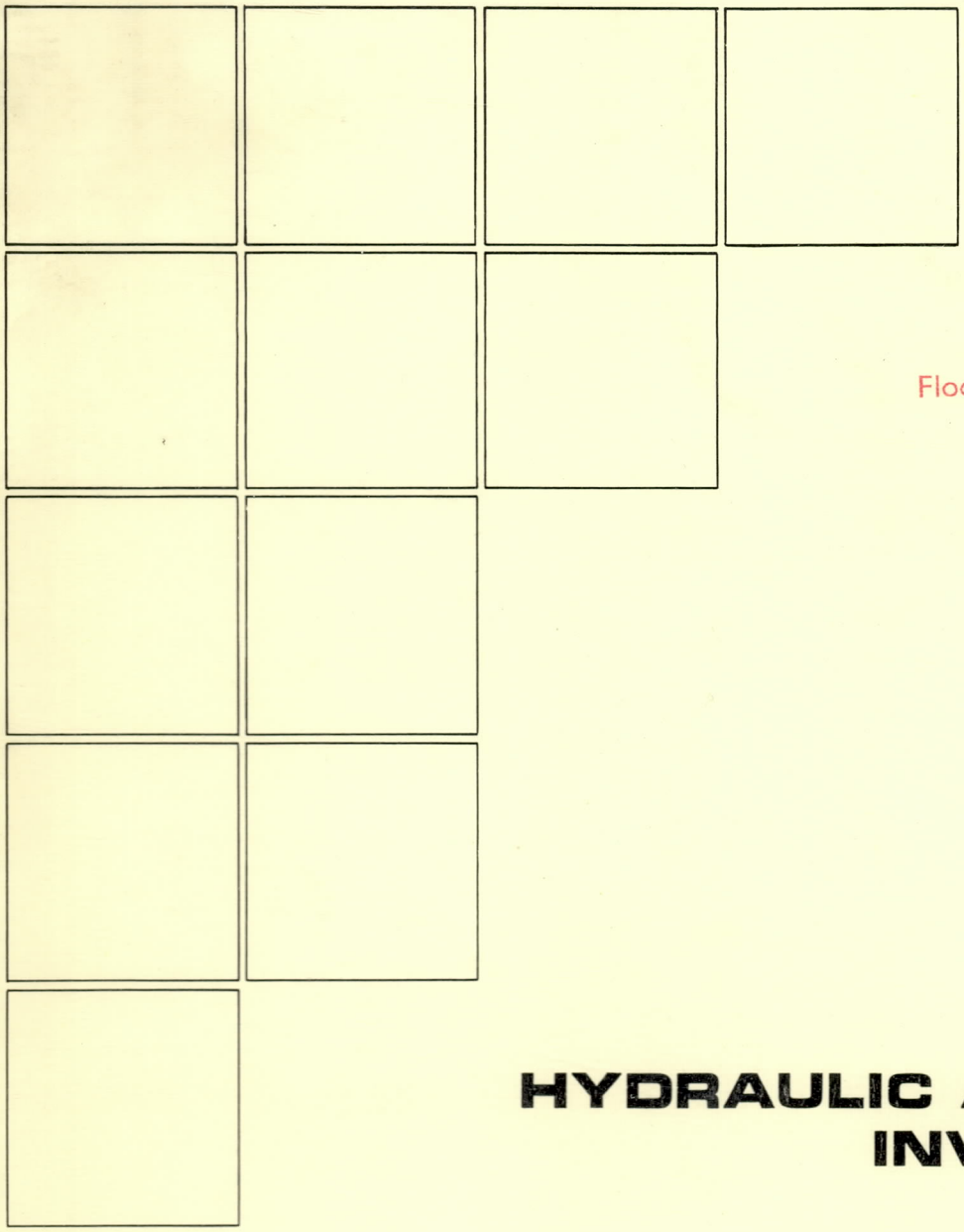
Sievert



DRAFT REPORT

HYDRAULIC ANALYTICAL INVESTIGATION

FOR COMBINING PROPOSED U.S. ARMY CORPS OF ENGINEERS ARIZONA CANAL DIVERSION CHANNEL (ACDC) WITH EXISTING ARIZONA CANAL (AC)

JUNE 1987

HNTB
HOWARD NEEDLES TAMMEN & BERGENDOFF
ARCHITECTS ENGINEERS PLANNERS
ANCHOR CENTRE TWO
2207 EAST CAMELBACK ROAD, SUITE 400
PHOENIX, ARIZONA 85016
(602) 954-7420

DRAFT REPORT
HYDRAULIC ANALYTICAL INVESTIGATION
OF
COMBINING THE PROPOSED
U.S. ARMY CORPS OF ENGINEERS
ARIZONA CANAL DIVERSION CHANNEL
WITH
EXISTING ARIZONA CANAL

PURCHASE ORDER NO. VV 13404 CSS
JUNE 1987

HOWARD NEEDLES TAMMEN & BERGENDOFF
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ANCHOR CENTRE TWO, SUITE 400
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PHOENIX, ARIZONA 85016
(602) 954-7420

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I. OBJECTIVE

The objective of this investigation is to study the hydraulic conditions associated with joining the proposed Arizona Canal Diversion Channel for Reaches 3 and 4 with the existing SRP Arizona Canal. The combining of the AC/ACDC will result in an irrigation/storm water channel.

See Exhibit I which shows Reach 3 located between 19th Avenue and 12th Street; and Reach 4 is located between 12th and 40th Streets.

II. HYPOTHESIS

The proposed U.S. Army Corps of Engineers Arizona Canal Diversion Channel (ACDC) can be utilized to convey and distribute SRP irrigation water in addition to the intended use as a storm water interceptor channel.

III. DISCUSSION

A. Arizona Canal Diversion Channel

The Arizona Canal Diversion Channel (ACDC), as proposed and presently designed by the U.S. Army Corps of Engineers is a flood control and abatement device. The ACDC is identified as a rectangular concrete lined channel with definite geometric, hydraulic and topographic characteristics which enable it to perform the intended purpose of intercepting, collecting, conveying and discharging the storm water runoff traversing southwesterly across the Salt River Valley during and after each storm event.

1. **Interception:** In order to enable the ACDC to best perform the intended function, the U.S. Army Corps of Engineers (C.O.E.) has designed this channel below the existing ground elevation throughout the length of the project, to allow for the direct discharge of storm water sheet flows to enter the channel. Exhibit I of this report shows the Arizona Canal alignment. In general the ACDC is located immediately north of the Arizona Canal and in some areas encroaches the existing SRP Arizona Canal.

2. **Collection and Conveyance:** The desirable performance of this device is to intercept the storm water flows along the northerly wall and convey those flows to the Agua Fria River in a safe manner without flooding adjacent properties.

B. Arizona Canal (AC)

The existing Arizona Canal is an open surface arterial raw water transmission and distribution conduit. At present the AC transmits water to two potable water treatment plants, water for irrigation purposes and other beneficial uses along the Northern portion of the Salt River Valley. SRP estimates this canal to have a maximum operating capacity of 700 cfs. More specifically the canal distributes water to approximately 30 lateral connections which are shown on Exhibit I. The SRP operates four radial gates located at 19th Avenue, 7th Street, 16th Street and 32nd Street. The gates raise the water surface in the canal to approximately one foot above adjacent existing ground elevation throughout the length of the canal, and thereby provide the necessary elevation head to deliver by gravity irrigation water to the land south of the canal. The size, roughness, and shape of the canal is tailored to achieve an efficient high water surface in this canal.

A freeboard of approximately three feet is provided above the operational high water elevation throughout the canal length, on both banks. Service roads along both sides of the canal are approximately twenty feet wide.

The existing radial gates are operated by remote control and can maintain surface levels through and around the gate structures to within one-tenth of a foot accuracy. Deliveries from the main canal to the different laterals are manually controlled by gates which are operated by the local zanjero at the check or turnout structures.

C. AC/ACDC Joint Operation:

Since the water surface profile for the ACDC is considerably lower in elevation than the adjacent ground elevation and the AC surface profile is above the existing adjacent ground elevation, it can be seen that the operational requirements of a Storm Water Interceptor Canal and an Irrigation Water Transmission Canal <u>are not readily compatible</u>.

While a free and unimpeded hydraulic section is required for optimal performance for the ACDC, multiple gate control structures will be necessary for the successful operation of the AC requirements at strategic points along the alignment.

IV. METHOD OF ANALYSIS

In approaching the problem, HNTB performed the following procedure:

1. Performed the necessary Field Survey by running a separate Bench Mark (BM) Level Circuit to correlate National Geodetic Service BM Elevations used by the U.S. Army Corps of Engineers with the SRP BM Datum. This work established the vertical relationship between the existing irrigation canal (AC) operational characteristics and the proposed Storm Water Channel (ACDC).

2. Visited the SRP Master Control Station which operates the valley wide canal system to become aware of the operational requirements of the Arizona Canal.

3. Determined from the U.S. Army Corps of Engineers study that the maximum storm water flows at 19th Avenue, 7th Street, 16th Street and 32nd Street are 13,000, 12,600, 8,700, and 7,900 cfs respectively.

4. Prepared a computer model utilizing the data from the U.S. Army Corps of Engineers Final Design Memorandum for the ACDC.

   The following steps were performed:

   a. Modeled the ACDC hydrologic data provided by the Corps of Engineers using the TR-20 program.

   b. From the TR-20 program the Hydrograph for the 100 year storm was established.

   c. Ran a HEC I Model to determine the maximum water surface elevation for the 100 year storm. Within the HEC I Program the time to release irrigation water and replenish it with storm water for Reaches 3 and 4 was evaluated.

V. FINDINGS

1. The minimum time required to empty Reaches 3 and 4 of the AC prior to a storm is 2.07 hours.

2. The time to peak for the 100 year storm is 2.02 hours. This makes the assumption that upstream irrigation flows are terminated. See Appendix "A" Calculations.

3. The total volume of irrigation water contained in the AC is approximately 1,070 acre-feet.

4. The total volume of storm water for the 100 year storm is approximately 3900 acre-feet.

5. Contrary to an original assumption that partial depletion of the combined Channel could be accomplished to save irrigation water, it is now known that the channel gates should be opened completely at the start of the 100 year storm. That would allow barely enough time for the stored irrigation water to empty in time to allow the channel to carry the storm peak. See Exhibit II - Composite Irrigation/Storm Water Hydrograph.

VI. RESULTS OF ANALYSIS

If a joint-use canal is desired, the following adjustments to the ACDC design would be necessary:

1. Raise the Channel walls throughout Reaches 3 and 4 approximately five to ten feet in order to provide the elevation and freeboard necessary to operate in the irrigation mode.

2. Provide a storm water collection system at various points along the North wall of the Channel to collect and accept the storm water runoff that would have entered the ACDC as designed by the Corps of Engineers.

3. Install irrigation laterals along the South side of the Channel to serve the SRP customers from the upper reach where the Hydraulic Grade Line (HGL) is much higher. See Exhibit I, shaded areas which demonstrate in profile those portions of the reach that will not readily serve SRP customers because the HGL for the combined channel is lower than the existing SRP operational HGL. This is due to discharging only 700 cfs out of a channel which has a much greater carrying capacity.

4. Install new significantly larger radial gate structures at the approximate locations of the present structures. The addition of intermediate gates located between the present gate structures could be used to maintain a customer service HGL and possibly eliminate the need for new parallel irrigation laterals identified in Item 3. The disadvantage of this corrective measure is the introduction of more gate structures to maintain and increased potential for malfunction during major storm events.

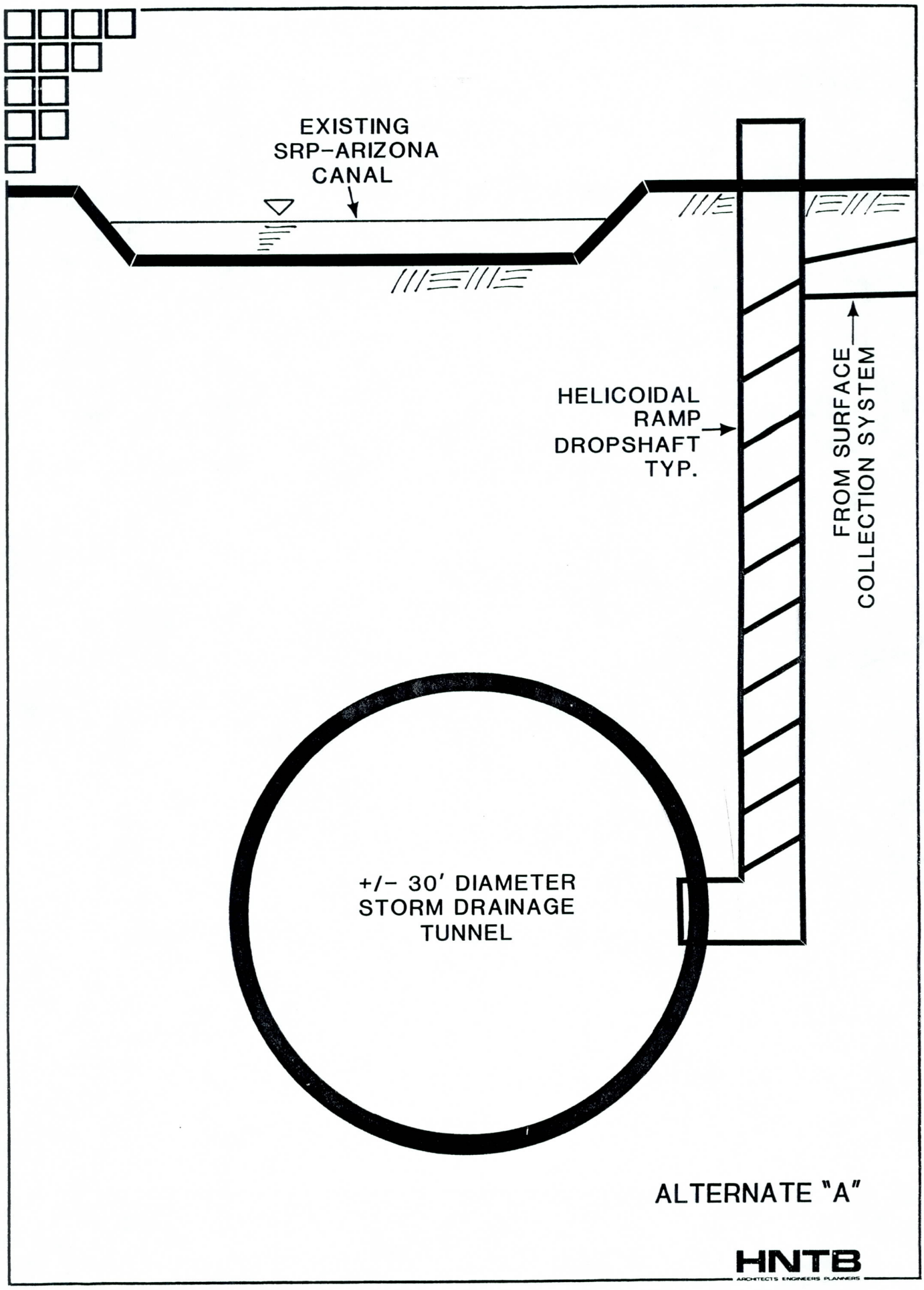
5. Install an early storm water warning system. Such a system could consist of a structure with electronic level control equipment set to activate via telemetry or radio control the radial gates to open and begin lowering the channel so as to provide the necessary channel capacity to accomodate the pending stormwater volumes. The structures could be located in the major upstream washes.

   As a backup measure, a high water alarm could be placed at each gate structure in the event there is a malfunction in the early warning system. We believe SRP already utilizes this system in the present canal operation system.

6. Make Major Channel Connections Up and Down Stream at Cudia City Wash and 19th Avenue. See Exhibits III and IV.

VII

OTHER POSSIBLE ALTERNATIVES


EXISTING
SRP-ARIZONA
CANAL
HELICOIDAL
RAMP
DROPSHAFT
TYP.
FROM SURFACE
COLLECTION SYSTEM
+/- 30' DIAMETER
STORM DRAINAGE
TUNNEL
ALTERNATE "A"
HNTB
ARCHITECTS ENGINEERS PLANNERS

ALTERNATIVE "A"

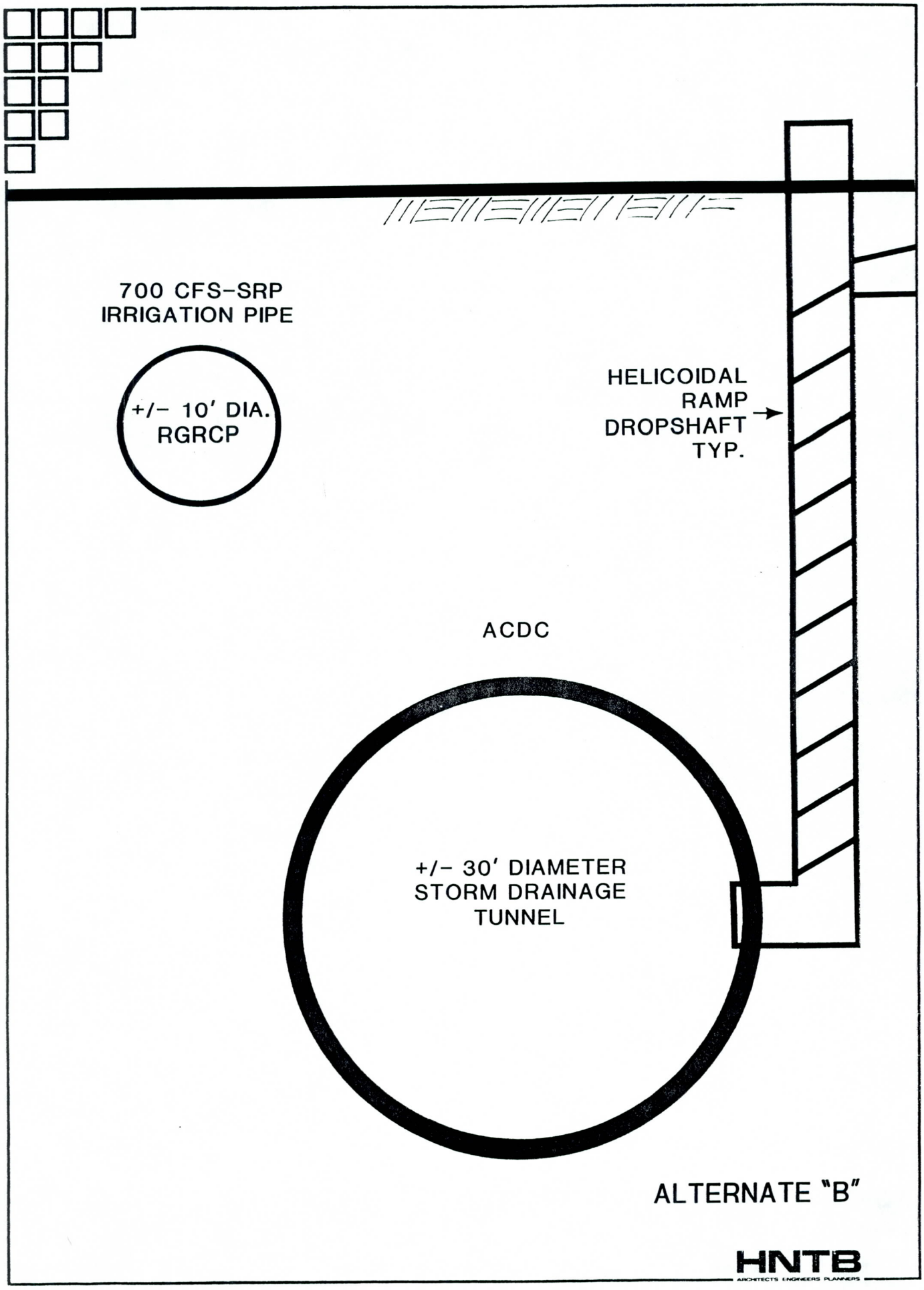
DESCRIPTION: Lease underground right-of-way to Maricopa County Flood Control District (MCFCD) to build ACDC tunnel under the SRP Arizona Canal right-of-way.

ADVANTAGES

- SRP Customer Service probably not interrupted.
- Minimize right-of-way requirements of ACDC.
- SRP could possibly gain revenue by leasing underground right-of-way.
- MCFCD could save substantial money by switching to tunnel.
- Least cost alternative.

DISADVANTAGES

- Continued maintenance of open channel for SRP.
- Possible canal disruption from tunneling ground loss.


700 CFS-SRP
IRRIGATION PIPE
+/- 10' DIA.
RGRCP
HELICOIDAL
RAMP
DROPSHAFT
TYP.
ACDC
+/- 30' DIAMETER
STORM DRAINAGE
TUNNEL
ALTERNATE "B"
HNTB
ARCHITECTS ENGINEERS PLANNERS

ALTERNATIVE "B"

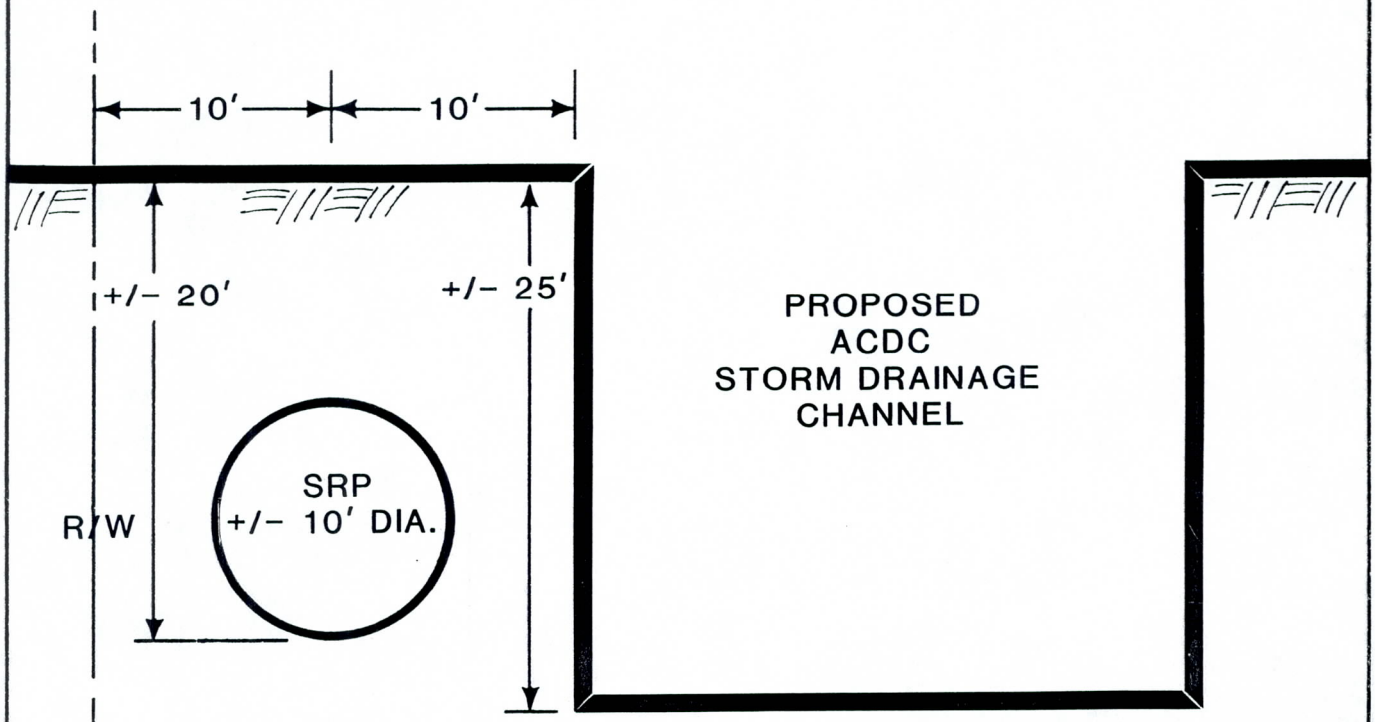
DESCRIPTION: SRP - Build a pipe conduit in lieu of Arizona Canal. Then lease underground right-of-way to MCFCD - for underground tunnel.

ADVANTAGES

- Eliminates maintenance of open channel and gates.
- SRP customer's service not interrupted.
- Possible Additional revenue to SRP from MCFCD for lease of underground right-of-way.
- MCFCD could save substantially by switch to tunnel.
- SRP could lease surface right-of-way for park, etc.
- Safety enhanced.

DISADVANTAGES

- Additional cost to SRP (may pass on to MCFCD).



ALTERNATE "C"

HNTB
ARCHITECTS ENGINEERS PLANNERS

ALTERNATIVE "C"

DESCRIPTION: Install SRP pipe conduit in lieu of Arizona Canal. Lease remaining right-of-way to MCFCD for ACDC canal as designed:

ADVANTAGES

- Slight ACDC redesign required.
- Safety, operational ease enhanced.

DISADVANTAGES

- ACDC remains open.
- Maximum cost.

VIII. CLOSING STATEMENT

The main purpose of this investigation was to determine if the hypothesis "Can the ACDC be fit to function as an irrigation canal," is valid or not.

1. Based on our findings it is our opinion that the ACDC can be fit to function as an irrigation facility after extensive adaptation and redesign. It is also important to note that in the course of the analytical process other alternatives were encountered which merit further investigation and are shown in Chapter VII. Such other alternatives may prove to be more desirable to SRP and to others.

2. The work performed as reported in this investigation addresses the theoretical worst case senario of the 100 year storm event. As a result, the gate structures would need to be opened completely at the onset of the pending storm. Further study will be necessary to evaluate the specifics of partial channel drawdown and the impacts of lesser storm events such as the 2, 5, 10, 25 and 50 year storms. Also, further study should be conducted to evaluate the constructability, costs, operation, maintenance, safety and environmental impacts of this basic concept described in this report as well as the other alternatives before a final decision is made.

IX

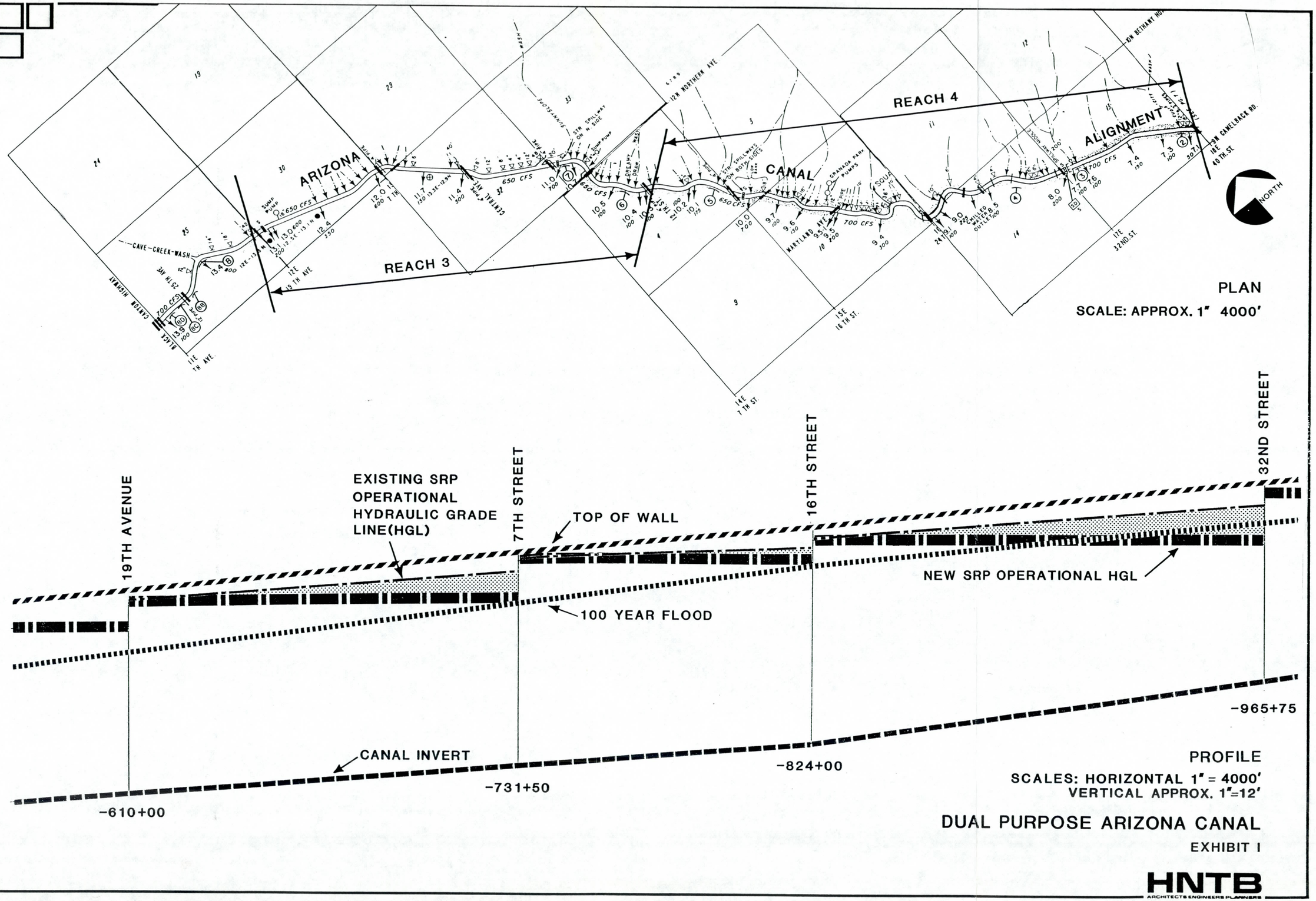
EXHIBITS

I. JOINT CHANNEL (PLAN & PROFILE)

II. COMPOSITE IRRIGATION/STORM WATER HYDROGRAPH

III. CONCEPTUAL TRANSITION AT CUDIA CITY WASH (PLAN & PROFILE)

IV. CONCEPTUAL TRANSITION AT 19TH AVENUE (PLAN & PROFILE)


ARIZONA CANAL
REACH 3
REACH 4
ALIGNMENT
CAVE-CREEK-WASH
CAMELBACK ROAD
NORTH
PLAN
SCALE: APPROX. 1" 4000'
1250
1245
1240
1235
1230
1225
1220
1215
1210
1205
1200
19TH AVENUE
7TH STREET
16TH STREET
32ND STREET
EXISTING SRP OPERATIONAL HYDRAULIC GRADE LINE(HGL)
TOP OF WALL
100 YEAR FLOOD
NEW SRP OPERATIONAL HGL
CANAL INVERT
-610+00
-731+50
-824+00
-965+75
PROFILE
SCALES: HORIZONTAL 1" = 4000'
VERTICAL APPROX. 1"=12'
DUAL PURPOSE ARIZONA CANAL
EXHIBIT I
HNTB
ARCHITECTS ENGINEERS PLANNERS

STATION 1

(O) OUTFLOW

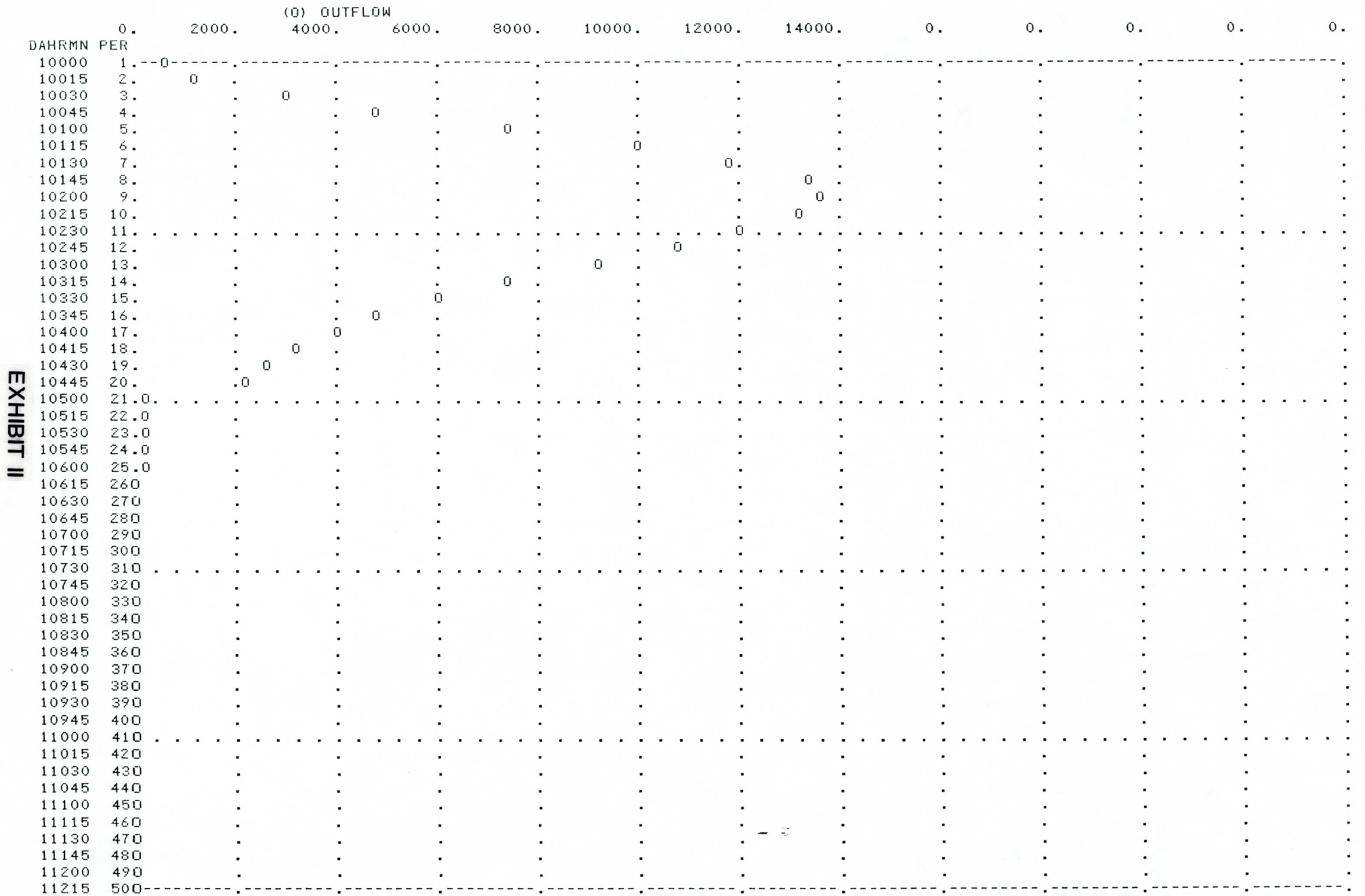
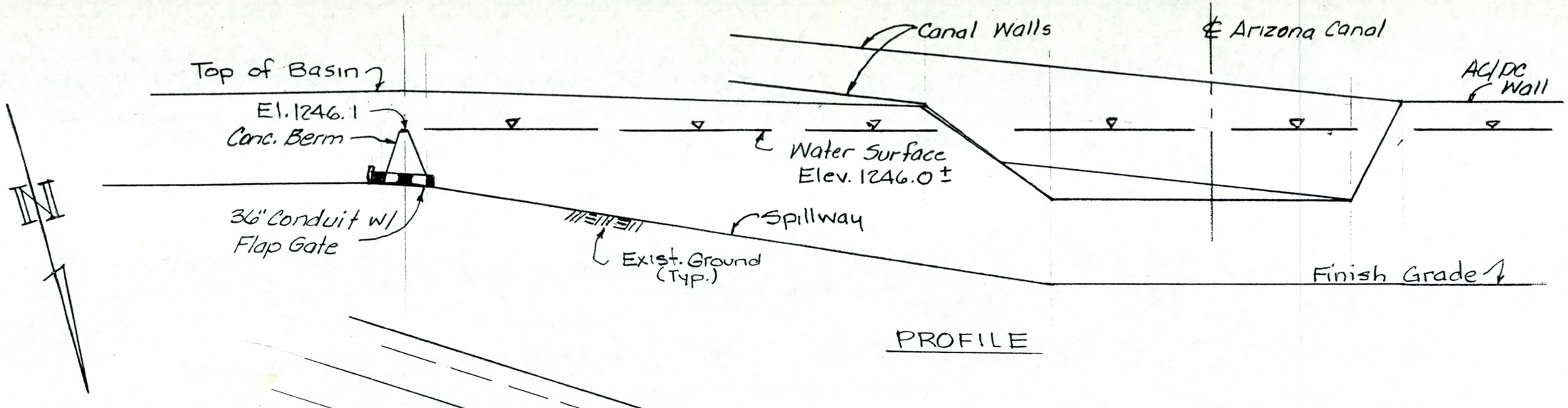
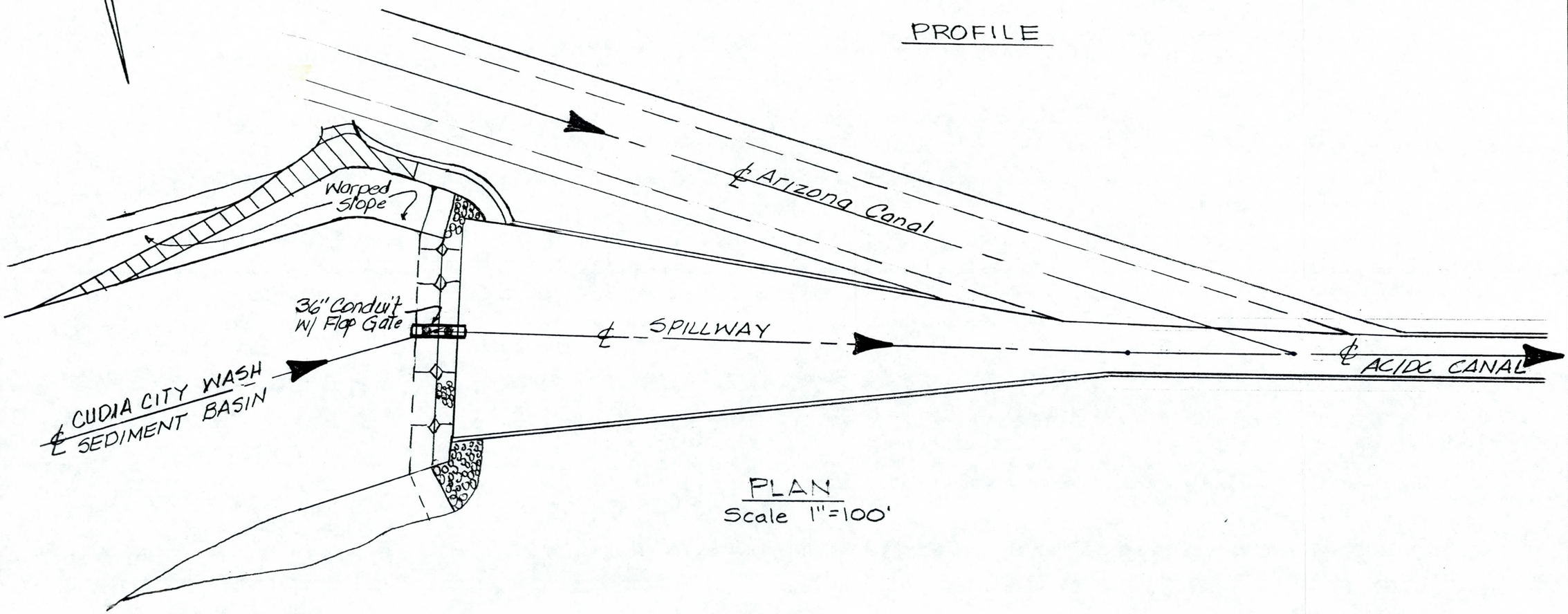


EXHIBIT II



PROFILE



PLAN
Scale 1"=100'

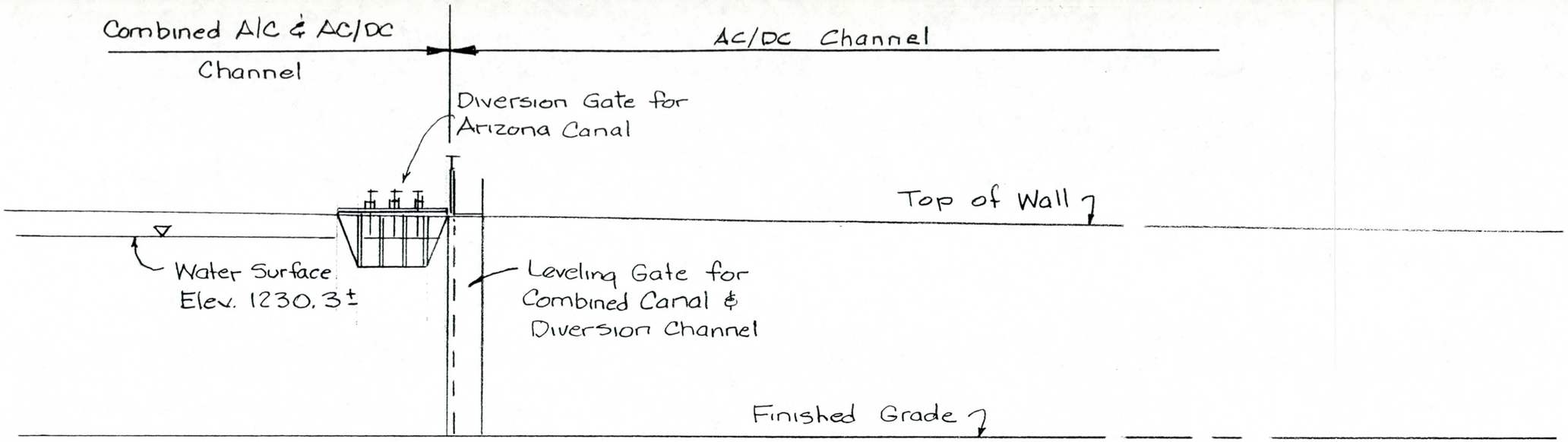
HNTB
ARCHITECTS ENGINEERS PLANNERS

HOWARD
NEEDLES
TAMMEN
& BERGENDOFF

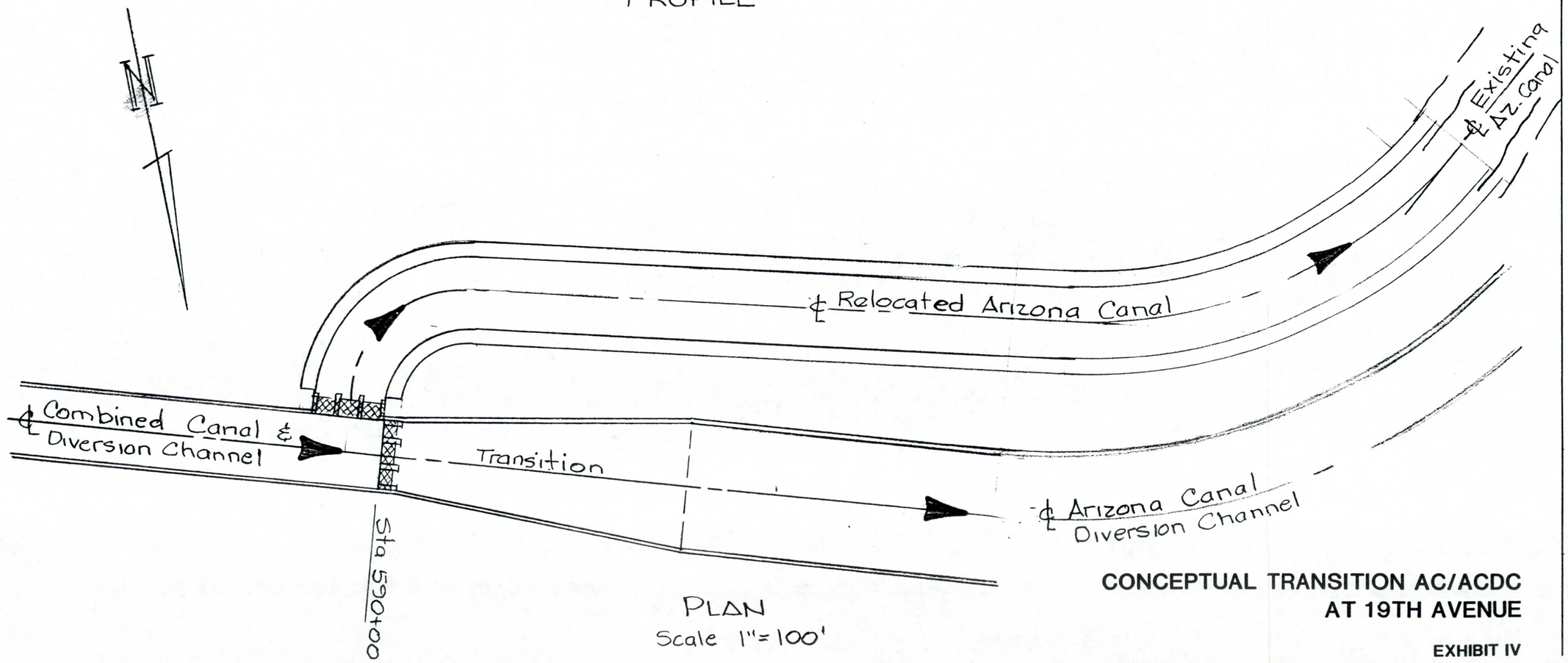
ANCHOR CENTRE TWO, SUITE 400
2207 EAST CAMELBACK ROAD
PHOENIX, ARIZONA 85016
PHONE 602 954-7420

CONCEPTUAL TRANSITION AC/ACDC
AT CUDIA CITY WASH

EXHIBIT III



PROFILE



PLAN
Scale 1"=100'

CONCEPTUAL TRANSITION AC/ACDC AT 19TH AVENUE

EXHIBIT IV

HNTB
ARCHITECTS ENGINEERS PLANNERS

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TAMMEN
& BERGENDOFF

ANCHOR CENTRE TWO, SUITE 400
2207 EAST CAMELBACK ROAD
PHOENIX, ARIZONA 85016
PHONE 602 954-7420

X

APPENDICES

"A" CALCULATIONS

"B" REFERENCES

APPENDICES

"A" CALCULATIONS

HNTB
HOWARD NEEDLES TAMMEN & BERGENDOFF

Made by D.F.M.	Date 6-17-87	Job No. 1863-11-02
Checked by [illegible]	Date 6/19/87	Sheet No. 1 of 2

For SRP IRRIGATION -

Station	Length	Width	Avg. Hgt.	Volume	Time to drain
590+00					
	14,150. ✓	60' ✓	25.15' ✓	21,252,350 ~~21,348,105.~~	48 ~~47~~ minutes
731+50					
	9,100. ✓	50' ✓	23.81' ✓	10,833,550.	33 minutes ✓
822+50				11,704,016	36
	14,155. ✓	40' ✓	20.68' ✓	~~11,706,185.~~	~~35~~ minutes
964+05				2,804,821	
	3,588. ✓	36' ✓	21.73' ✓	~~2,806,175.~~	9 minutes ✓
999+93					

EL = 40,993' LF
EV = 46,604,015.0 ~~46,701,737~~ ft³ Total time to drain => ~~2.07~~ 2.10 hours

$Q_1 = A_1 V_1$; $V_1 = \left(\frac{1.49}{0.015}\right)\left[\frac{(60)(25.15)}{60+2(25.15)}\right]^{2/3}(0.0003)^{1/2} = 9.93$ ~~9.81~~ ft/sec.

(5.72)

$A_1 = (60)(25.15) = 1509.0$ ft² ✓

9.31 ft/sec.

$Q_1 = (1509.)(9.93) = 14,984.37$ ~~14,811.07~~ ft³/sec.

$Q_2 = A_2 V_2$; $V_2 = \left(\frac{1.49}{0.015}\right)\left[\frac{(50)(23.81)}{50+2(23.81)}\right]^{2/3}(0.0003)^{1/2} = 9.19$ ~~9.09~~ ft/sec.

(5.30)

$A_2 = (50)(23.81) = 1190.5$ ft² ✓

$Q_2 = (1190.5)(9.19) = 10,942.91$ ~~10,822.84~~ ft³/sec.

$Q_3 = A_3 V_3$; $V_3 = \left(\frac{1.49}{0.015}\right)\left[\frac{(40)(20.68)}{40+2(20.68)}\right]^{2/3}(0.0008)^{1/2} = 13.29$ ~~13.15~~ ft/sec.

(4.61)

$A_3 = (40)(20.68) = 827.20$ ft² ✓

$Q_3 = (827.20)(13.29) = 10,993.45$ ~~10,877.68~~ ft³/sec.

ME101-0374-20M

$$Q_4 = A_4 V_4; \quad V_4 = \left(\frac{1.49}{0.015}\right)\left[\frac{(36)(21.73)}{(36)+2(21.73)}\right]^{2/3}(0.0008)^{1/2} = \text{~~13.0~~} \; 12.8 \text{ ft/sec}$$

(4.59)

$$A_4 = (36)(21.73) = 782.28 \text{ ft}^2 \checkmark$$

$$Q_4 = (782.28)(\text{~~13.0~~}) = \text{~~10,173.15 ft}^3/\text{sec.}$$

10,016.79

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*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             FEBRUARY 1981             *
*           REVISED 30 OCT 81           *
*                                       *
*  RUN DATE19-JUN-87     TIME08:31:15   *
*                                       *
*****************************************
```


```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET             *
*       DAVIS, CALIFORNIA 95616         *
*  (916) 440-3285 OR (FTS) 448-3285     *
*                                       *
*****************************************
```


```
X      X  XXXXXXX   XXXXX           X
X      X  X         X     X        XX
X      X  X         X                X
XXXXXXX  XXXX      X         XXXXX   X
X      X  X         X                X
X      X  X         X     X          X
X      X  XXXXXXX   XXXXX           XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE. THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. SEE SEPTEMBER 1981 INPUT DESCRIPTION FOR NEW DEFINITIONS.

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LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

    1         ID         SRP/ACDC GATE SRUCTURES ANALYSIS
    2         IT       15                0      50
    3         IO        1       2

    4         KK        1  INFLOW HUDROGRAPH FOR THE 100 YEAR STORM
    5         KM           TR-20
    6         BA    19.7
    7         QI  566.64 1274.94 2946.12 4851.18 7393.3710085.8511810.4413313.4513600.0013164.34
    8         QI  12072.10793.62 9151.39 7433.18 6087.58 4817.22 3974.57 3215.48 2662.92 2149.38
    9         QI  231.65  185.97  154.60  125.31  104.21   84.23   66.23   48.48   30.75   13.02
   10         QI    6.18     .66     .05     .00

   11         KK        2 TOTAL REACH
   12         KM         MODIFIED PULS FOR THE GATE STRUCTURES
   13         RS        1    ELEV   18.81
   14         SA   45.91
   15         SE   18.81
   16         SQ       024934.94
   17         SE   18.81   29.77
   18         ZZ
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*                                       *
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*             FEBRUARY 1981             *
*           REVISED 30 OCT 81           *
*                                       *
*  RUN DATE19-JUN-87     TIME08:31:15   *
*                                       *
*****************************************
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*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET             *
*       DAVIS, CALIFORNIA 95616         *
*  (916) 440-3285 OR (FTS) 448-3285     *
*                                       *
*****************************************
```


SRP/ACDC GATE SRUCTURES ANALYSIS

```
  3 IO          OUTPUT CONTROL VARIABLES
                      IPRNT            1  PRINT CONTROL
                      IPLOT            2  PLOT CONTROL
                      QSCAL           0.  HYDROGRAPH PLOT SCALE

    IT          HYDROGRAPH TIME DATA
                       NMIN           15  MINUTES IN COMPUTATION INTERVAL
                      IDATE       1    0  STARTING DATE
                      ITIME         0000  STARTING TIME
                         NQ           50  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE       1    0  ENDING DATE
                     NDTIME         1215  ENDING TIME

                  COMPUTATION INTERVAL    0.25 HOURS
                       TOTAL TIME BASE   12.25 HOURS

        ENGLISH UNITS
             DRAINAGE AREA          SQUARE MILES
             PRECIPITATION DEPTH    INCHES
             LENGTH, ELEVATION      FEET
             FLOW                   CUBIC FEET PER SECOND
             STORAGE VOLUME         ACRE-FEET
             SURFACE AREA           ACRES
             TEMPERATURE            DEGREES FAHRENHEIT
```

*** ***

```
            **************
            *            *
  4 KK      *          1 *       INFLOW HUDROGRAPH FOR THE 100 YEAR STORM
            *            *
            **************
```

TR-20

```
            SUBBASIN RUNOFF DATA

  6 BA          SUBBASIN CHARACTERISTICS
                      TAREA       19.70  SUBBASIN AREA
```

***

HYDROGRAPH AT STATION 1

DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW
1		0000	1	567.	1		0315	14	7433.	1		0630	27	66.	1		0945	40	0.
1		0015	2	1275.	1		0330	15	6088.	1		0645	28	48.	1		1000	41	0.
1		0030	3	2946.	1		0345	16	4817.	1		0700	29	31.	1		1015	42	0.
1		0045	4	4851.	1		0400	17	3975.	1		0715	30	13.	1		1030	43	0.
1		0100	5	7393.	1		0415	18	3215.	1		0730	31	6.	1		1045	44	0.
1		0115	6	10086.	1		0430	19	2663.	1		0745	32	1.	1		1100	45	0.
1		0130	7	11810.	1		0445	20	2149.	1		0800	33	0.	1		1115	46	0.
1		0145	8	13313.	1		0500	21	232.	1		0815	34	0.	1		1130	47	0.
1		0200	9	13600.	1		0515	22	186.	1		0830	35	0.	1		1145	48	0.
1		0215	10	13164.	1		0530	23	155.	1		0845	36	0.	1		1200	49	0.
1		0230	11	12072.	1		0545	24	125.	1		0900	37	0.	1		1215	50	0.
1		0245	12	10794.	1		0600	25	104.	1		0915	38	0.					
1		0300	13	9151.	1		0615	26	84.	1		0930	39	0.					

PEAK FLOW (CFS)	TIME (HR)
13600.	2.00

MAXIMUM AVERAGE FLOW

	6-HR	24-HR	72-HR	12.25-HR
(CFS)	5910.	2901.	2901.	2901.
(INCHES)	2.789	2.795	2.795	2.795
(AC-FT)	2930.	2937.	2937.	2937.

CUMULATIVE AREA = 19.70 SQ MI

*** ***

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          **************
          *            *
 11 KK    *          2 *      TOTAL REACH
          *            *
          **************
                                MODIFIED PULS FOR THE GATE STRUCTURES

             HYDROGRAPH ROUTING DATA

 13 RS           STORAGE ROUTING
                      NSTPS           1  NUMBER OF SUBREACHES
                       ITYP        ELEV  TYPE OF INITIAL CONDITION
                      RSVRIC       18.81  INITIAL CONDITION
                           X        0.00 WORKING R AND D COEFFICIENT

 14 SA                 AREA         45.9

 15 SE           ELEVATION         18.81

 16 SQ           DISCHARGE           0.     24935.

 17 SE           ELEVATION         18.81      29.77

                                                ***

                                        COMPUTED STORAGE-ELEVATION DATA

          STORAGE        0.00
        ELEVATION       18.81

                                    COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

          STORAGE      287.86    1141.16
          OUTFLOW        0.00   24934.94
        ELEVATION       18.81      29.77
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****

HYDROGRAPH AT STATION 2

****

DA	MON	HRMN	ORD	OUTFLOW	STORAGE	STAGE	DA	MON	HRMN	ORD	OUTFLOW	STORAGE	STAGE	DA	MON	HRMN	ORD	OUTFLOW	STORAGE	STAGE
1		0000	1	0.	287.9	18.8	1		0415	18	4780.	451.4	20.9	1		0830	35	3.	288.0	18.8
1		0015	2	427.	302.5	19.0	1		0430	19	3927.	422.2	20.5	1		0845	36	2.	287.9	18.8
1		0030	3	1208.	329.2	19.3	1		0445	20	3221.	398.1	20.2	1		0900	37	1.	287.9	18.8
1		0045	4	2456.	371.9	19.9	1		0500	21	2280.	365.9	19.8	1		0915	38	0.	287.9	18.8
1		0100	5	4156.	430.1	20.6	1		0515	22	1319.	333.0	19.4	1		0930	39	0.	287.9	18.8
1		0115	6	6282.	502.8	21.6	1		0530	23	786.	314.8	19.2	1		0945	40	0.	287.9	18.8
1		0130	7	8446.	576.9	22.5	1		0545	24	487.	304.5	19.0	1		1000	41	0.	287.9	18.8
1		0145	8	10355.	642.2	23.4	1		0600	25	314.	298.6	18.9	1		1015	42	0.	287.9	18.8
1		0200	9	11793.	691.4	24.0	1		0615	26	212.	295.1	18.9	1		1030	43	0.	287.9	18.8

1	0215	10	12530.	716.7	24.3	*	1	0630	27	149.	292.9	18.9	*	1	1045	44	0.	287.9	18.8
1	0230	11	12571.	718.0	24.3	*	1	0645	28	106.	291.5	18.9	*	1	1100	45	0.	287.9	18.8
1	0245	12	12043.	700.0	24.1	*	1	0700	29	75.	290.4	18.8	*	1	1115	46	0.	287.9	18.8
1	0300	13	11083.	667.1	23.7	*	1	0715	30	51.	289.6	18.8	*	1	1130	47	0.	287.9	18.8
1	0315	14	9789.	622.8	23.1	*	1	0730	31	32.	288.9	18.8	*	1	1145	48	0.	287.9	18.8
1	0330	15	8384.	574.8	22.5	*	1	0745	32	19.	288.5	18.8	*	1	1200	49	0.	287.9	18.8
1	0345	16	7025.	528.2	21.9	*	1	0800	33	10.	288.2	18.8	*	1	1215	50	0.	287.9	18.8
1	0400	17	5806.	486.5	21.4	*	1	0815	34	5.	288.0	18.8	*						
						*							*						

****

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	12.25-HR
12571.	2.50	(CFS)	5890.	2901.	2901.	2901.
		(INCHES)	2.780	2.795	2.795	2.795
		(AC-FT)	2921.	2937.	2937.	2937.

PEAK STORAGE (AC-FT)	TIME (HR)	MAXIMUM AVERAGE STORAGE 6-HR	24-HR	72-HR	12.25-HR
718.	2.50	489.	387.	387.	387.

PEAK STAGE (FEET)	TIME (HR)	MAXIMUM AVERAGE STAGE 6-HR	24-HR	72-HR	12.25-HR
24.34	2.50	21.40	20.08	20.08	20.08

CUMULATIVE AREA = 19.70 SQ MI

STATION 2

(I) INFLOW, (O) OUTFLOW

	0.	2000.	4000.	6000.	8000.	10000.	12000.	14000.	0.	0.	0.	0.	0.							
									(S) STORAGE											
	0.	0.	0.	0.	0.	0.	200.	400.	600.	800.	0.	0.	0.							
DAHRMN	PER																			
10000	10	--I							S											
10015	2.	0 I							S											
10030	3.	0	I						S											
10045	4.	0	I						S											
10100	5.		0	I					S											
10115	6.		0	I					S											
10130	7.		0	I					S											
10145	8.		0	I					S											
10200	9.		0	I					S											
10215	10.		0	I					S											
10230	11.		0	I					S											
10245	12.		0	I					S											
10300	13.		0	I					S											
10315	14.		0	I					S											
10330	15.		0	I					S											
10345	16.		0	I					S											
10400	17.		0	I					S											
10415	18.		0	I					S											
10430	19.		0	I					S											
10445	20.		0	I					S											
10500	21.	I	0						S											
10515	22.	I	0						S											
10530	23.	I	0						S											
10545	24.	I	0						S											
10600	25.	I	0						S											
10615	26	I	0						S											
10630	27	I	0						S											
10645	28	I	0						S											
10700	29	I							S											
10715	30	I							S											
10730	31	I							S											
10745	32	I							S											
10800	33	I							S											
10815	34	I							S											
10830	35	I							S											
10845	36	I							S											
10900	37	I							S											
10915	38	I							S											
10930	39	I							S											
10945	40	I							S											
11000	41	I							S											
11015	42	I							S											
11030	43	I							S											
11045	44	I							S											
11100	45	I							S											
11115	46	I							S											
11130	47	I							S											
11145	48	I							S											
11200	49	I							S											
11215	50	I							S											

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	1	13600.	2.00	5910.	2901.	2901.	19.70		
ROUTED TO	2	12571.	2.50	5890.	2901.	2901.	19.70	24.34	2.50

*** NORMAL END OF HEC-1 ***

SUMMARY TABLE 1

ALT	STORM	ID	DA SQ-MI.	RAIN TBLE	AMC	DELTA-T HRS.	TZERO HRS.	PRECIP IN.	PRECIP DURATION	PEAK-Q CFS	PEAK-TIME	PEAK-ELEV	RUNOFF IN.	CSM
1	1	1	19.70	1	2	0.05	0.00	4.81	1.00	13600.66	2.02	0.00	2.96	690.39

PASS= 1

XECUTIVE CONTROL CARD 170 OPERATION INCREM, MAIN TIME INCREMENT= 0.05
XECUTIVE CONTROL CARD 180 OPERATION COMPUT, FROM XSECTN/STRUCT 1/ 0 TO XSECTN/STRUCT 3/ 0
STARTING TIME= 0.00 RAIN DEPTH= 4.81 RAIN DURATION= 1.00 RAIN TABLE NO.= 1 SOIL CONDITION=
ALTERNATE NO.= 1 STORM NO.= 1

JBROUTINE RUNOFF CROSS SECTION 1
AREA= 19.70 INPUT RUNOFF CURVE= 82.6 TIME OF CONCENTRATION= 2.91

PEAK TIMES
2.02

PEAK DISCHARGES
13600.662

PEAK ELEVATIONS
(RUNOFF)

HYDROGRAPH, TZERO= 0.00 DELTA T= 0.05 DRAINAGE AREA= 19.70

TIME											
0.00	DISCHG	0.00	141.66	283.32	424.98	566.64	708.30	849.96	991.62	1133.28	1274.9
0.50	DISCHG	1422.07	1803.08	2184.09	2565.10	2946.12	3327.13	3708.14	4089.15	4470.17	4851.1
1.00	DISCHG	5239.39	5777.88	6316.38	6854.88	7393.37	7931.87	8470.36	9008.86	9547.35	10085.8
1.50	DISCHG	10608.04	10908.64	11209.24	11509.84	11810.44	12111.04	12411.64	12712.25	13012.85	13313.4
2.00	DISCHG	13582.33	13535.88	13489.44	13443.00	13396.56	13350.11	13303.67	13257.23	13210.78	13164.3
2.50	DISCHG	13094.00	12838.40	12582.81	12327.21	12071.61	11816.01	11560.42	11304.82	11049.22	10793.6
3.00	DISCHG	10525.96	10182.32	9838.67	9495.03	9151.39	8807.75	8464.11	8120.47	7776.82	7433.1
3.50	DISCHG	7103.87	6849.80	6595.72	6341.65	6087.58	5833.51	5579.43	5325.36	5071.29	4817.2
4.00	DISCHG	4581.84	4430.02	4278.20	4126.38	3974.57	3822.75	3670.93	3519.11	3367.29	3215.4
4.50	DISCHG	3073.76	2971.05	2868.34	2765.63	2662.92	2560.21	2457.50	2354.79	2252.08	2149.3
5.00	DISCHG	2054.24	1984.65	1915.06	1845.47	1775.89	1706.30	1636.71	1567.12	1497.53	1427.9
5.50	DISCHG	1364.05	1317.10	1270.16	1223.21	1176.26	1129.31	1082.37	1035.42	988.47	941.5
6.00	DISCHG	899.11	868.68	838.25	807.82	777.39	746.96	716.53	686.10	655.67	625.2
6.50	DISCHG	597.99	578.29	558.58	538.87	519.17	499.46	479.76	460.05	440.34	420.6
7.00	DISCHG	402.88	389.26	375.63	362.01	348.39	334.77	321.15	307.53	293.91	280.2
7.50	DISCHG	268.20	259.06	249.93	240.79	231.65	222.52	213.38	204.24	195.10	185.9
8.00	DISCHG	178.03	172.17	166.32	160.46	154.60	148.74	142.89	137.03	131.17	125.3
8.50	DISCHG	120.18	116.19	112.19	108.20	104.21	100.21	96.22	92.22	88.23	84.2
9.00	DISCHG	80.42	76.87	73.32	69.78	66.23	62.68	59.13	55.58	52.03	48.4
9.50	DISCHG	44.93	41.39	37.84	34.29	30.75	27.20	23.66	20.11	16.56	13.0
10.00	DISCHG	10.59	9.49	8.38	7.28	6.18	5.07	3.97	2.87	1.76	0.6
10.50	DISCHG	0.08	0.07	0.06	0.06	0.05	0.04	0.03	0.02	0.01	0.0

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 2.9595 CFS-HRS= 37625.98 ACRE-FT= 3109.41

ENDCMP

----- T.R. 20 ---------- INPUT LISTING -----

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JOB TR-20                          FULLPRINT          SUMMARY                                  10
TITLE 001    AREA'S ONE AND TWO 1HR. 100YR. STORM FOR SRP/ACDC PROJ.                          20
 5 RAINFL 1                0.0278                                                           30
 8           0.0000        0.2244        0.3261        0.3824        0.4299               40
 8           0.4662        0.5065        0.5292        0.5614        0.5828               50
 8           0.6069        0.6377        0.6591        0.6964        0.7167               60
 8           0.7374        0.7594        0.7723        0.7811        0.7859               70
 8           0.7933        0.8116        0.8204        0.8499        0.8543               80
 8           0.8560        0.8726        0.8879        0.9018        0.9143               90
 8           0.9154        0.9249        0.9330        0.9510        0.9683              100
 8           0.9849        1.0000        1.0000        1.0000        1.0000              110
 9 ENDTBL                                                                                 120
 6 RUNOFF 1 001         1 19.700        82.596        2.9100        1 1    1    1         150
   ENDATA                                                                                 160
 7 INCREM 6                0.0500                                                         170
 7 COMPUT 7 001   003      0.0000        4.8100        1.0000             101 201          180
   ENDCMP 1                                                                               190
   ENDJOB 2                                                                               200
```

SUMMARY TABLE 3

	DISCHARGE, CFS									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q1
XSEC/STRUC NO. 1										
ALTERNATE 1	13600.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0

ENDJOB CARD ENCOUNTERED. END OF JOB.

APPENDIX "B"

LIST OF REFERENCES

- Corps of Engineers Design Memorandum No. 12.
- SRP Field Books - Arizona Canal Asbuilts.
- HNTB Field Surveys to Correlate NGS BM Datum and SRP BM Datum.
- Open Channel Hydraulics by Chow, McGraw-Hill.
- U.S. Army Corps of Engineers, HEC I Hydraulic Program.
- Design of Small Canal Structures, U.S. Department of the Interior, Bureau of Reclamation, 1983.
- Handbook of Hydraulics, King & Brater, McGraw Hill.
- "Hydraulics"; Daugherty, R.L. - Wiley & Sons.
- Soils Conservation Service (SCS) TR-20 Hydrology Program.

DII.164.25/all