	$ 60,000
Concrete lining	450 c.y. @ $180/c.y.	81,000
Westover Ave.	400 l.f. @ $40/l.f.	16,000
	Subtotal	157,000
	Administration (15%)	23,550
	Engineering (10%)	15,700
	Misc Contingency (20%)	31,400
	TOTAL COST	**$ 227,650**

IV. Option "B" - Section B-10 (fully lined concrete channel)

Earthwork	5,500 c.y. @ $5/c.y.	$ 27,500
Concrete lining	1,400 c.y. @ $180/c.y.	252,000
Westover Ave.	400 l.f. @ $40/l.f.	16,000
	Subtotal	295,500
	Administration (15%)	44,325
	Engineering (10%)	29,550
	Misc Contingency (20%)	59,100
	TOTAL COST	**$ 428,475**

Reviewing the cost estimates indicates the channel with a concrete lined slope and an earth bottom is the most cost effective.

6. SUMMARY AND RECOMMENDATION

6.1 Project Summary

The Valencia Wash Basin Management Study developed the 100-year floodplain limits within the watershed and identified the area between Westover Avenue and Valencia Road as a major flood hazard area affecting most of the properties along the channel. Major reasons for flooding of this area are: 1) Inadequate capacity of the existing drainageway and the channel, and 2) Lack of a proper outlet at Westover Avenue created by sedimentation, collection of debris and total lack of maintenance of the drainageway within the Indian Reservation land. The existing channel capacity is less than the 5-year flood discharge.

Properties in Mission Terrace No. 3, located along Oriole Circle east of Hildreth Avenue, specifically located along the west bank of Valencia Wash, are also affected by local drainage within the subdivision. Most of the houses are constructed with the slab on grade and there are no storm drain facilities within the subdivision. The only outlet from the subdivision is a 16' wide drainage easement between lot no. 9 and 10.

In order to provide flood protection to properties within the subject area at a reasonable cost, the existing channel must be improved to carry the 100-year flood discharge and also provide a proper outlet at Westover Avenue. Moreover, improvement in Mission Terrace No. 3 in the form of inverted crown street reconstruction of Oriole Circle and storm drainage facilities are needed to provide protection from local drainage.

The Circle K property will need to be acquired and additional drainage easement in the El Paso Natural Gas property will need to be obtained. Land area remained after the channel construction within the Circle K parcel will offer a high potential for development and a partial acquisition cost can be recovered by disposal of the remaining property. As an alterative, the remaining land could be developed as a park and recreational area to serve the neighborhood.

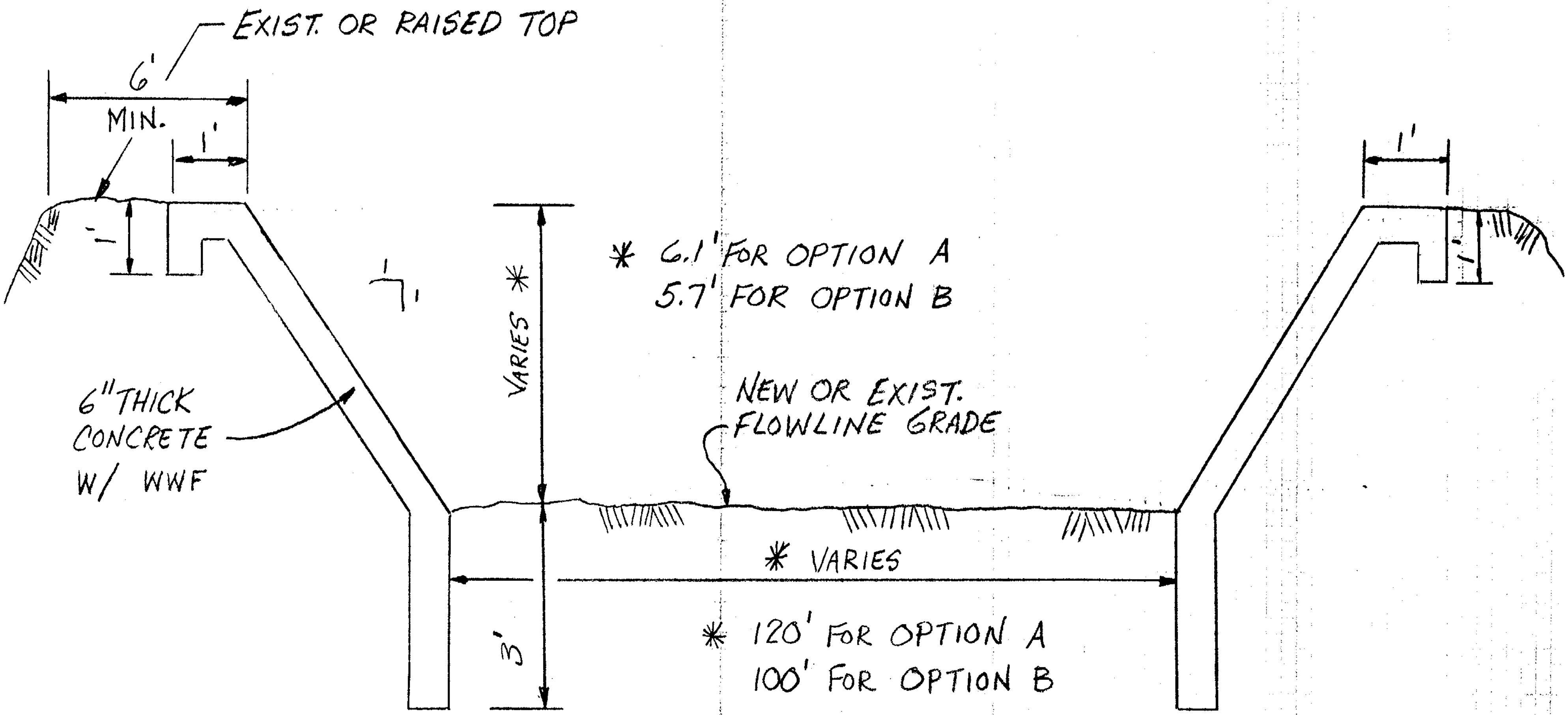
Review of the evaluation of alternatives described in Section 5 reveals that the most cost effective and practical solution is to enlarge the drainageway and construct a channel with concrete lined slopes and natural bottom along with improvement of Westover Avenue dip section designated as type 2-option "B," in section 5 and other relevant facilities. Improvement of the outlet at Westover Avenue must be carried out for efficient operation of the channel. Without a proper outlet the back-flow effects will still cause flooding within the subject area. Figure 2 depicts the typical channel section.

6.2 Recommendation

The following recommendations are presented to provide effective flood protection to the properties along Valencia Wash between Westover Avenue and Valencia Road.

1. Acquire Circle K parcel
2. Construct channel, between Westover Avenue and Valencia Road, with concrete lined slopes and earth bottom. Also construct appropriate transitions at the Valencia Road box culvert and at the Westover Avenue dip section.

3. Obtain drainage easement from El Paso Natural Gas Company.
4. Clear the area downstream of Westover Avenue, and provide an efficient outlet to prevent back-flow into Mission Terrace No. 3.
5. Construct storm drain facilities and inverted crown street in Oriole Circle between Hildreth Avenue and Valencia Wash.
6. Continue the next phase of the project to include design and preparation of construction plans for the selected alternative.



VALENCIA WASH BASIN MANAGEMENT STUDY

RECOMMENDED TYPICAL CHANNEL SECTION (TYPE 2)

NO SCALE

FIGURE 2

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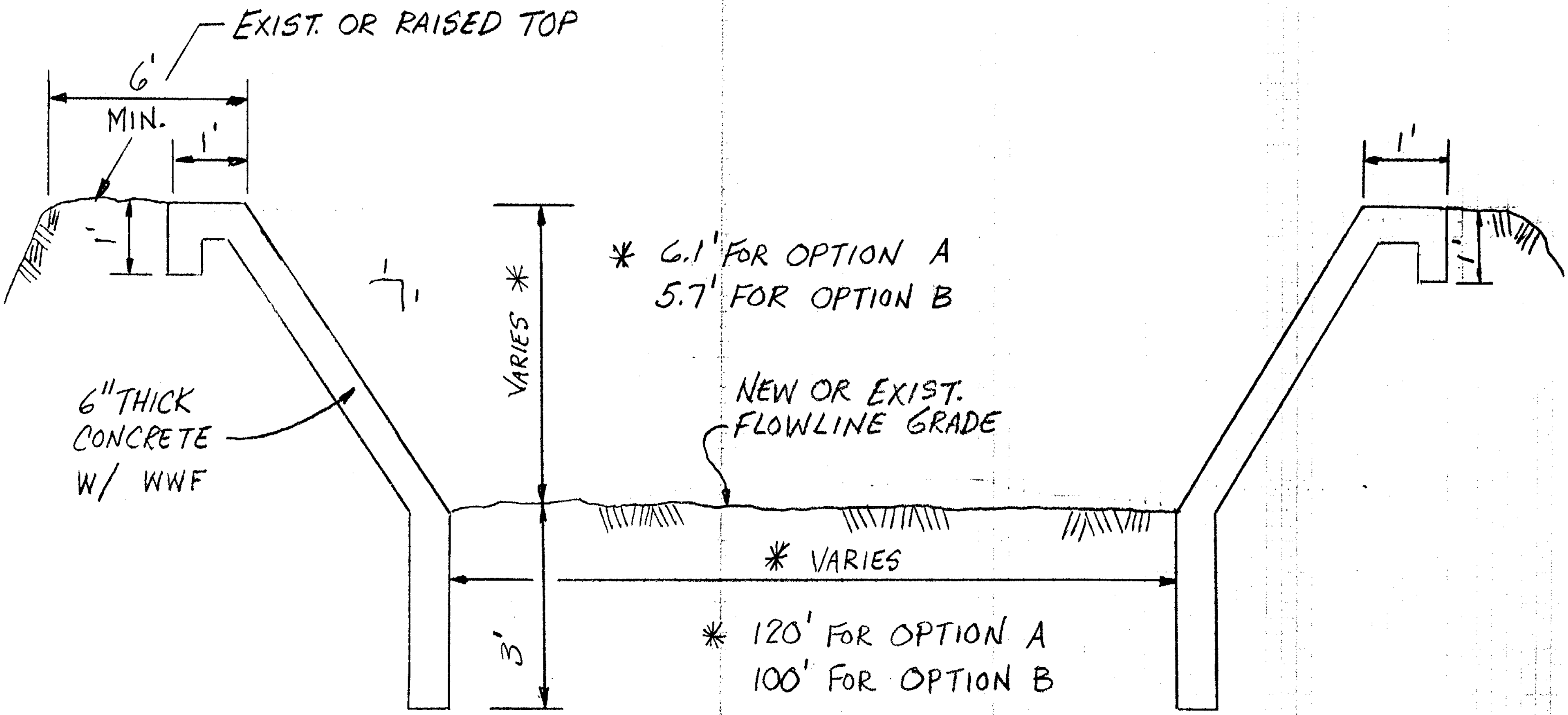

VALENCIA WASH BASIN MANAGEMENT STUDY

RECOMMENDED TYPICAL CHANNEL SECTION (TYPE 2)

NO SCALE

FIGURE 2

Alpha Engineering

APPENDIX A

NORMAL and CRITICAL DEPTH PROGRAM
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
TRAPEZOIDAL and RECTANGULAR CHANNELS
Newton's Method

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            Input                                           Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                   3  NORMAL DEPTH =         7.423
FLOW RATE, cfs = ? 5310            3  VELOCITY =        6.994
                                   3  TOP WIDTH, ft =     124.541
MANNING'S COEFFICIENT = ? .028     3  AREA =     759.203
                                   3  WET PERIM =     126.950
CHANNEL SLOPE, ft/ft = ? .0016     3  HYD RAD =        5.980
                                   3  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 80        3  DM =        6.096
                                   3  E =       8.183
SIDE SLOPE RATIO (h/v) = ? 3       3  FROUDE NO. =        0.499
                                   CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                   3  CRITICAL DEPTH, ft =        4.836
                                   3  VELOCITY @ CRITICAL DEPTH, ft/sec =      11.619
                                   3  CRITICAL SLOPE, ft/ft =       0.007

Hit <Return> Key to Continue . . .
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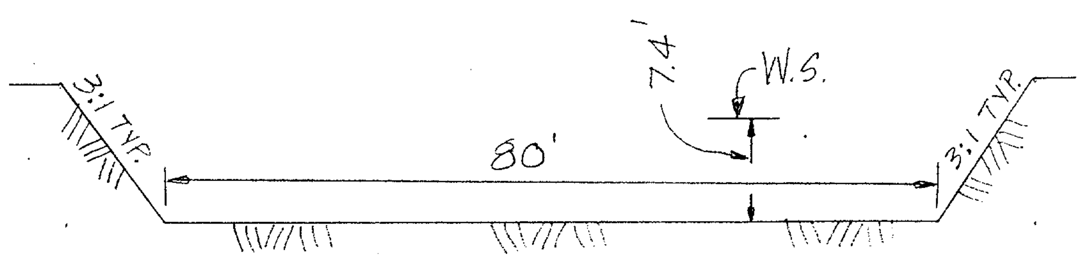

SECTION A-1

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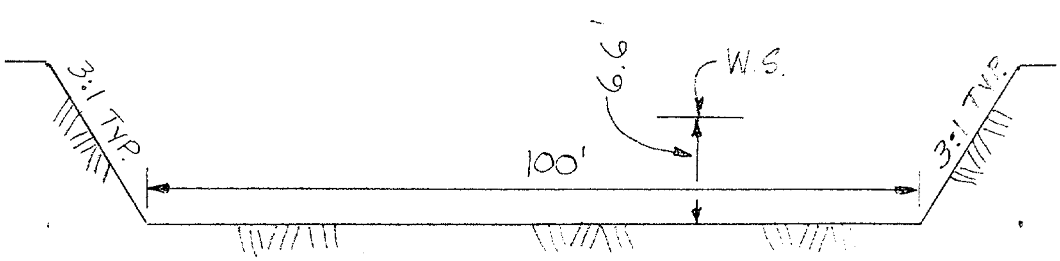
                 NORMAL and CRITICAL DEPTH  PROGRAM
              DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                 TRAPEZOIDAL and RECTANGULAR CHANNELS
                          Newton's Method

         Input                                  Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                      3  NORMAL DEPTH =       6.622
FLOW RATE, cfs = ? 5310               3  VELOCITY =      6.690
                                      3  TOP WIDTH, ft =     139.731
MANNING'S COEFFICIENT = ? .028        3  AREA =     793.730
                                      3  WET PERIM =     141.880
CHANNEL SLOPE, ft/ft = ? .0016        3  HYD RAD =      5.594
                                      3  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 100          3  DM =       5.680
                                      3  E =     7.317
SIDE SLOPE RATIO (h/v) = ? 3          3  FROUDE NO. =       0.495
                                      CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                      3  CRITICAL DEPTH, ft =       4.248
                                      3  VELOCITY @ CRITICAL DEPTH, ft/sec =      11.086
                                      3  CRITICAL SLOPE, ft/ft =      0.007
```

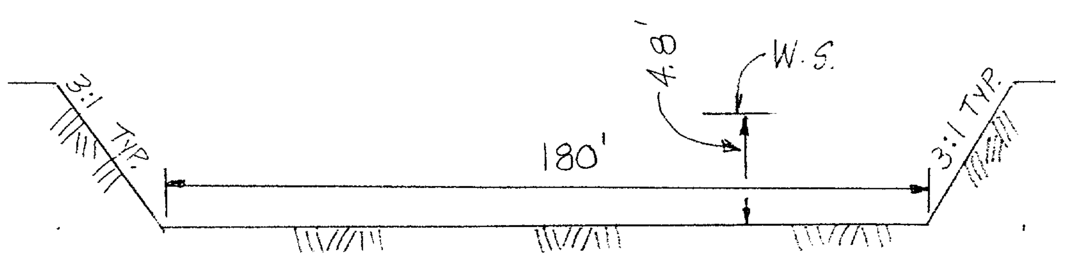


SECTION A-2

TYPE 1

```
                    NORMAL and CRITICAL DEPTH  PROGRAM
                 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                   TRAPEZOIDAL and RECTANGULAR CHANNELS
                             Newton's Method

         Input                                 Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                3  NORMAL DEPTH =       4.780
FLOW RATE, cfs = ? 5310         3  VELOCITY =       5.716
                                3  TOP WIDTH, ft =     208.680
MANNING'S COEFFICIENT = ? .028  3  AREA =     928.930
                                3  WET PERIM =     210.231
CHANNEL SLOPE, ft/ft = ? .0016  3  HYD RAD =       4.419
                                3  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 180    3  DM =      4.451
                                3  E =      5.287
SIDE SLOPE RATIO (h/v) = ? 3    3  FROUDE NO. =       0.477
                                CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                3  CRITICAL DEPTH, ft =       2.951
                                3  VELOCITY @ CRITICAL DEPTH, ft/sec =       9.527
                                3  CRITICAL SLOPE, ft/ft =      0.008
```



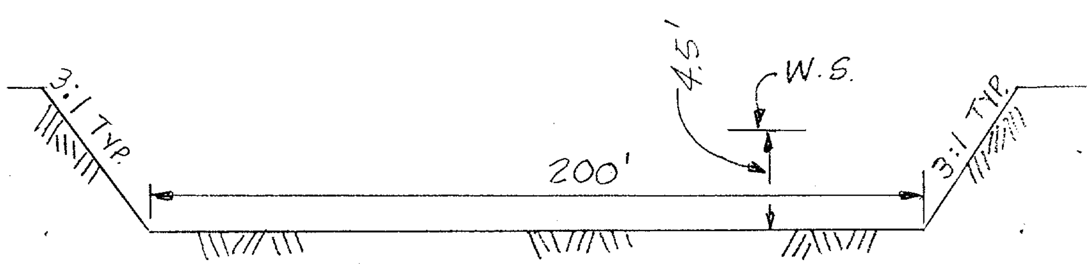
SECTION A-3

TYPE I

```
                    NORMAL and CRITICAL DEPTH  PROGRAM
                  DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                   TRAPEZOIDAL and RECTANGULAR CHANNELS
                             Newton's Method

           Input                                Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                 3  NORMAL DEPTH =       4.498
FLOW RATE, cfs = ? 5310          3  VELOCITY =       5.529
                                 3  TOP WIDTH, ft =    226.989
MANNING'S COEFFICIENT = ? .028   3  AREA =    960.329
                                 3  WET PERIM =    228.449
CHANNEL SLOPE, ft/ft = ? .0016   3  HYD RAD =      4.204
                                 3  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 200     3  DM =      4.231
                                 3  E =     4.973
SIDE SLOPE RATIO (h/v) = ? 3     3  FROUDE NO. =       0.474
                                 CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                 3  CRITICAL DEPTH, ft =      2.758
                                 3  VELOCITY @ CRITICAL DEPTH, ft/sec =      9.243
                                 3  CRITICAL SLOPE, ft/ft =      0.008

Hit <Return> Key to Continue . . .
```



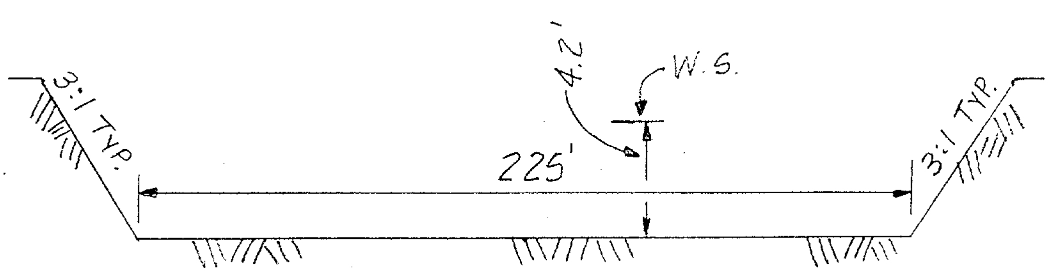
SECTION A-4

TYPE I

NORMAL and CRITICAL DEPTH PROGRAM
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
TRAPEZOIDAL and RECTANGULAR CHANNELS
Newton's Method

```
        Input                                        Output
D DDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                3  NORMAL DEPTH =       4.201
FLOW RATE, cfs = ? 5310         3  VELOCITY =       5.320
                                3  TOP WIDTH, ft =      250.204
M NNING'S COEFFICIENT = ? .028  3  AREA =      998.081
                                3  WET PERIM =      251.567
CHANNEL SLOPE, ft/ft = ? .0016  3  HYD RAD =      3.967
                                3  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 225    3  DM =      3.989
                                3  E =      4.640
S DE SLOPE RATIO (h/v) = ? 3    3  FROUDE NO. =       0.469
                                CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                3  CRITICAL DEPTH, ft =       2.557
                                3  VELOCITY @ CRITICAL DEPTH, ft/sec =       8.927
                                3  CRITICAL SLOPE, ft/ft =       0.008

Hit <Return> Key to Continue . . .
```



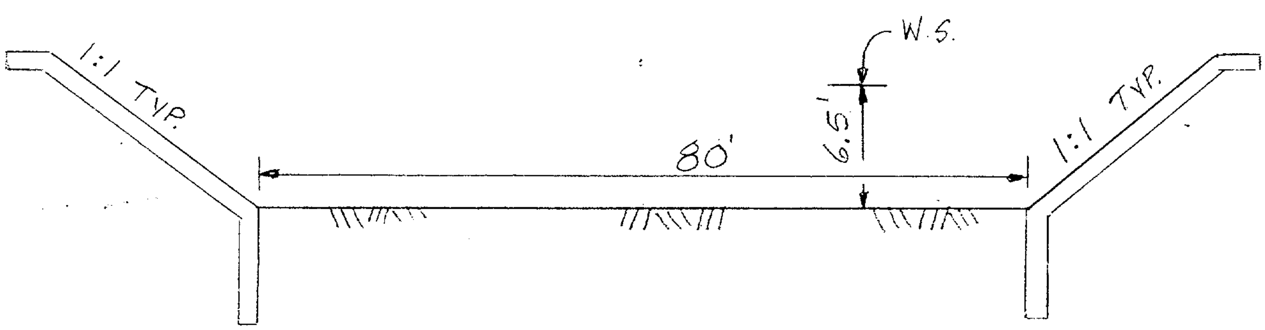
SECTION A-5

TYPE I

```
                 NORMAL and CRITICAL DEPTH  PROGRAM
                 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                  TRAPEZOIDAL and RECTANGULAR CHANNELS
                           Newton's Method

         Input                               Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                 3  NORMAL DEPTH =        6.477
FLOW RATE, cfs = ? 5310          3  VELOCITY =       9.480
                                 3  TOP WIDTH, ft =       92.954
MANNING'S COEFFICIENT = ? .02    3  AREA =     560.124
                                 3  WET PERIM =       98.320
CHANNEL SLOPE, ft/ft = ? .0016   3  HYD RAD =       5.697
                                 3  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 80      3  DM =       6.026
                                 3  E =      7.873
SIDE SLOPE RATIO (h/v) = ? 1     3  FROUDE NO. =       0.681
                                 CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                 3  CRITICAL DEPTH, ft =       5.043
                                 3  VELOCITY @ CRITICAL DEPTH, ft/sec =      12.381
                                 3  CRITICAL SLOPE, ft/ft =       0.004

Hit <Return> Key to Continue . . .
```

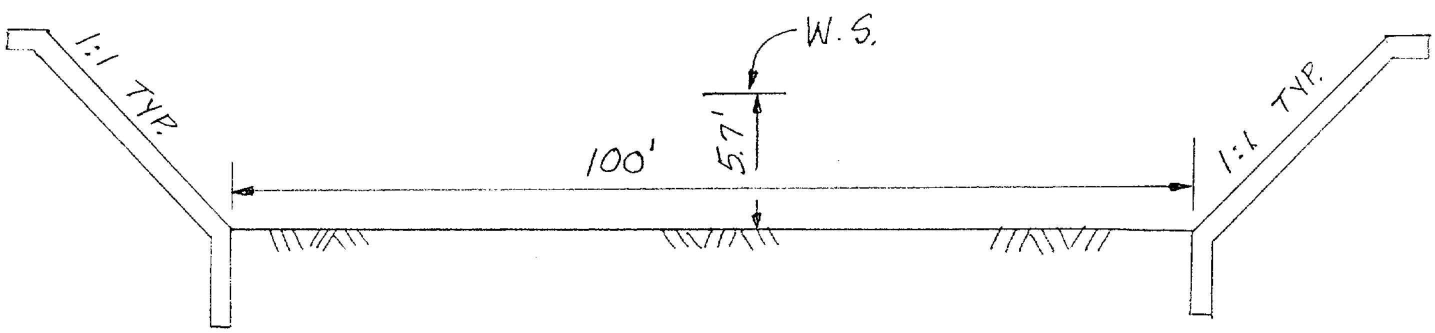


SECTION A-6

TYPE 2

```
                    NORMAL and CRITICAL DEPTH  PROGRAM
                 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                   TRAPEZOIDAL and RECTANGULAR CHANNELS
                             Newton's Method

         Input                                      Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                 3  NORMAL DEPTH =        5.664
FLOW RATE, cfs = ? 5310          3  VELOCITY =       8.873
                                 3  TOP WIDTH, ft =    111.328
MANNING'S COEFFICIENT = ? .02    3  AREA =     598.467
                                 3  WET PERIM =     116.020
CHANNEL SLOPE, ft/ft = ? .0016   3  HYD RAD =       5.158
                                 3  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 100     3  DM =       5.376
                                 3  E =      6.886
SIDE SLOPE RATIO (h/v) = ? 1     3  FROUDE NO. =       0.674
                                 CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                 3  CRITICAL DEPTH, ft =       4.375
                                 3  VELOCITY @ CRITICAL DEPTH, ft/sec =     11.628
                                 3  CRITICAL SLOPE, ft/ft =      0.004
```



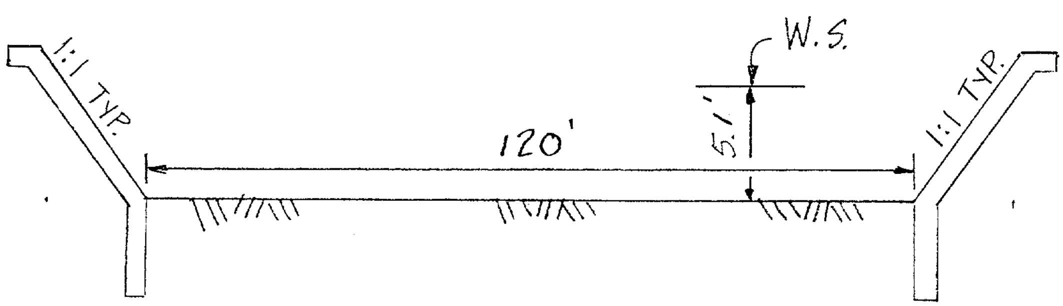
SECTION A-7

TYPE 2

```
                 NORMAL and CRITICAL DEPTH  PROGRAM
                áááááááááááááááááááááááááááááááááááááááá
                 TRAPEZOIDAL and RECTANGULAR CHANNELS
                            Newton's Method

         Input                                       Output
á áááááááááááááááááááááááááááááá°ááááááááááááááááááááááááááááááááááááááááááááá
                                °  NORMAL DEPTH =       5.074
FLOW RATE, cfs = ? 5310         °  VELOCITY =      8.367
                                °  TOP WIDTH, ft =     130.148
MANNING'S COEFFICIENT = ? .02   °  AREA =     634.636
                                °  WET PERIM =     134.352
CHANNEL SLOPE, ft/ft = ? .0016  °  HYD RAD =      4.724
                                °  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 120    °  DM =      4.876
                                °  E =      6.161
SIDE SLOPE RATIO (h/v) = ? 1    °  FROUDE NO. =       0.668
                                ûáááááááááááááááááááááááááááááááááááááááááááááá
                                °  CRITICAL DEPTH, ft =      3.890
                                °  VELOCITY @ CRITICAL DEPTH, ft/sec =     11.020
                                °  CRITICAL SLOPE, ft/ft =      0.004

Hit <Return> Key to Continue . . .
```



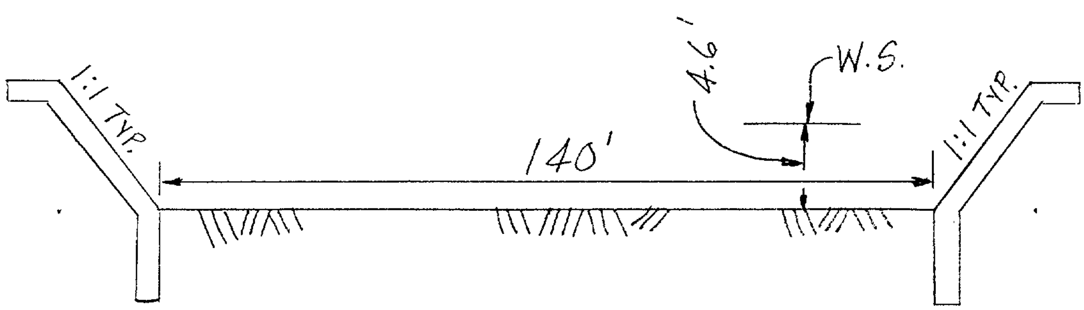
SECTION A-8

TYPE 2

```
                 NORMAL and CRITICAL DEPTH   PROGRAM
             áááááááááááááááááááááááááááááááááááááááá
               TRAPEZOIDAL and RECTANGULAR CHANNELS
                          Newton's Method

         Input                                  Output
á áááááááááááááááááááááááááááááá°ááááááááááááááááááááááááááááááááááááááááááááá
                                °  NORMAL DEPTH =       4.623
F OW RATE, cfs = ? 5310         °  VELOCITY =      7.942
                                °  TOP WIDTH, ft =    149.247
MANNING'S COEFFICIENT = ? .02   °  AREA =     668.638
                                °  WET PERIM =     153.077
C ANNEL SLOPE, ft/ft = ? .0016  °  HYD RAD =      4.368
                                °  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 140    °  DM =       4.480
                                °  E =      5.603
S DE SLOPE RATIO (h/v) = ? 1    °  FROUDE NO. =      0.661
                                ûáááááááááááááááááááááááááááááááááááááááááááááá
                                °  CRITICAL DEPTH, ft =      3.518
                                °  VELOCITY @ CRITICAL DEPTH, ft/sec =     10.516
                                °  CRITICAL SLOPE, ft/ft =      0.004

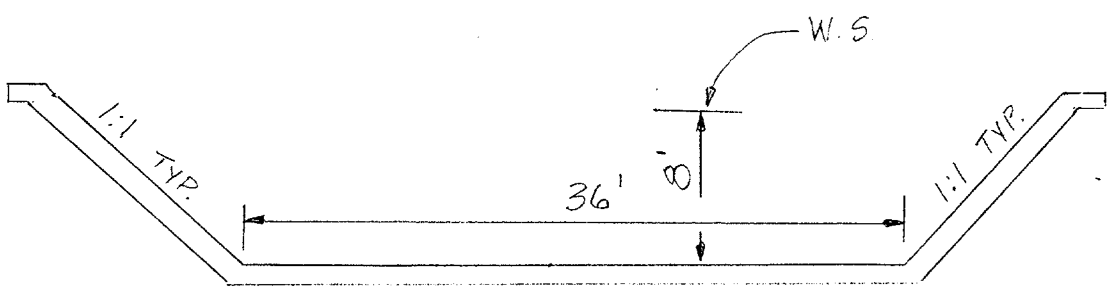
H t <Return> Key to Continue . . .
```



SECTION A-9

```
               NORMAL and CRITICAL DEPTH  PROGRAM
              DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
               TRAPEZOIDAL and RECTANGULAR CHANNELS
                         Newton's Method

         Input                                      Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                  3  NORMAL DEPTH =        7.994
FLOW RATE, cfs = ? 5310           3  VELOCITY =      15.098
                                  3  TOP WIDTH, ft =       51.988
MANNING'S COEFFICIENT = ? .013    3  AREA =     351.695
                                  3  WET PERIM =       58.611
CHANNEL SLOPE, ft/ft = ? .0016    3  HYD RAD =       6.001
                                  3  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 36       3  DM =        6.765
                                  3  E =      11.534
SIDE SLOPE RATIO (h/v) = ? 1      3  FROUDE NO. =       1.023
                                  CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                  3  CRITICAL DEPTH, ft =        8.107
                                  3  VELOCITY @ CRITICAL DEPTH, ft/sec =     14.850
                                  3  CRITICAL SLOPE, ft/ft =       0.001
```



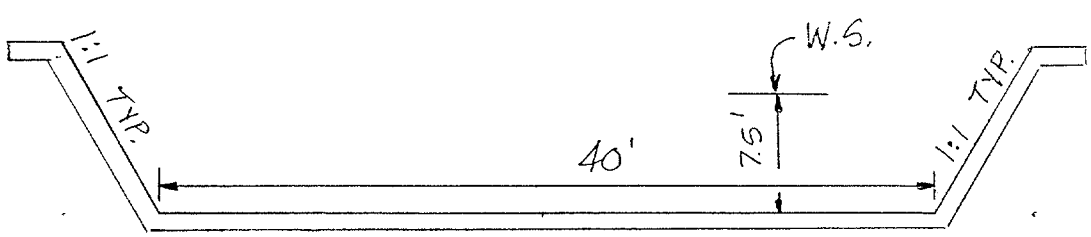
SECTION A-10

TYPE 3

```
                 NORMAL and CRITICAL DEPTH  PROGRAM
                ááááááááááááááááááááááááááááááááááááááááá
                  TRAPEZOIDAL and RECTANGULAR CHANNELS
                            Newton's Method

         Input                                Output
áááááááááááááááááááááááááááááááá°ááááááááááááááááááááááááááááááááááááááááááááá
                                °  NORMAL DEPTH =      7.533
F  OW RATE, cfs = ? 5310        °  VELOCITY =     14.829
                                °  TOP WIDTH, ft =     55.067
MANNING'S COEFFICIENT = ? .013  °  AREA =    358.080
                                °  WET PERIM =     61.307
C  ANNEL SLOPE, ft/ft = ? .0016 °  HYD RAD =     5.841
                                °  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 40     °  DM =     6.503
                                °  E =    10.948
S  DE SLOPE RATIO (h/v) = ? 1   °  FROUDE NO. =     1.025
                                ûááááááááááááááááááááááááááááááááááááááááááááá
                                °  CRITICAL DEPTH, ft =      7.649
                                °  VELOCITY @ CRITICAL DEPTH, ft/sec =     14.568
                                °  CRITICAL SLOPE, ft/ft =      0.001

H t <Return> Key to Continue . . .
```



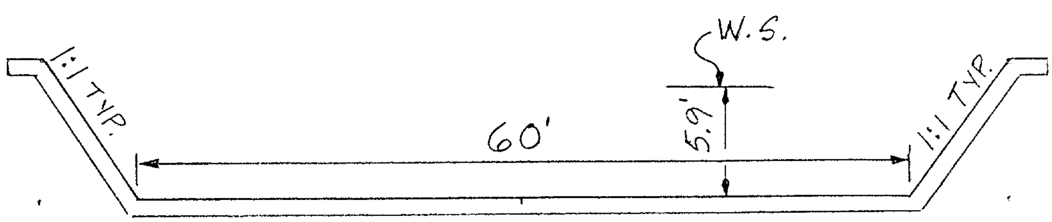
SECTION A-11

TYPE 3

```
                 NORMAL and CRITICAL DEPTH  PROGRAM
               ááááááááááááááááááááááááááááááááááááááá
                TRAPEZOIDAL and RECTANGULAR CHANNELS
                          Newton's Method

         Input                                  Output
áááááááááááááááááááááááááááááááá°ááááááááááááááááááááááááááááááááááááááááááááá
                                °  NORMAL DEPTH =      5.943
FLOW RATE, cfs = ? 5310         °  VELOCITY =     13.551
                                °  TOP WIDTH, ft =     71.885
MANNING'S COEFFICIENT = ? .013  °  AREA =    391.867
                                °  WET PERIM =      76.808
CHANNEL SLOPE, ft/ft = ? .0016  °  HYD RAD =      5.102
                                °  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 60     °  DM =      5.451
                                °  E =      8.794
SIDE SLOPE RATIO (h/v) = ? 1    °  FROUDE NO. =      1.023
                                ûáááááááááááááááááááááááááááááááááááááááááááá
                                °  CRITICAL DEPTH, ft =      6.029
                                °  VELOCITY @ CRITICAL DEPTH, ft/sec =     13.338
                                °  CRITICAL SLOPE, ft/ft =      0.001

Hit <Return> Key to Continue . . .
```



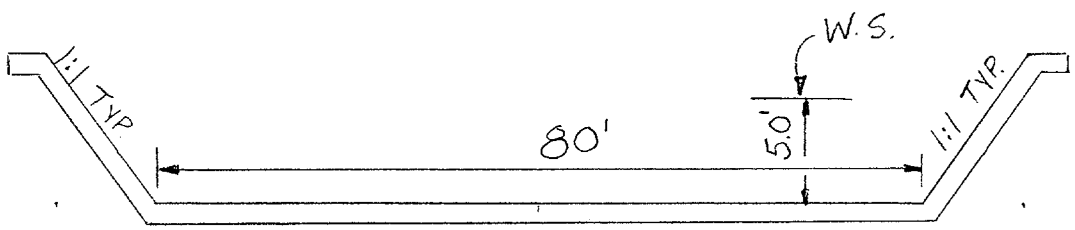
SECTION A-12

A-12

```
                    NORMAL and CRITICAL DEPTH  PROGRAM
                 áááááááááááááááááááááááááááááááááááááááá
                   TRAPEZOIDAL and RECTANGULAR CHANNELS
                              Newton's Method

         Input                                Output
á áááááááááááááááááááááááááááááá°ááááááááááááááááááááááááááááááááááááááááááááá
                                °  NORMAL DEPTH =       5.001
F OW RATE, cfs = ? 5310         °  VELOCITY =     12.491
                                °  TOP WIDTH, ft =      90.002
MANNING'S COEFFICIENT = ? .013  °  AREA =    425.104
                                °  WET PERIM =     94.145
C ANNEL SLOPE, ft/ft = ? .0016  °  HYD RAD =     4.515
                                °  CONVEYANCE = 132750.000
CHANNEL BOTTOM WIDTH = ? 80     °  DM =      4.723
                                °  E =     7.424
S DE SLOPE RATIO (h/v) = ? 1    °  FROUDE NO. =      1.013
                                ûááááááááááááááááááááááááááááááááááááááááááááá
                                °  CRITICAL DEPTH, ft =      5.043
                                °  VELOCITY @ CRITICAL DEPTH, ft/sec =     12.381
                                °  CRITICAL SLOPE, ft/ft =      0.001

H t <Return> Key to Continue . . .
```



SECTION A-13

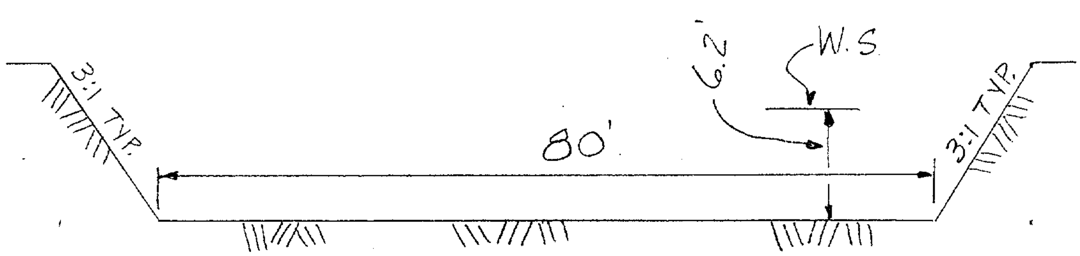
TYPE 3

APPENDIX B

NORMAL and CRITICAL DEPTH PROGRAM
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
TRAPEZOIDAL and RECTANGULAR CHANNELS
Newton's Method

Input	Output
	NORMAL DEPTH = 6.217
FLOW RATE, cfs = ? 5310	VELOCITY = 8.658
	TOP WIDTH, ft = 117.303
MANNING'S COEFFICIENT = ? .028	AREA = 613.324
	WET PERIM = 119.320
CHANNEL SLOPE, ft/ft = ? .003	HYD RAD = 5.140
	CONVEYANCE = 96946.880
CHANNEL BOTTOM WIDTH = ? 80	DM = 5.229
	E = 7.381
SIDE SLOPE RATIO (h/v) = ? 3	FROUDE NO. = 0.667
	CRITICAL DEPTH, ft = 4.836
	VELOCITY @ CRITICAL DEPTH, ft/sec = 11.61
	CRITICAL SLOPE, ft/ft = 0.007

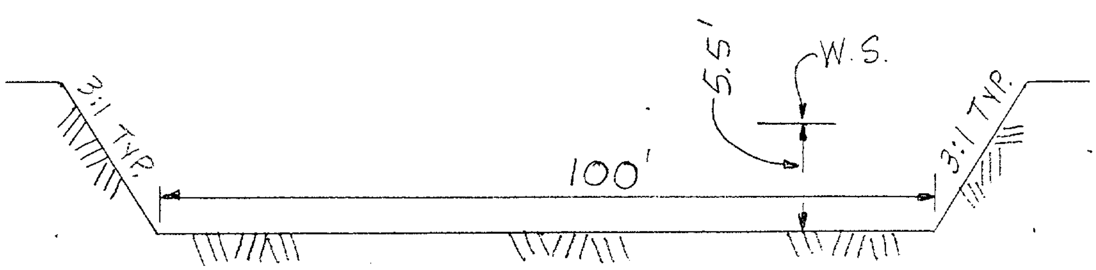
Hit (Return) Key to Continue . . .



SECTION B-1

```
                    NORMAL and CRITICAL DEPTH  PROGRAM
                  DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                    TRAPEZOIDAL and RECTANGULAR CHANNELS
                              Newton's Method

          Input                                  Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                 3  NORMAL DEPTH =        5.527
FLOW RATE, cfs = ? 5310          3  VELOCITY =        8.242
                                 3  TOP WIDTH, ft =     133.159
MANNING'S COEFFICIENT = ? .028   3  AREA =     644.283
                                 3  WET PERIM =     134.953
CHANNEL SLOPE, ft/ft = ? .003    3  HYD RAD =      4.774
                                 3  CONVEYANCE =  96946.860
CHANNEL BOTTOM WIDTH = ? 100     3  DM =       4.838
                                 3  E =      6.581
SIDE SLOPE RATIO (h/v) = ? 3     3  FROUDE NO. =        0.660
                                 CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                 3  CRITICAL DEPTH, ft =       4.248
                                 3  VELOCITY @ CRITICAL DEPTH, ft/sec =      11.086
                                 3  CRITICAL SLOPE, ft/ft =       0.007
```



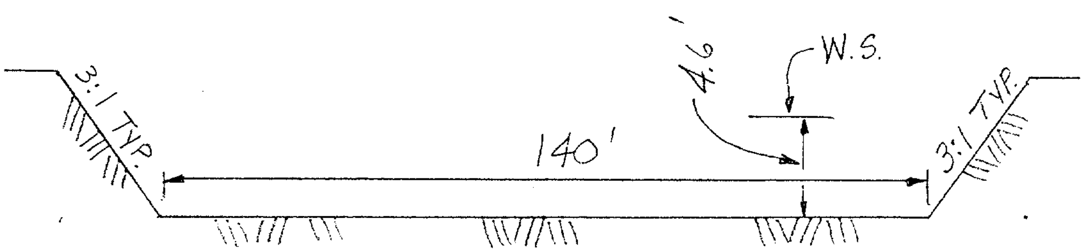
SECTION B-2

TYPE I

```
                    NORMAL and CRITICAL DEPTH  PROGRAM
                 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                   TRAPEZOIDAL and RECTANGULAR CHANNELS
                             Newton's Method

          Input                                  Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                3  NORMAL DEPTH =       4.585
FLOW RATE, cfs = ? 5310         3  VELOCITY =      7.532
                                3  TOP WIDTH, ft =     167.509
MANNING'S COEFFICIENT = ? .028  3  AREA =     704.946
                                3  WET PERIM =     168.997
CHANNEL SLOPE, ft/ft = ? .003   3  HYD RAD =       4.171
                                3  CONVEYANCE =  96946.890
CHANNEL BOTTOM WIDTH = ? 140    3  DM =        4.208
                                3  E =       5.466
SIDE SLOPE RATIO (h/v) = ? 3    3  FROUDE NO. =       0.647
                                CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                3  CRITICAL DEPTH, ft =       3.459
                                3  VELOCITY @ CRITICAL DEPTH, ft/sec =      10.208
                                3  CRITICAL SLOPE, ft/ft =       0.008

Hit <Return> Key to Continue . . .
```

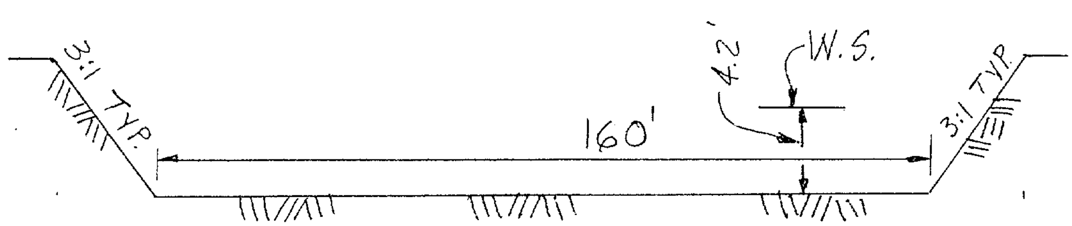


SECTION B-3

TYPE 1

NORMAL and CRITICAL DEPTH PROGRAM
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
TRAPEZOIDAL and RECTANGULAR CHANNELS
Newton's Method

```
            Input                                       Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                     3  NORMAL DEPTH =        4.248
FLOW RATE, cfs = ? 5310              3  VELOCITY =        7.236
                                     3  TOP WIDTH, ft =     185.490
MANNING'S COEFFICIENT = ? .028       3  AREA =     733.869
                                     3  WET PERIM =     186.868
CHANNEL SLOPE, ft/ft = ? .003        3  HYD RAD =       3.927
                                     3  CONVEYANCE =  96946.910
CHANNEL BOTTOM WIDTH = ? 160         3  DM =        3.956
                                     3  E =       5.061
SIDE SLOPE RATIO (h/v) = ? 3         3  FROUDE NO. =        0.641
                                     CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                     3  CRITICAL DEPTH, ft =        3.181
                                     3  VELOCITY @ CRITICAL DEPTH, ft/sec =        9.847
                                     3  CRITICAL SLOPE, ft/ft =       0.008
```



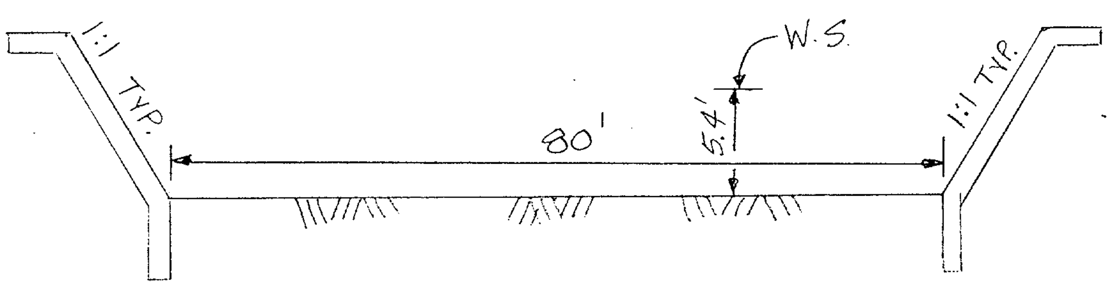
SECTION B-4

TYPE I

```
                    NORMAL and CRITICAL DEPTH  PROGRAM
                  DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                    TRAPEZOIDAL and RECTANGULAR CHANNELS
                              Newton's Method

          Input                                  Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                               3  NORMAL DEPTH =         5.364
FLOW RATE, cfs = ? 5310        3  VELOCITY =        11.598
                               3  TOP WIDTH, ft =        90.727
MANNING'S COEFFICIENT = ? .02  3  AREA =     457.855
                               3  WET PERIM =        95.171
CHANNEL SLOPE, ft/ft = ? .003  3  HYD RAD =        4.811
                               3  CONVEYANCE =  96946.870
CHANNEL BOTTOM WIDTH = ? 80    3  DM =          5.047
                               3  E =         7.452
SIDE SLOPE RATIO (h/v) = ? 1   3  FROUDE NO. =        0.910
                               CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                               3  CRITICAL DEPTH, ft =         5.043
                               3  VELOCITY @ CRITICAL DEPTH, ft/sec =      12.381
                               3  CRITICAL SLOPE, ft/ft =        0.004

Hit <Return> Key to Continue . . .
```

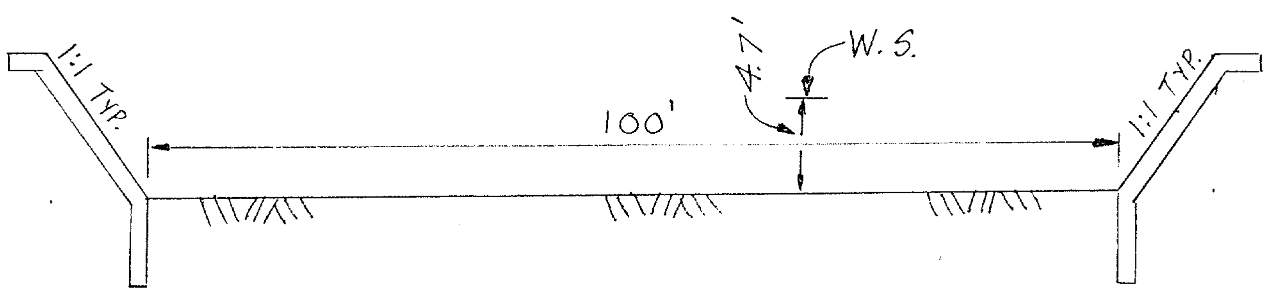


SECTION B-5

TYPE 2

```
                NORMAL and CRITICAL DEPTH  PROGRAM
              DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                TRAPEZOIDAL and RECTANGULAR CHANNELS
                          Newton's Method

          Input                               Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                  3  NORMAL DEPTH =       4.689
FLOW RATE, cfs = ? 5310           3  VELOCITY =     10.818
                                  3  TOP WIDTH, ft =    109.378
MANNING'S COEFFICIENT = ? .02     3  AREA =    490.863
                                  3  WET PERIM =    113.262
CHANNEL SLOPE, ft/ft = ? .003     3  HYD RAD =      4.334
                                  3  CONVEYANCE =  96946.890
CHANNEL BOTTOM WIDTH = ? 100      3  DM =      4.488
                                  3  E =     6.506
SIDE SLOPE RATIO (h/v) = ? 1      3  FROUDE NO. =       0.900
                                  CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                  3  CRITICAL DEPTH, ft =      4.375
                                  3  VELOCITY @ CRITICAL DEPTH, ft/sec =     11.628
                                  3  CRITICAL SLOPE, ft/ft =      0.004
```

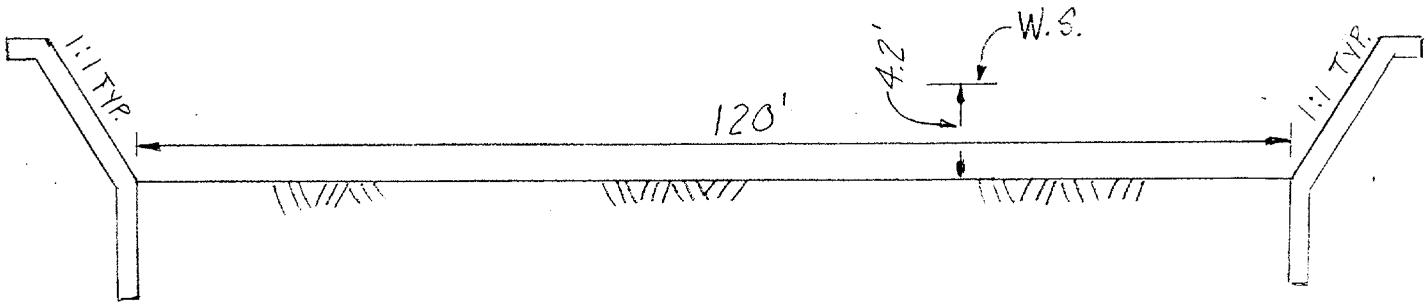


SECTION B-6

NORMAL and CRITICAL DEPTH PROGRAM
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
TRAPEZOIDAL and RECTANGULAR CHANNELS
Newton's Method

Input	Output
	NORMAL DEPTH = 4.200
FLOW RATE, cfs = ? 5310	VELOCITY = 10.179
	TOP WIDTH, ft = 128.401
MANNING'S COEFFICIENT = ? .02	AREA = 521.674
	WET PERIM = 131.880
CHANNEL SLOPE, ft/ft = ? .003	HYD RAD = 3.956
	CONVEYANCE = 96946.910
CHANNEL BOTTOM WIDTH = ? 120	DM = 4.063
	E = 5.809
SIDE SLOPE RATIO (h/v) = ? 1	FROUDE NO. = 0.890
	CRITICAL DEPTH, ft = 3.890
	VELOCITY @ CRITICAL DEPTH, ft/sec = 11.020
	CRITICAL SLOPE, ft/ft = 0.004

Hit (Return) Key to Continue . . .



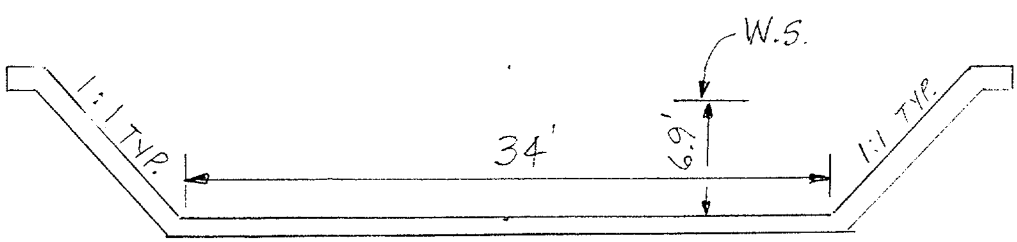
SECTION B-7

TYPE 2

```
                    NORMAL and CRITICAL DEPTH  PROGRAM
                    DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                    TRAPEZOIDAL and RECTANGULAR CHANNELS
                             Newton's Method

          Input                                Output
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                3  NORMAL DEPTH =       6.867
 LOW RATE, cfs = ? 5310         3  VELOCITY =    18.920
                                3  TOP WIDTH, ft =     47.735
MANNING'S COEFFICIENT = ? .013  3  AREA =    280.653
                                3  WET PERIM =     53.424
CHANNEL SLOPE, ft/ft = ? .003   3  HYD RAD =     5.253
                                3  CONVEYANCE =  96946.870
 HANNEL BOTTOM WIDTH = ? 34     3  DM =      5.879
                                3  E =    12.426
SIDE SLOPE RATIO (h/v) = ? 1    3  FROUDE NO. =      1.375
                                CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                                3  CRITICAL DEPTH, ft =      8.360
                                3  VELOCITY @ CRITICAL DEPTH, ft/sec =     14.994
                                3  CRITICAL SLOPE, ft/ft =      0.001

 ..it <Return> Key to Continue . . .
```



SECTION B-8

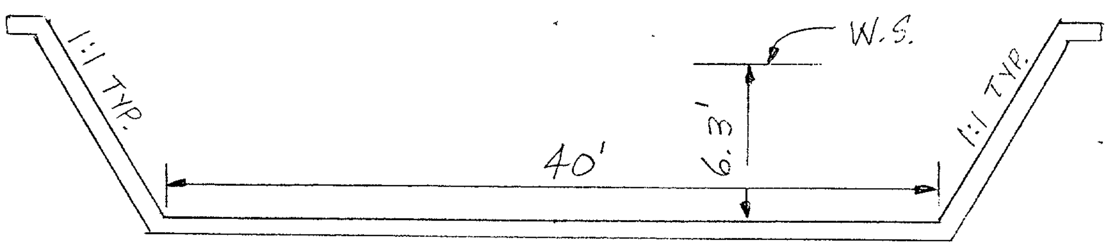
TYPE 3

NORMAL and CRITICAL DEPTH PROGRAM
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
TRAPEZOIDAL and RECTANGULAR CHANNELS
Newton's Method

Input | Output

DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD3DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

Input	Output
	3 NORMAL DEPTH = 6.257
LOW RATE, cfs = ? 5310	3 VELOCITY = 18.347
	3 TOP WIDTH, ft = 52.514
MANNING'S COEFFICIENT = ? .013	3 AREA = 289.426
	3 WET PERIM = 57.697
HANNEL SLOPE, ft/ft = ? .003	3 HYD RAD = 5.016
	3 CONVEYANCE = 96946.880
CHANNEL BOTTOM WIDTH = ? 40	3 DM = 5.511
	3 E = 11.484
IDE SLOPE RATIO (h/v) = ? 1	3 FROUDE NO. = 1.377
	CDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
	3 CRITICAL DEPTH, ft = 7.649
	3 VELOCITY @ CRITICAL DEPTH, ft/sec = 14.568
	3 CRITICAL SLOPE, ft/ft = 0.001



SECTION B-9

TYPE 3

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                 NORMAL and CRITICAL DEPTH  PROGRAM
                 ááááááááááááááááááááááááááááááááááááááá
                   TRAPEZOIDAL and RECTANGULAR CHANNELS
                             Newton's Method

         Input                                  Output
á áááááááááááááááááááááááááááááá°ááááááááááááááááááááááááááááááááááááááááááááá
                                ° NORMAL DEPTH =       4.923
F OW RATE, cfs = ? 5310         ° VELOCITY =      16.615
                                ° TOP WIDTH, ft =      69.845
MANNING'S COEFFICIENT = ? .013  ° AREA =    319.586
                                ° WET PERIM =      73.923
C ANNEL SLOPE, ft/ft = ? .003   ° HYD RAD =      4.323
                                ° CONVEYANCE =  96946.910
CHANNEL BOTTOM WIDTH = ? 60     ° DM =      4.576
                                ° E =     9.209
S DE SLOPE RATIO (h/v) = ? 1    ° FROUDE NO. =      1.369
                                ûááááááááááááááááááááááááááááááááááááááááááááááá
                                ° CRITICAL DEPTH, ft =      6.029
                                ° VELOCITY @ CRITICAL DEPTH, ft/sec =     13.338
                                ° CRITICAL SLOPE, ft/ft =      0.001

H t <Return> Key to Continue . . .
```

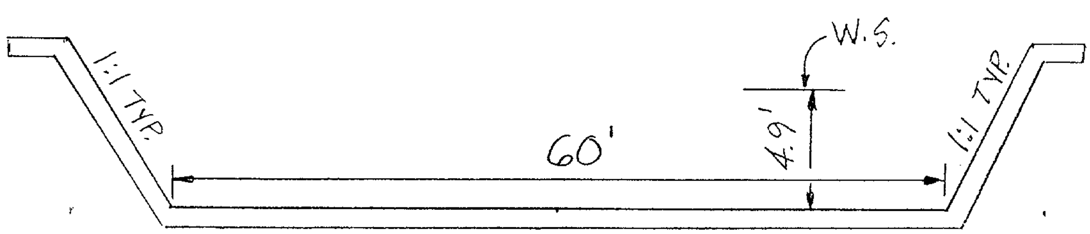

SECTION B-10

TYPE 3