Drainage Study

for

48th Street Storm Sewer

Baseline Road to the Tempe Ditch

Prepared For City of Tempe/City of Phoenix

July, 1985

Revised September, 1985

Sverdrup & Parcel and Associates

DRAINAGE STUDY

FOR

48TH ST. STORM SEWER

BASELINE RD. TO THE TEMPE DITCH

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Sverdrup

84072

DRAINAGE STUDY

FOR

48TH ST. STORM SEWER

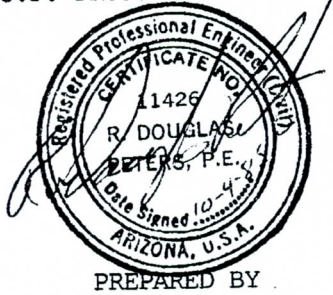
BASELINE RD. TO THE TEMPE DITCH

PREPARED FOR

CITY OF TEMPE/CITY OF PHOENIX

C.O.T. PROJ. NO. 84072

C.O.P. PROJ. NO. ST-833103



PREPARED BY

SVERDRUP & PARCEL AND ASSOCIATES, Inc.

JULY, 1985
REVISED SEPTEMBER, 1985

S & P PROJECT NO. 9408

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October 3, 1985

Mr. Howard Hargis
Manager of Engineering
City of Tempe
31 E. 5th St.
Tempe, AZ 85282

Re: 48th St. Storm Sewer
Baseline Rd. - Tempe Ditch
City Of Tempe - Proj. No. 84072
City of Phoenix - Proj. No. ST-833103
S & P Job No. 9408

Dear Mr. Hargis:

Transmitted herewith are two (2) bound copies of the revised Drainage Study for the 48th St. Storm Sewer from Baseline Rd. to the Tempe Ditch. The report covers approximately two miles of sewer trunk line from Baseline Road to Broadway Road as well as 0.25 mile of lateral along Baseline Rd. The balance of the proposed storm sewer cannot be completed without input from the Arizona Department of Transportation.

The original study, has been revised per comments from the City of Tempe and the City of Phoenix to reflect what each agency considers to be its contribution.

This study presents the results of the hydrologic analysis of the proposed ultimate drainage area to Broadway Rd. for three (3) design events: the 2-year, the 5-year and the 10-year, 24-hour storms. The present model does not extend north of Broadway Rd. as the alignment beyond that point has not been finalized. Also included in this study is the 1" = 200' scale profile from Broadway Rd. to Baseline Rd. based on the 2-year flow.

We have proceeded with the final design per your direction. We will complete the plans as soon as we have your approval of this revised report.

The TR-20 results have not materially changed as the suggestion by the City of Phoenix to use a different curve on the Upland Method velocity chart resulted in lowering some times of concentration. This offset the City of Tempe's elimination of certain drainage areas as being noncontributing.

We would appreciate the opportunity to review this report with you at the earliest possible time.

Sincerely,

SVERDRUP & PARCEL AND ASSOCIATES, Inc.

R. Douglas Peters
Project Engineer

cc: Reginald Swartz (City of Phoenix)

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Section I

1. INTRODUCTION

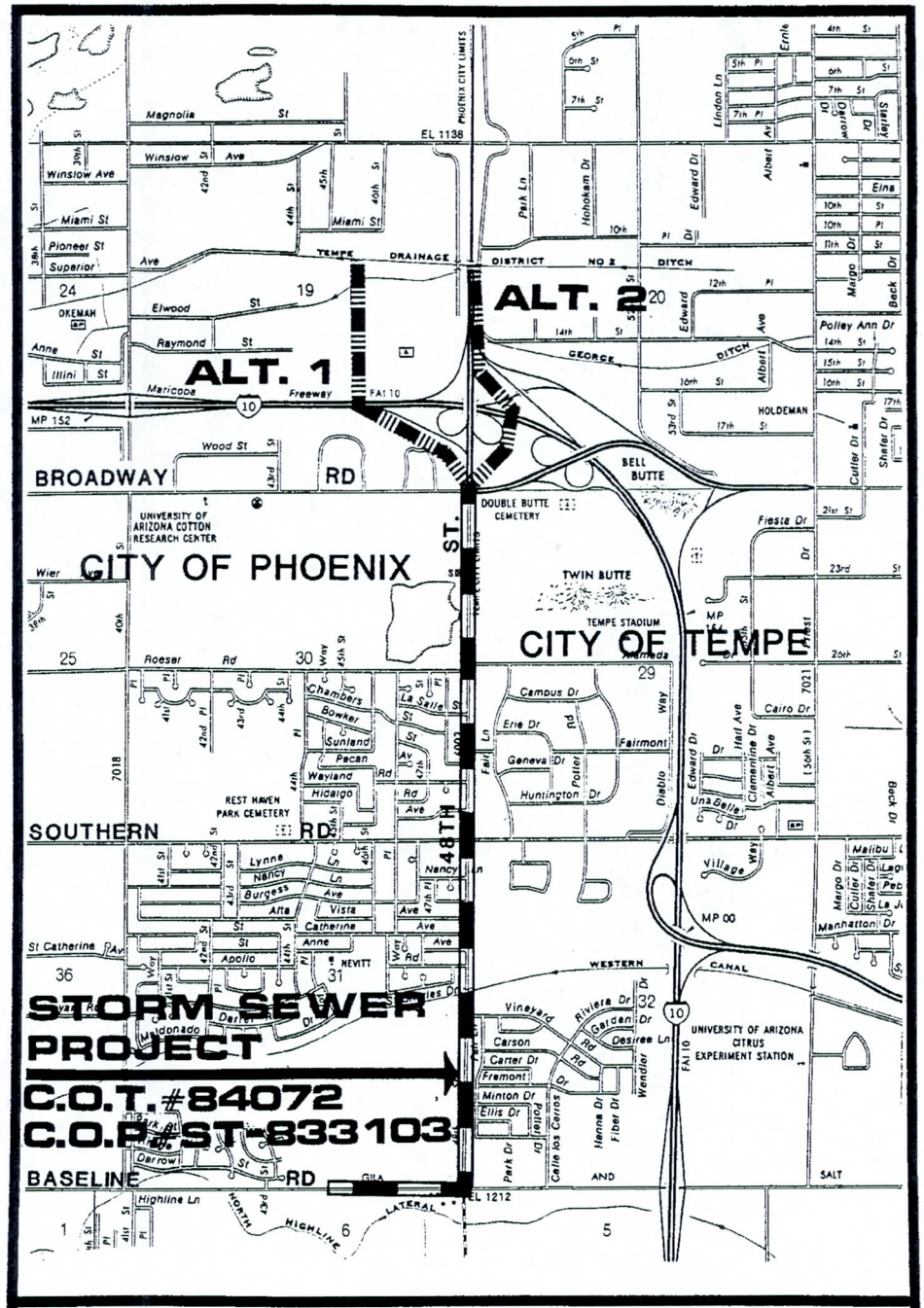
1.1 Scope of Work

The project consists of the preparation of construction plans and related items, including this hydrology study, for a joint City of Tempe - City of Phoenix storm sewer project. This storm sewer is to run south along 48th St. from the Tempe Ditch to Baseline Rd. (see Figure 1, Vicinity Map). The project will include a lateral running approximately 1330 feet west of 48th St. along Baseline Rd. The system will be designed to accept surface drainage flowing onto 48th St., as well as piped flows from the Svob Park Detention Pond, the Western Canal, and the Alameda Drive Storm Sewer. The system is also to be designed for future additions. These include a 1300-foot lateral running along 48th St. from Beverly Rd. to Baseline Rd., and a 5070-foot lateral running from a low point on Baseline Rd., approximately 370 feet west of 44th St., to the intersection of 48th St. and Vineyard Rd. via 44th St. and Vineyard Rd (see Figure 2, Drainage Area Map).

1.2 Drainage Features

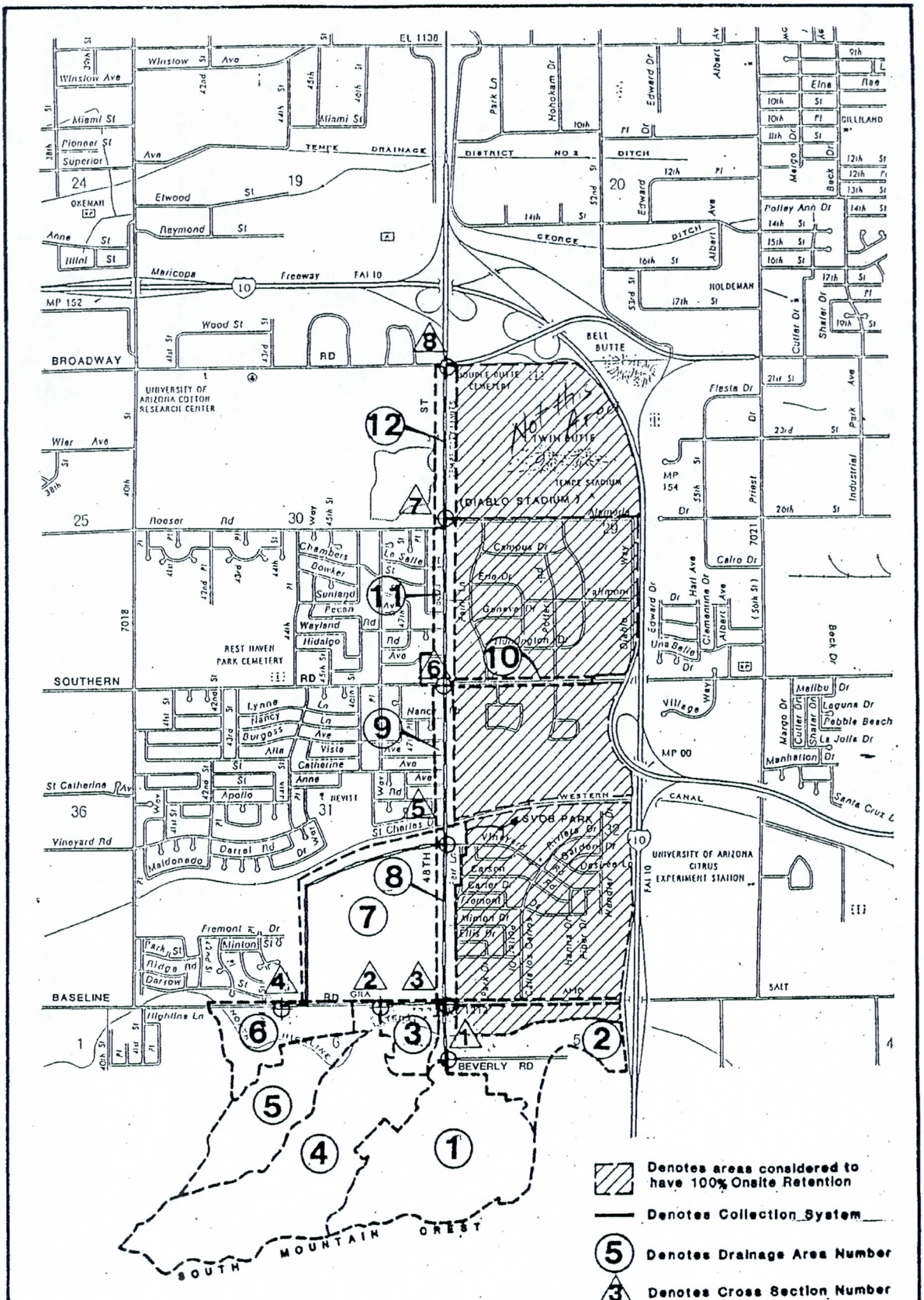
The area to be drained by this project is largely developed commercial and residential communities. Much of the remaining undeveloped land will be developed in the near future, including a hotel complex near Diablo Stadium. The only exceptions to this are a few agricultural lots near Baseline Rd., South Mountain Park at the upper end of the project's watershed, and the ball fields and cemetery between Broadway Rd. and Alameda Dr.

The area in the project vicinity is located on alluvial material from South Mountain, whose ridges form the crest of the watershed. The land falls away from the crest to the Salt River in a north-northwesterly direction. Surface flows are diverted by site development, city streets, and two(2) Salt River Project Canals. The Western Canal, located between Baseline Rd. and Southern Ave., acts as a complete barrier to surface flows. The Highline Canal, on the other hand, (located south of Baseline Rd.) has drainage pipes under it in several locations to route surface runoff from South Mountain northward.



VICINITY MAP

FIGURE 1



DRAINAGE AREA MAP

FIGURE 2

Section II

2. HYDROLOGY

2.1 Drainage Area

Since a project alignment has not been selected from the alternatives north of Broadway Rd., the present hydrological analysis confines itself to south of that road. Pipe sizing to the north will either be based on this flow alone, or include additional contributions resulting from an addendum to this report.

The project drainage area is bounded by the crest of South Mountain on the south, the east Not true side of 48th Street, Broadway Rd. on the north, and the west side of 48th St. - Vineyard Rd. - 44th St. on the west (see Figure 2, Drainage Area Map). This area was divided into 12 drainage areas for the purpose of modeling flow contributions to the project storm sewer.

2.2 Methodology

The hydrology for this project was generated through use of the TR-20 computer program, whose full title is Computer Program for Project Formulation, Hydrology (TR-20). This program utilizes the Soil Conservation Service (SCS) Method of hydrologic analysis. The SCS Method calculates a hydrograph for each drainage area based on its ground cover, size, and the rainfall distribution. The hydrographs are then routed through a series of channels, or reaches, representing the hydrologic system, and their values superimposed whenever two or more combine.

The City of Phoenix Hydraulics Department has adapted the SCS Method for urbanized areas. They have done this by correlating the type of zoning and the soil classification with a curve number (see Appendix I, Table 2 and Figure 4). A weighted average curve number is obtained for each drainage area based on the relative sizes of its components which have different curve numbers.

A time of concentration for each drainage area is based on the average slope of that area. If the flow is sheet (overland) flow, the "upland" method is used to obtain the average velocity. If the flow is channelized (e.g. gutter flow), some form of the Manning equation is used. Combinations of these two (2) types of flow are possible within a given drainage area. With either method a flow path must be chosen. This is usually the route taken by runoff from the most remote high point in the drainage area to its point of concentration. This length is used in determining both the average drainage slope (when divided into the path's total elevation differential) and its time of concentration (when divided by the average flow velocity).

In order to model the pipe flow of the storm sewer as it receives runoff from the drainage areas, a pipe velocity is inserted in lieu of cross section data or open channel reach parameters which are usually used in TR-20. Initially, a value of five (5) feet per second is used, as this is the minimum velocity required by the City of Phoenix. After the initial run, pipes may be sized based on their slopes and the rates of flow generated by the first run. Pipe velocities are then calculated and substituted into the program. These velocities are kept below ten (10) feet per second if at all possible. By this method, the system is sized during analysis.

In generating the runoff, the City of Phoenix's 24-hour, cumulative unit distribution rainfall table was utilized, together with a precipitation chart giving a rainfall value (in inches) for a range of frequency - duration design events (see Appendix I, Tables 5 & 6).

2.3 Modeling Assumptions

2.3.1 Retention

Generally, the developments within the project drainage area are recent and are required to have on-site retention. For City of Phoenix drainage areas, only 15 percent of the gross surface area was used for calculating runoff. This is to account for public streets and other conditions not subject to retention. The City of Phoenix has found this to be a reasonable average when a detailed analysis of the drainage areas is not required. The two (2) major exceptions to this retention factor are the undeveloped areas of South Mountain Park and the major streets. The City of Tempe asumes 100% retention, therefore these areas were not included in the project drainage. - Not in Diablo Stadium

All drainage from South Mountain Park tributary to Baseline Rd. from a point 1000 feet west of 44th St. to its eastern boundary, together with the residential and commercial developments between the mountain and that road was considered to be part of the project's drainage area, except for that portion falling within the City of Tempe

(see Figure 2, Drainage Area Map). While the zoned areas were assumed to have retention capabilities, this was not the case with the areas within South Mountain Park. Detention of these flows as they pass through the Gosnell development was not modeled as it was considered too involved and beyond the scope of this analysis.

Since one of the main functions of this storm sewer is to drain the major streets within the project (i.e. 48th St., Baseline Rd., Southern Ave., and Alameda Dr.), these surface areas were given special attention. Some of these were given the status of separate drainage areas which included adjacent land directly draining into the street (Drainage Area No.'s 8, 9, 11, and 12 represent segments of 48th St. and Drainage Area No. 12 10 represents 100-foot wide Southern Ave. - see Figure 2, Drainage Area Map). Other streets were included with an adjacent zoned area, but averaged without any reduction in area. Whenever possible ultimate design widths were used. Baseline Rd. was based on the Holgate design width (101 feet) and was incorporated into Drainage Area No.'s 2, 3, 4, and 6. Alameda Dr. pavement runoff was assumed to be picked up by its storm sewer and is included in that tributary's contribution. These road surface areas were considered to have no retention, so that their total area became a significant portion when compared with the 15 percent of the retained areas. This in turn weights the drainage area's average curve numbers upward, resulting in larger runoffs.

Although the detention basin at Svob Park will have its outlet pipe attached to the future storm sewer, the mainline has not been sized to accept this flow. What this means is that if the storm sewer is flowing full, the basin's outlet pipe will not drain. It will only

start to do so once the flood crest in the main pipe has passed. Since the basin is designed to detain runoff from the adjacent subdivision for several hours, there is no need to accommodate its outlet flow into the peak flow of the storm sewer. Therefore, its contribution will be ignored in sizing the storm sewer. A flow of 7.0 c.f.s. will be used for any sizing of the connection that will be necessary (per City of Tempe).

The connection from the retention basins of the mobile home parks along Southern Avenue will be treated in a similar manner. It is assumed that their contributions will not be pumped into the storm sewer until after the design storm has passed. The connection sizing will be for 5.0 c.f.s. (per City of Tempe).

2.3.2 Drainage Area Parameters

The TR-20 requires three (3) parameters for each drainage area. These parameters are its effective drainage area, weighted curve number, and time of concentration. These values were calculated by hand and placed in the program input. A sketch of each drainage area showing zoning and flow paths used to generate these values is located in Appendix II, Figures 5 through 12.

The effective areas were simply a summation of 15 percent of the City of Phoenix areas which were considered to have retention and 100 percent of the non-retaining areas. The weighted curve numbers were generated based on these effective areas. Zoned areas were assigned City of Phoenix zoning and curve numbers (see Tables 2 and 4, Appendix I). Non-zoned areas (i.e. pavement tributary areas and mountainous areas) were assigned curve numbers based on SCS guidelines for various

types of ground cover (see Table 3, Appendix I). Those areas zoned P.C. (Planned Community) or P.A.D. (Planned Area Development) were assigned a zoning of C-0, C-1, or A-1 based upon developer's plans or the most likely use for that area. Summary calculations for effective areas and weighted curve numbers are tabulated in Tables 8 & 9, Appendix II.

Times of concentration were developed for each drainage area by taking the longest flow path for that area, determining its average slope and deriving a velocity based on this slope. Overland flows were given velocities through use of the Upland Method Chart (see Table 7, Appendix I), based on average slope and ground cover type. Channelized (gutter) flows were solved using the standard modified Manning's equation for gutter flow. In order to simplify flow velocity determinations, it was assumed that all gutters carrying these flows were 6-inch high vertical curbs flowing full (City of Phoenix curb height was used as most of the drainage areas are within its city limits), and an 'n' value of 0.015, resulting in:

$$Q = 0.56 \left(\frac{Z}{n}\right) So^{1/2} d^{8/3}$$

$$V = \frac{Q}{A} = \frac{0.56}{(1/2\ Zd^2)} \left(\frac{Z}{n}\right) So^{1/2} d^{8/3}$$

$$= 2\left(\frac{0.56}{n}\right) \left(\frac{1}{d}\right)^{6/3} d^{8/3} So^{1/2}$$

$$= \frac{1.12}{n}\ d^{2/3}\ So^{1/2}$$

$$= \frac{1.12}{0.015} (0.5^{2/3}) \; So^{1/2}$$

$$V = 47.04 \; So^{1/2}$$

Where Z = 1/Sx = reciprocal of the cross slope

d = curb height, in feet

n = Manning's coefficient

So = longitudinal slope in feet per foot

Q = rate of flow in cubic feet per second

A = cross sectional area in square feet

V = flow velocity in feet per second

This is a conservative result. In most cases the flow depth will not be to the top of the gutter, which lowers the velocity and increases the time of concentration, thus dispersing the accumulation of runoff. On the other hand, a 10-year storm may cause many gutters to run full, which increases its impact. As it turned out, most of the gutter velocities calculated were between 2.0 and 6.0 feet per second (see Time of Concentration Calculations, Table 9, Appendix II). This seems to be a reasonable range of values for this type of flow. Even a velocity of 1.0 foot per second would result in times of concentration of less than an hour for the sizes of the drainage areas modeled. Since the design storm duration is 24 hours, small fractions of an hour deviation will not significantly change the overall result. It should also be noted that the minimum allowable time of concentration was ten (10) minutes (0.17 hr.), a generally recognized lower limit. Any calculated values less than this were assigned this value as being the minimum time a flow could be expected to accumulate to an "inlet" from all parts of the

drainage area. For a summary of the time of concentration calculations, see Table 9, Appendix II.

2.3.3 Pipe Modeling

As previously mentioned, the proposed storm sewer system was modeled by using channel reaches as major pipe lengths. This was done on this version of TR-20 through use of the rating curve coefficients. These coefficients are used to model discharge - flow area relationships of channels with simple cross sections by assuming that relationship is of the form $Q = xA^m$. The version of TR-20 used for this project uses these coefficients to calculate the amount of attenuation the channel is capable of inducing into the flood hydrograph*. This method is called the Modified Att-Kin procedure and is explained in Appendices G and H of the TR-20 User's Manual (ref. 1).

It was assumed that each reach would have a pipe of constant size and slope, and that there would be no flood attenuation in the pipes. In other words, X = pipe velocity = flood velocity and m = 1.0, or Q = VA. The first program run used a minimum pipe velocity of 5.0 feet per second. Subsequent runs used rates of flow from the previous run to size the pipes (flowing full or nearly full) and to determine the new reach velocity. After several runs, the system's rates of flow were within one (1) percent of the previous run, which indicated a converged

*Note that this version does not accept routing coefficients for the older Convex Routing Method, so that the City of Phoenix's "velocity/code" table values will not work.

solution. Thus the system was modeled and a preliminary pipe sizing made in the same series of operations. The pipes were assumed to be concrete with an n = 0.012. Pipe slopes were to the nearest 0.001 foot per foot.

The pipe reaches connected the drainage areas in a system analogous to the ultimate storm sewer system design down to Broadway Rd., including the 44th St. and the Beverly Rd. laterals. Drainage collection points were only at major intersections and at the ends of the laterals. Pavement drainage above the sewer line that in reality would periodically drain to that line via catch basins was modeled as being collected at the surface at the end of each reach, then added to the pipe flow (see Figure 3, TR-20 Schematic Layout). However, in sizing the pipe for each reach the flow rate for the pavement drainage area was added to the cumulative flows at the head of that reach, thus ensuring that the pipe would be adequately sized to accept the catch basin flows adjacent to it.

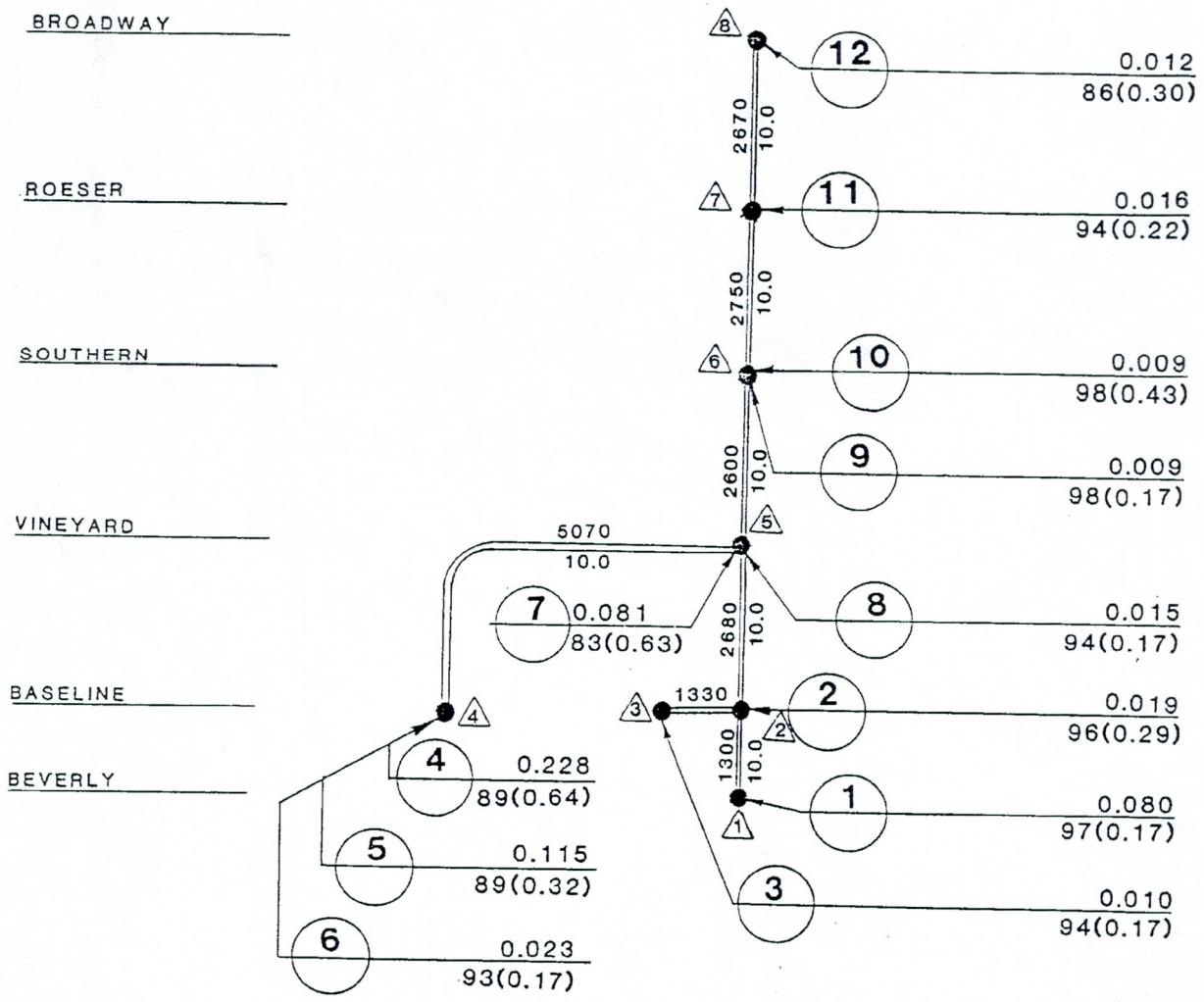
2.3.4 Constant Flow Contributions

Constant rates of flow were considered for two (2) locations in the model due to the following sources:

(1) Western Canal excess - 40.0 c.f.s.
(Vineyard and 48th St.)

(2) Alameda Dr. Storm Sewer - 43.0 c.f.s.
(Alameda and 48th St.)

The constant flows for Svob Park and at Southern Avenue were not modeled, as discussed in the previous section.



LEGEND

- Sewer Reach
- Inlet Node
- Drainage Area
- Drainage Area:Sq.Mi. / CN(T_C:Hrs.)
- Reach Length:Ft. / Reach Velocity:f.p.s.
- Cross Section No.

N

TR-20 SCHEMATIC LAYOUT

UPPER PORTION (South of Broadway)

FIGURE 3

The possible overload on the Western Canal was a quantity given by the Salt River Project. They requested this value be added to the system's peak flow. The model starts this flow at Vineyard and 48th St. for simplicity. In reality the flow will be added to the system north of the canal. This can be achieved by neglecting the added flow when sizing the pipe for design between Vineyard Dr. and the north side of the canal.

The other constant flow input was due to the newly installed Alameda Dr. storm sewer. Its present contributions are from an inlet on Diablo Way, two (2) inlets east of the freeway, and a connection to a Salt River Project irrigation line which services the area north of Alameda Dr. (the inlets at 48th St. are not included as they are at the pipe's lower end). However, the pipe's contribution of 43.0 c.f.s. has been based on its design capacity, at the City of Tempe's direction. They believe that the additional capacity will be required in the future when the area north of Alameda Dr. is developed.

The constant flows were not part of the TR-20 program analysis, but were added manually to the TR-20 output to size the pipes. The pipe sizes and velocities do, however, reflect these additional flows.

Section III

3. RESULTS

The TR-20 program was run with the input shown in Figure 3, TR-20 Schematic Layout as well as other parameters previously described. The final run included the 2-year, 5-year, and 10-year, 24-hour design events. The results for each pipe reach for all three (3) events are shown in Table 1, TR-20 Output Summary Table. The preliminary design resulting from these flows is shown in Appendix IV. This is a profile view of the trunk line from Broadway Rd. to Baseline Rd., drawn at 1" = 200' scale. The pipes are sized for the 2-year storm.

In examining the TR-20 Output Summary Table, it can be observed that the initial input at Beverly Rd. (Drainage Area No. 1 - see Drainage area Map) is quite significant. This results from the South Mountain Park contributions to this drainage area. This runoff from the park portion of the drainage area is not presently nor in the future likely to be retained/detained by developments downstream of it. The developed runoff contribution to the Beverly Rd. has been reduced to take into account on-site retention.

By the time the 48th St. flows have reached Vineyard Rd. they have increased by one-half (1/2) the original amount. This is due to additional contributions from south of Baseline Rd. being added at that street, plus 48th St. drainage to Vineyard. (Drainage Area Nos. 2, 3 & 8 - see Drainage Area Map).

Between Vineyard Rd. and the north side of the Western Canal, the flow increased three-and-one-half (3 1/2) times. This is due to the contributions from 44th St. and Vineyard, and the Salt River Project overflow from the Western Canal. The flow coming down the 48th St.

trunk line is only 42-55% of the flow which will enter at Vineyard Rd. from the west. This latter flow includes a large segment from South Mountain (Drainage Area No.'s 4, 5, 6 & 7 - see Drainage Area Map). As previously mentioned, at least one (1) major channel has been run through a detention system in a development south of Baseline Rd. which was not modeled due to its complexity. Since the developer is not required to retain/detain flow originating outside his property, his system is only designed to protect his property from flood damage and not to increase runoff leaving his site. Therefore, it was assumed that 15% of the rainfall falling on the developed area, together with the mountain runoff, will reach Baseline Rd. and enter the sewer system.

The remainder of the system modeling (not including the two (2) constant flows) from the Western Canal to Broadway Rd. increases the rate of flow by less than one (1) percent.

The constant flow contributions have already been discussed (see paragraph 2.3.3, above) and are a matter of agency policy rather than engineering analysis. Although both cases can be argued as being too conservative, this is not due to the modeling judgements used in formulating this hydrology model, and so will be accepted as uncontestable input.

the 43 cfs should be far enough downstream to have passed thru the drain prior to any contribution - could reduce by 30% w/o any difficulty - in determining pipe size

Section IV

4. CONCLUSION

This study has investigated potential runoff generated by 2-, 5- and 10-year, 24 hour storms on an urbanized drainage area extending from the South Mountain Park crest to Broadway Rd. The study is for a joint City of Tempe - City of Phoenix storm sewer project along 48th St. The modeled rates of flow from the project watershed to Vineyard Rd. along 48th St. and 44th St. for the 2-year event are 68 c.f.s. and 123 c.f.s., respectively (see Figure 2, Drainage Area Map). At Vineyard the flows combine. This flow is augmented by a 40.0 c.f.s. contribution from the Salt River Project's Western Canal. The total flow in the pipe immediately south of Southern Ave. for a 2-year storm is 227 c.f.s.; immediately south of Alameda Dr. for the same storm the flow is 205 c.f.s.; and at Broadway Rd. the cummulative flow is 267 c.f.s. (this last value includes the Alameda Storm Sewer's full capacity flow of 43.0 c.f.s.). Pipe velocities varied from 6.0 f.p.s. in the Baseline Rd. lateral to 10.0 f.p.s. in the Baseline Rd.-to-Vineyard Rd. segment.

REFERENCES

1. "TR-20 Computer Program for Project Formulation - Hydrology", Soil Conservation Service, U.S. Department of Agriculture; revised May, 1982; 2nd ed., May 1983. (User's Manual)

2. McCuen, Richard H., "A Guide to Hydrologic Analysis Using SCS Methods", Prentice-Hall, Inc., Englewood Cliffs, N.J.

3. "Storm Drain Design Manual - Storm Drains With Paving Of Major Streets", City of Phoenix Engineering Department, August, 1975 and subsequent revisions, including "TR-20 Procedure" outline.

TABLE NO. 1

TR-20 OUTPUT SUMMARY TABLE

Pipe Section	Peak Rate of Flow (c.f.s.) 2-yr.	5-yr.	10-yr.
48th St. - Beverly Rd. to Baseline Rd.	47	69	84
Baseline Rd. - 1300' W. of 48th St. to 48th St.	5	8	10
48th St. - Baseline Rd. to Vineyard Rd.	68	104	128
44th St./Vineyard Rd. - Baseline Rd. to 48th St.	123	232	308
48th St. - Vineyard Rd. to Southern Ave.	183 (223)*	320 (360)*	417 (457)*
48th St. - Southern Ave. to Alameda Dr.	186 (226)*	324 (364)*	421 (461)*
48th St. - Alameda Dr. to Broadway Rd.	184 (267)**	321 (404)**	419 (462)** 502 ?

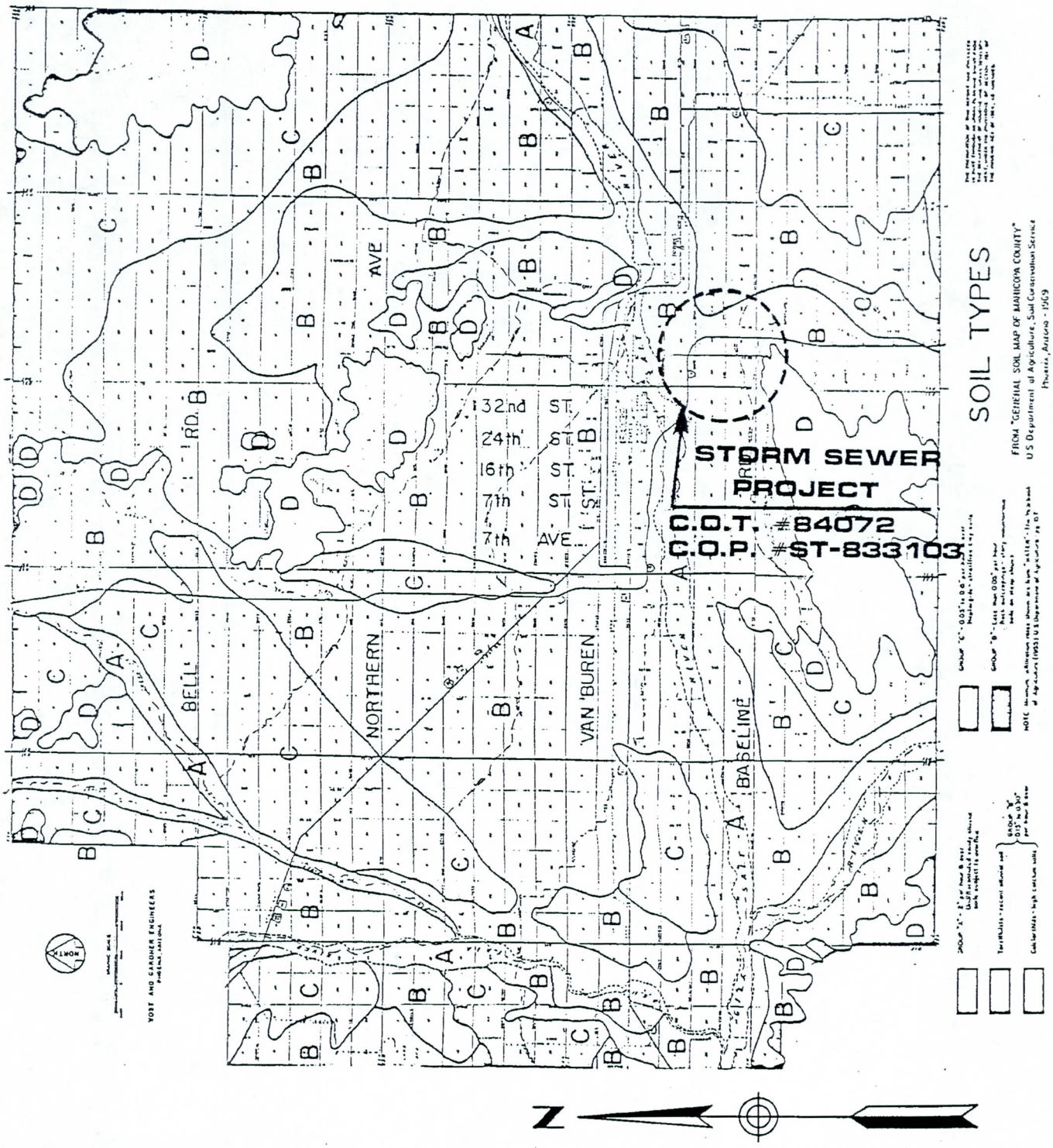
*Including 40 c.f.s. from Western Canal.

**Including 40 c.f.s. from Western Canal and 43 c.f.s. from Alameda Storm Drain.

Note: The constant flow rates from the Western Canal and the Alameda Storm Drain are the result of policy decisions and are independent of any storm interval.

Approved for 2 year design 10/20/85 - SEE MEMO dated

Appendix I



SOIL MAP

FIGURE 4

ZONING	.....CN for soil type..... TYPE B	TYPE C	TYPE D
RE-43) S-1) S-2)	77	83	86
RE-35	79	84	87
RE-25	79	84	87
R1-18	80	84	87
R1-14	80	85	88
R1-10	81	86	89
R1-8	82	87	90
R1-6	84	88	90
R -3,2	85	88	90
R -4) R -40) R -5)	86	89	91
A-1) A-2)	88	91	93
C-1) C-2) C-3)	92	94	95
CO	88	91	93
PSC	95	95	95
HR	95	95	95
R4A	87	90	92

CITY OF PHOENIX

CURVE NUMBER/ZONING TABLE

TABLE 2

CURVE NUMBERS FOR NON-ZONED AREAS

Description	CN
Desert Mountainous Region, slope > 10%	98
Desert Mountainous Region, slope < 10%	89
A.C. Pavement	98
Pavement Tributary Areas, including frontage roads, sidewalks, and gravel	95
Pavement Tributary Areas, including sidewalks, grass, and dirt	90
Pavement Tributary Areas (1/3 sidewalk, 2/3 grass)	73
Pavement Tributary Areas (100% dirt)	82
SRP Substation (gravel lot)	85
Park (grass in fair condition)	69

CURVE NUMBERS FOR NON-ZONED AREAS

TABLE 3

CITY OF TEMPE - CITY OF PHOENIX

ZONING EQUIVALENCIES

Tempe Zoning	Equivalent Phoenix Zoning
R1-6	R1-6
R-2	R-2
RMH	R-2
RO	R-5
C-1	C-1
PCC-1	C-2
C-2	C-3
I-1	A-1
I-2	A-1

CITY OF TEMPE - CITY OF PHOENIX

ZONING EQUIVALENCIES

TABLE 4

TIME HOUR	% TOTAL RAINFALL	TIME HOUR	% TOTAL RAINFALL
0	.000	12.5	.83
.5	.004	13.0	.86
1.	.008	13.5	.88
1.5	.013	14.0	.893
2.0	.018	14.5	.907
2.5	.022	15.0	.92
3.0	.026	15.5	.924
3.5	.031	16.0	.928
4.0	.035	16.5	.933
4.5	.040	17.0	.937
5.0	.044	17.5	.942
5.5	.048	18.0	.947
6.0	.053	18.5	.951
6.5	.057	19.0	.956
7.0	.062	19.5	.96
7.5	.066	20.0	.964
8.0	.071	20.5	.969
8.5	.075	21.0	.973
9.0	.08	21.5	.978
9.5	.093	22.0	.982
10.0	.107	22.5	.987
10.5	.12	23.0	.991
11.0	.14	23.5	.995
11.5	.17	24.0	1.00
12.0	.50		1.00

CITY OF PHOENIX

24HR. RAINFALL DISTRIBUTION TABLE

TABLE 5

ESTIMATED RETURN PERIODS FOR SHORT-DURATION PRECIPITATION IN ARIZONA
(Inches)

Station: Phoenix WBO

Latitude: 33° 26'

Longitude: 112° 01'

Elevation (feet): 1117

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	25	50	100
5 min.	0.17	0.26	0.38	0.47	0.59	0.68	0.77
10 min.	0.27	0.40	0.59	0.72	0.91	1.06	1.20
15 min.	0.34	0.50	0.74	0.92	1.15	1.34	1.52
30 min.	0.47	0.70	1.03	1.27	1.60	1.86	2.10
1 hr.	0.60	0.88	1.30	1.61	2.02	2.35	2.66
2 hr.	0.65	0.94	1.39	1.72	2.15	2.49	2.82
3 hr.	0.69	1.01	1.48	1.82	2.27	2.62	2.97
6 hr.	0.81	1.16	1.70	2.07	2.57	2.96	3.35
12 hr.	0.91	1.30	1.90	2.30	2.84	3.26	3.69
24 hr.	1.02	1.44	2.10	2.53	3.12	3.57	4.04

CITY OF PHOENIX

PRECIPITATION CHART

TABLE 6

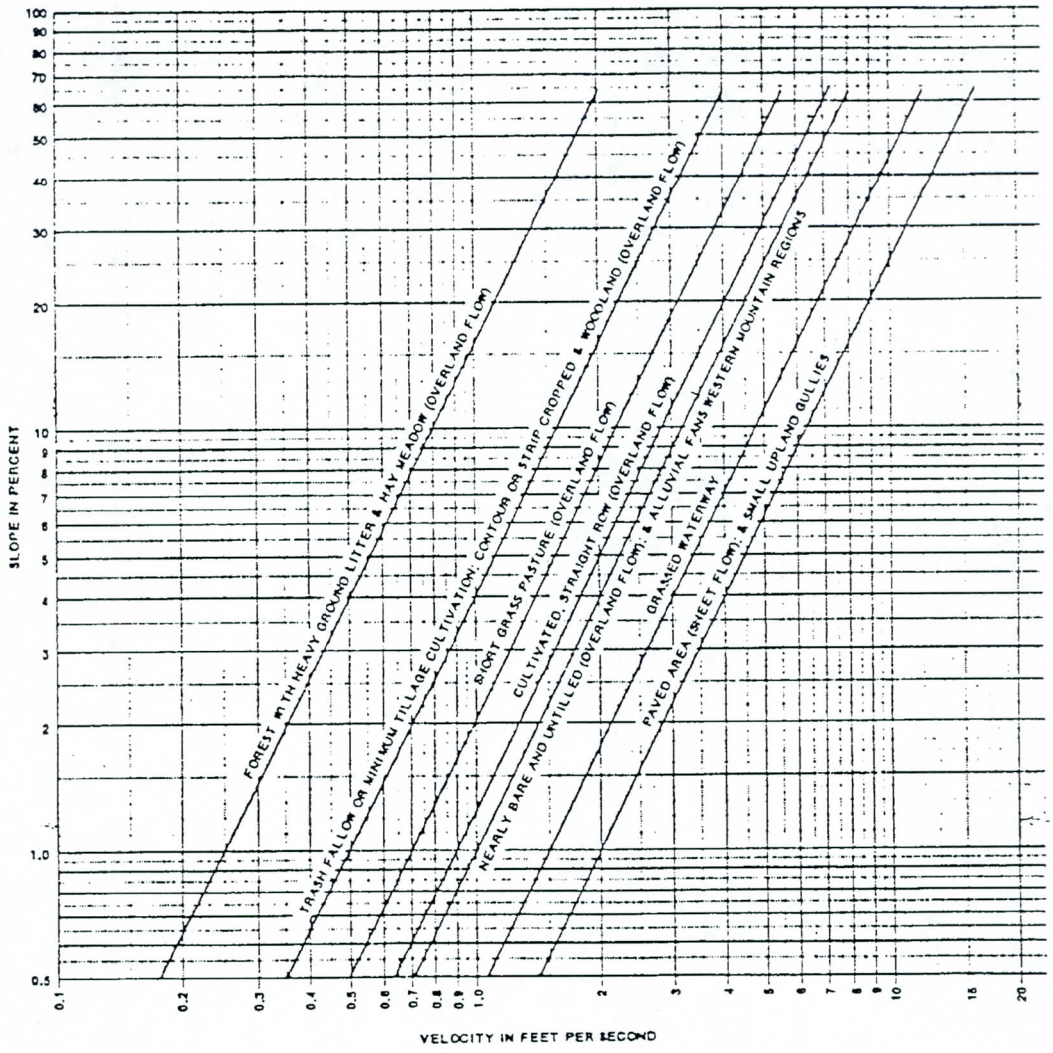
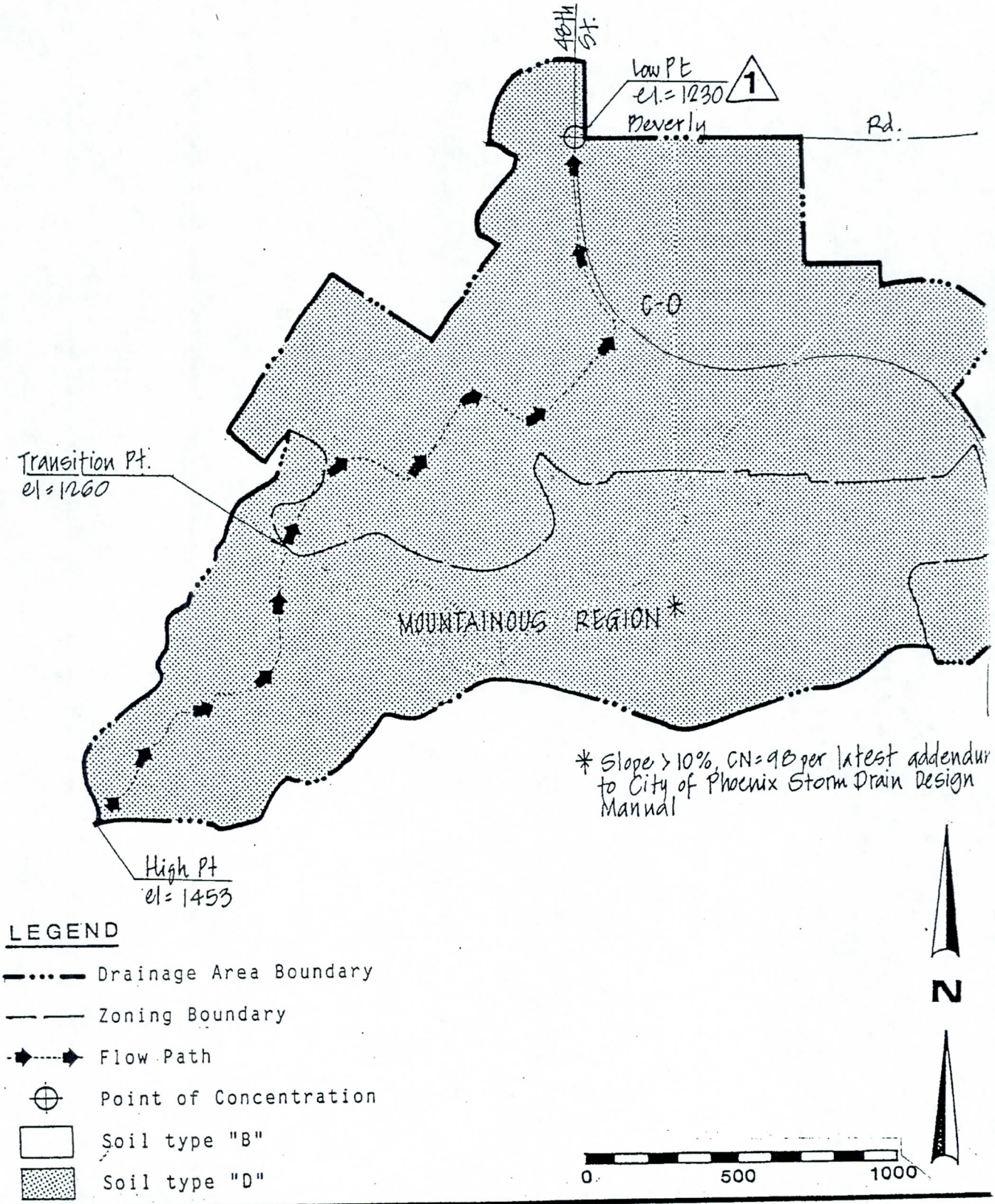


Figure 8. Velocities for upland method of estimating T_c

UPLAND METHOD VELOCITY CHART

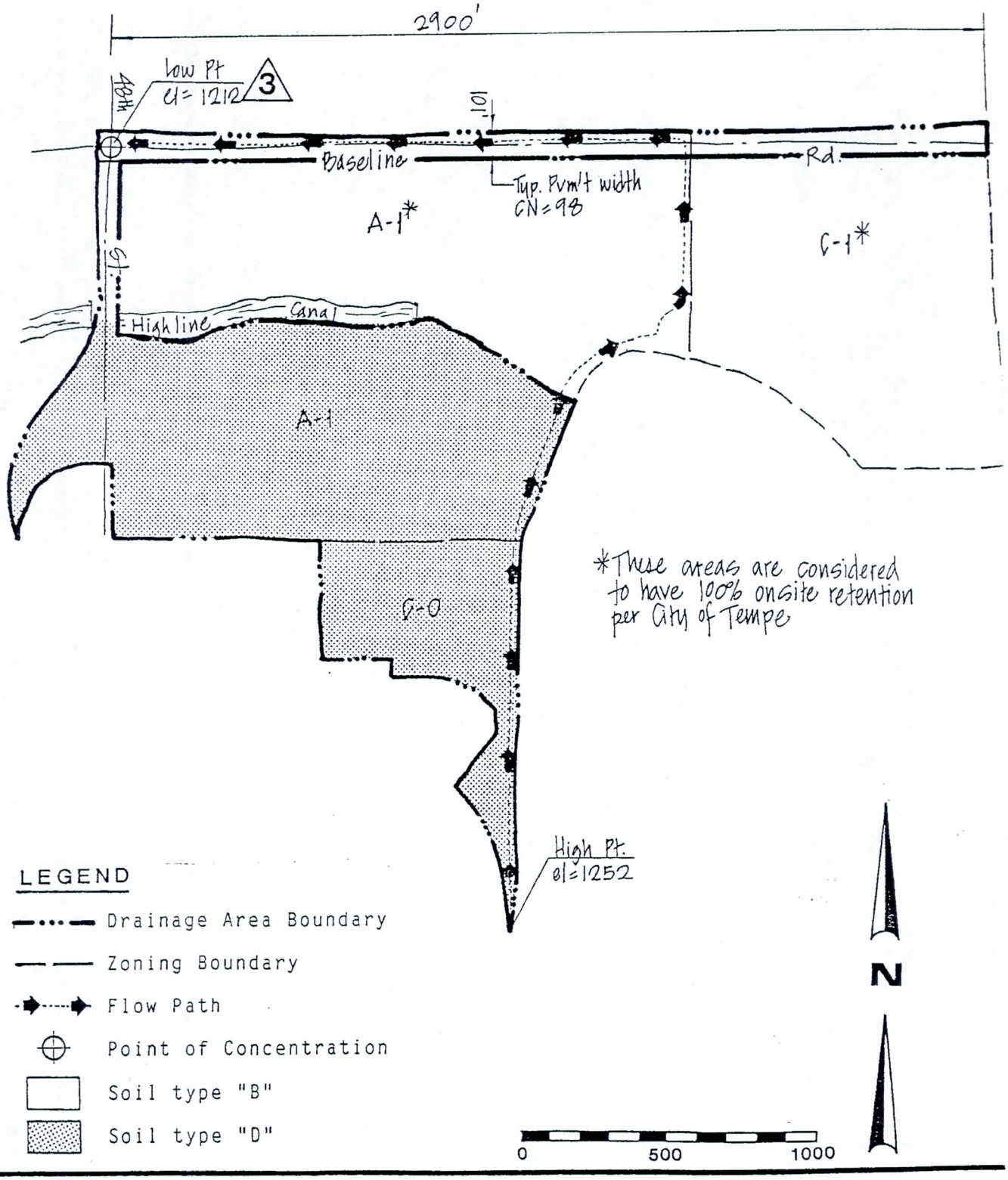
TABLE 7

Appendix II



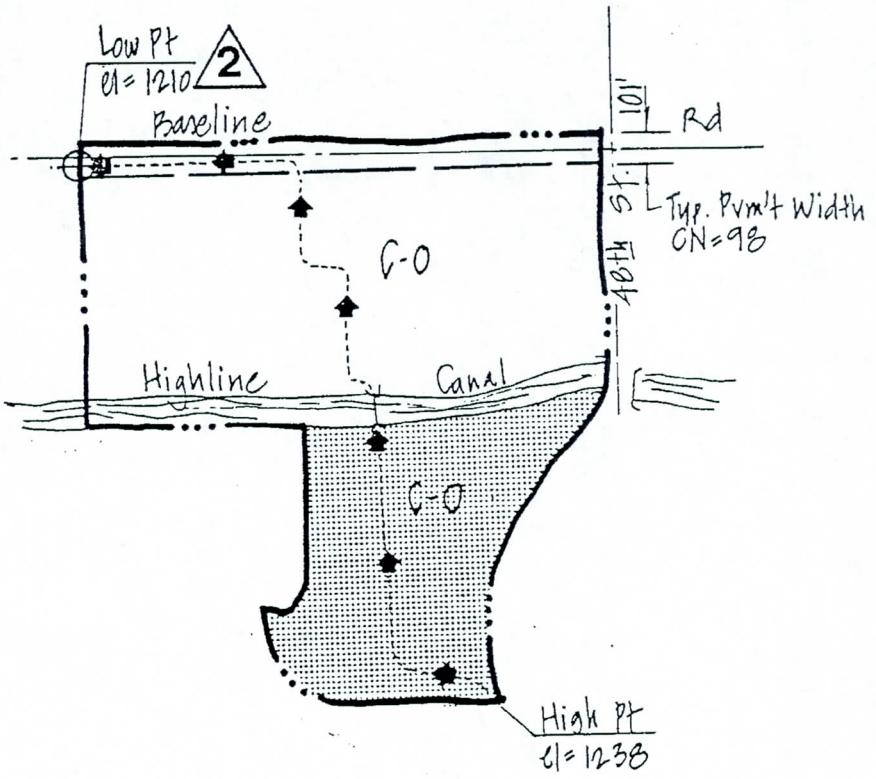
DRAINAGE AREA 1

FIGURE 5



DRAINAGE AREA 2

FIGURE 6



LEGEND

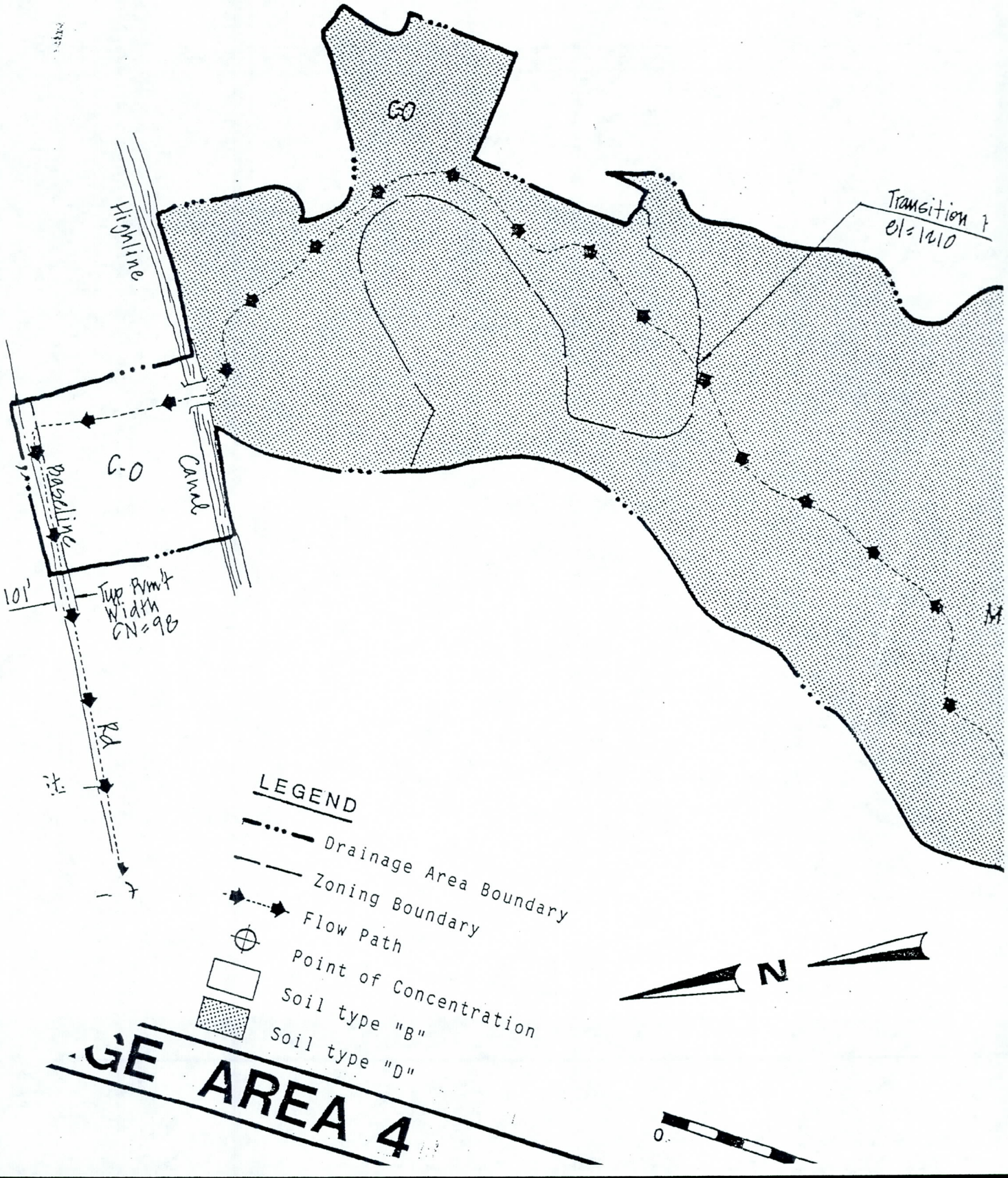
- Drainage Area Boundary
- Zoning Boundary
- Flow Path
- Point of Concentration
- Soil type "B"
- Soil type "D"

N

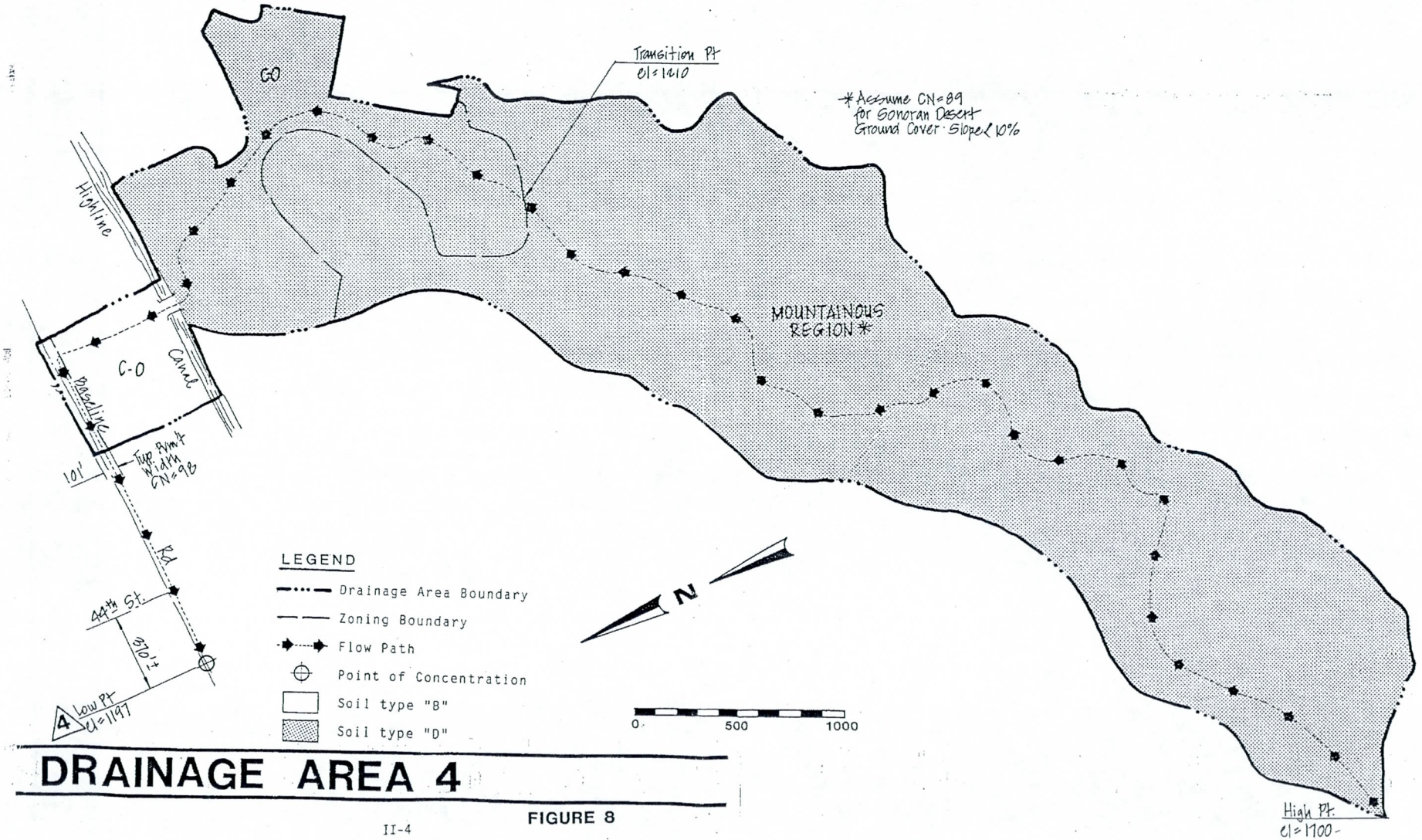
0 500 1000

DRAINAGE AREA 3

FIGURE 7

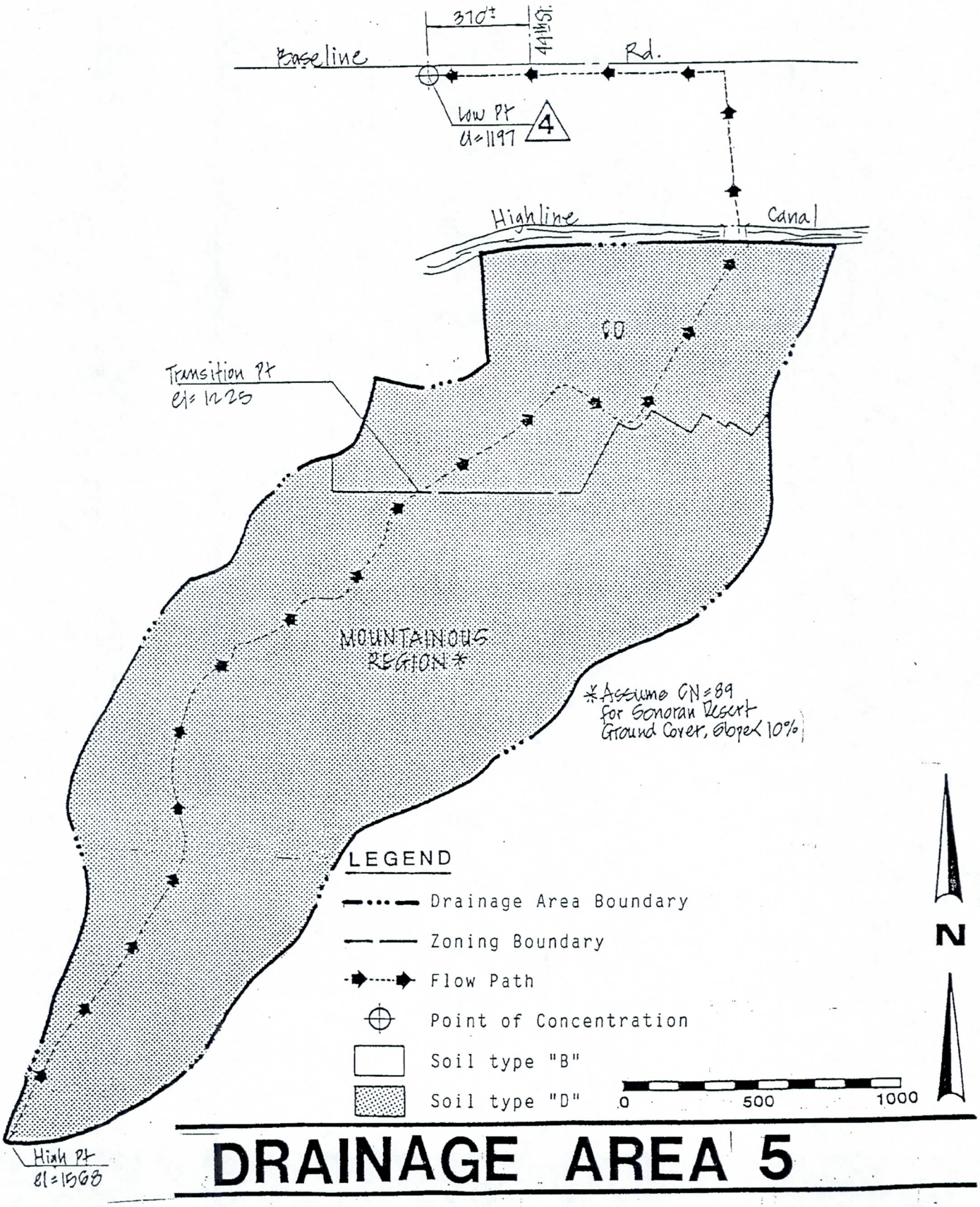

C-O
Highline
Transition 1
el = 1210
C-O
Canal
Baseline
101'
Typ. R/w't
Width
CN = 98
Rd
LEGEND
Drainage Area Boundary
Zoning Boundary
Flow Path
Point of Concentration
Soil type "B"
Soil type "D"
N
0

GE AREA 4



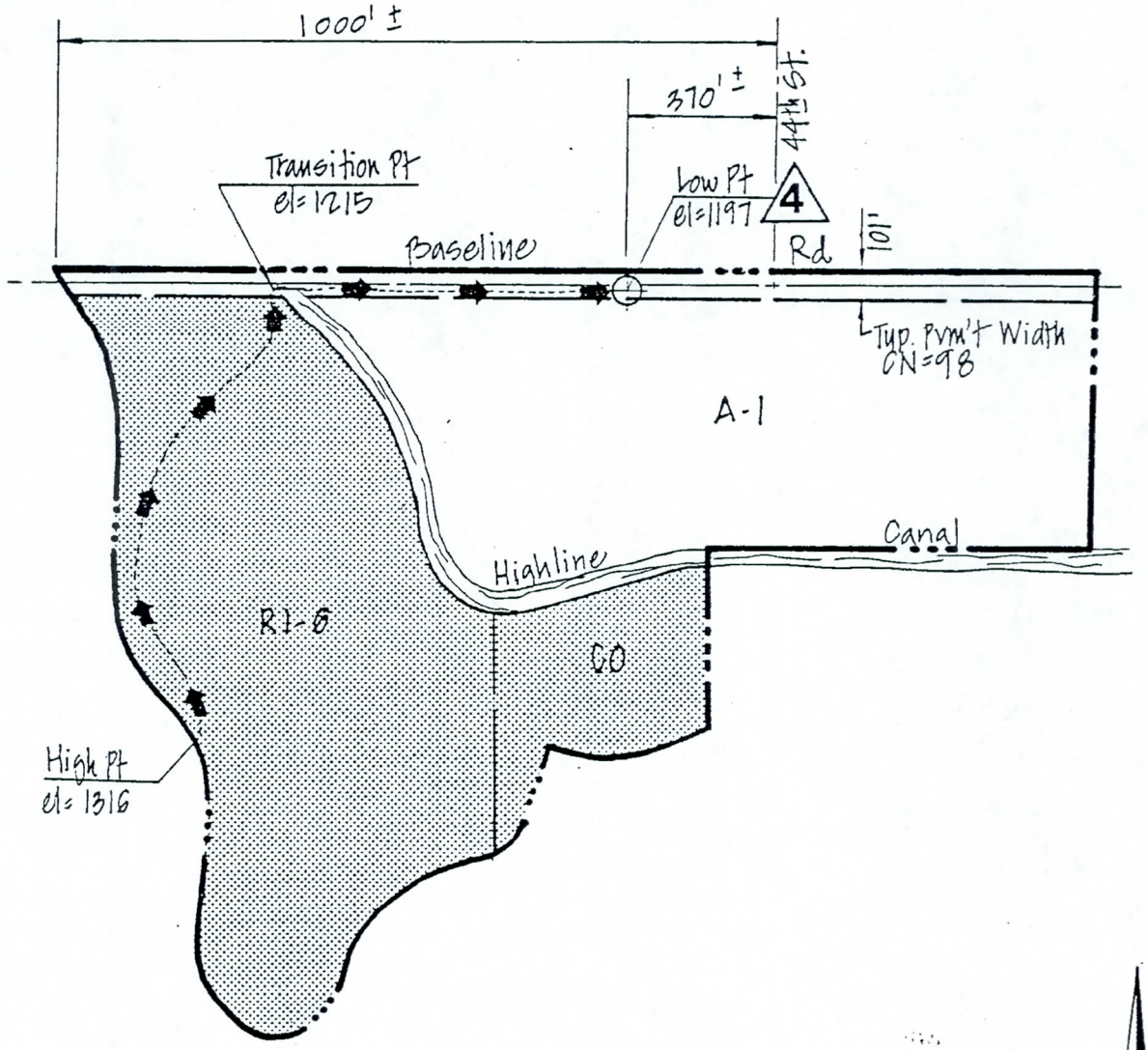
DRAINAGE AREA 4

FIGURE 8



DRAINAGE AREA 5

FIGURE 9



LEGEND

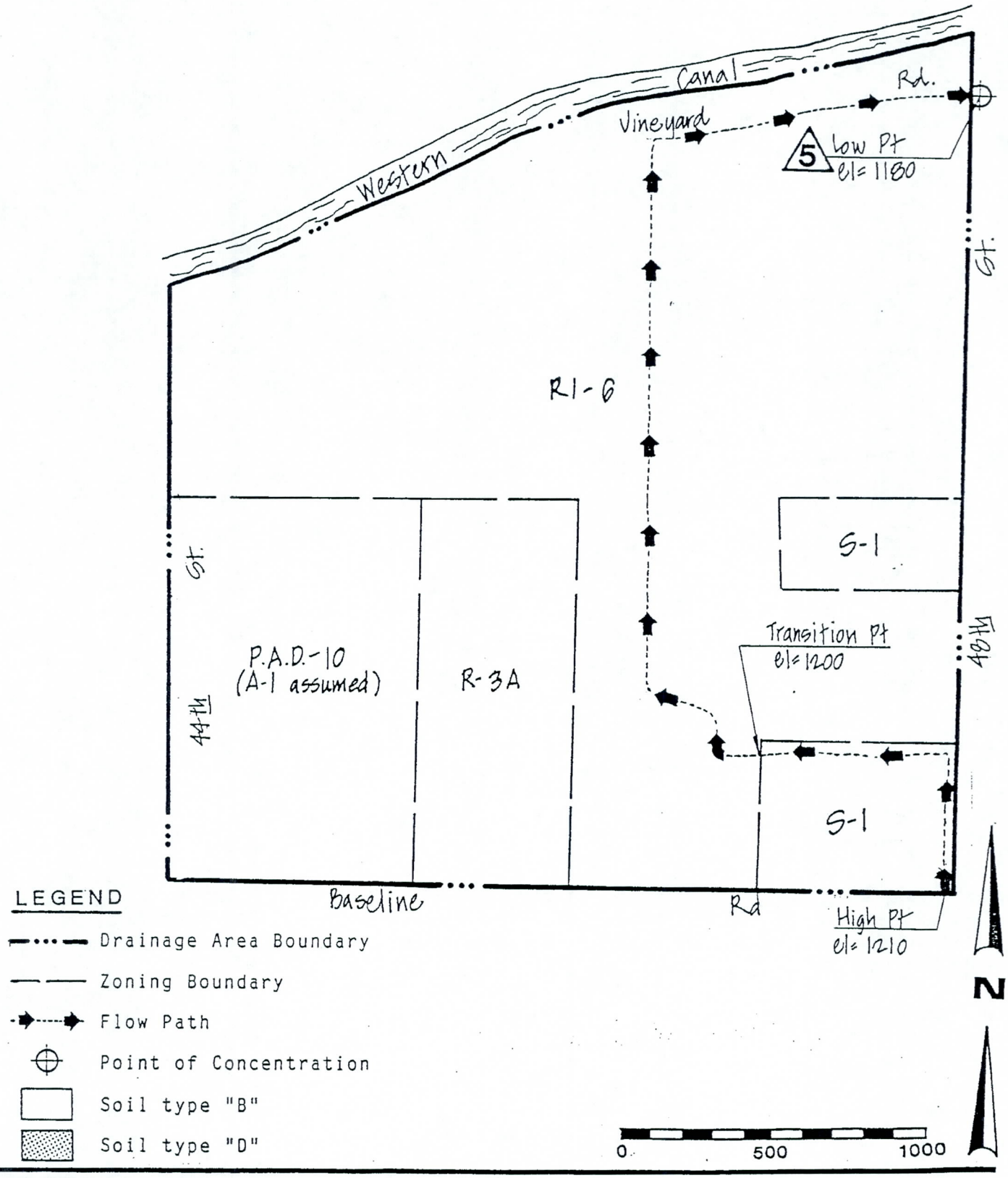
- Drainage Area Boundary
- Zoning Boundary
- Flow Path
- Point of Concentration
- Soil type "B"
- Soil type "D"

N

0 500 1000

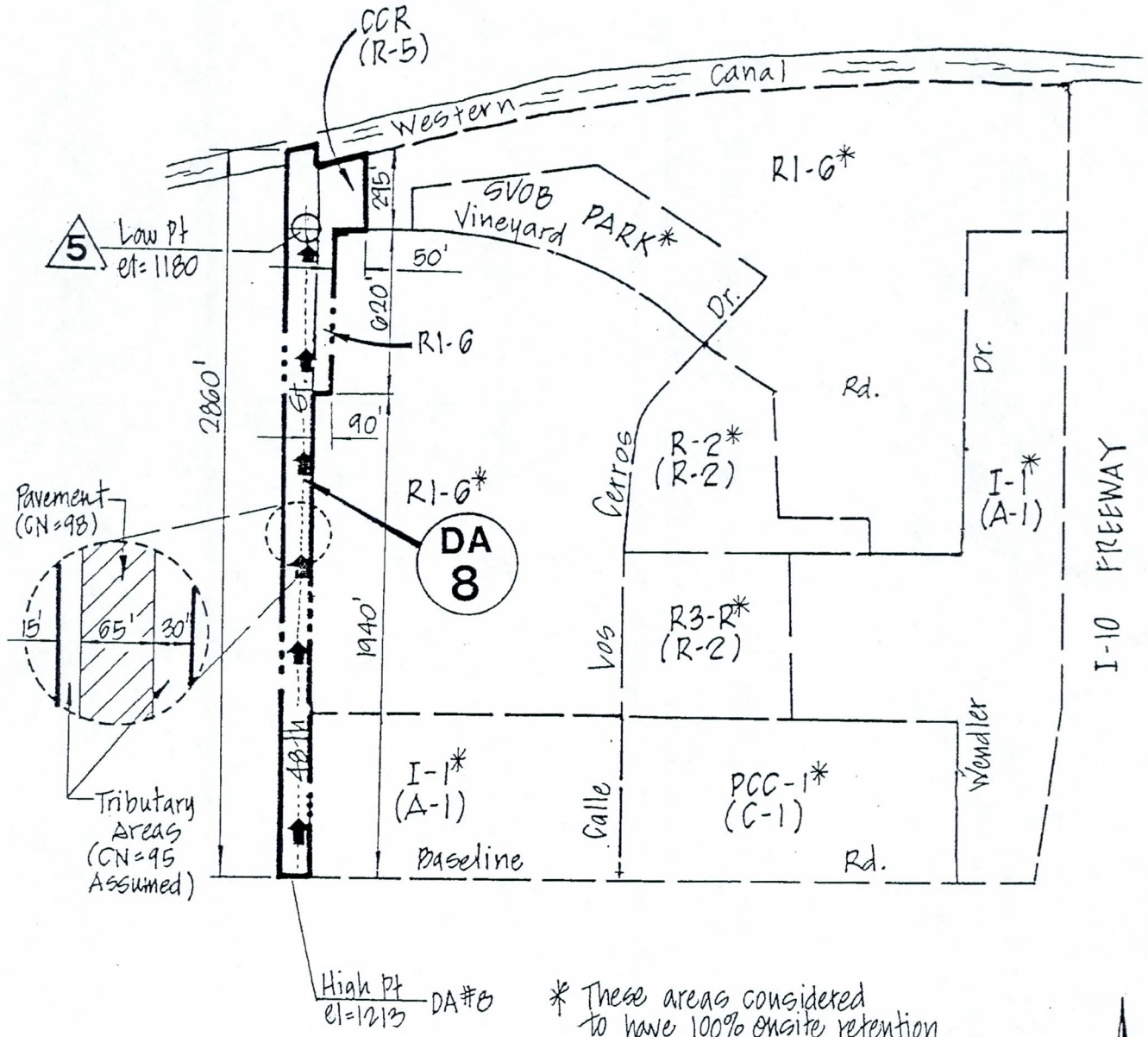
DRAINAGE AREA 6

FIGURE 10



DRAINAGE AREA 7

FIGURE 11



* These areas considered to have 100% onsite retention per City of Tempe

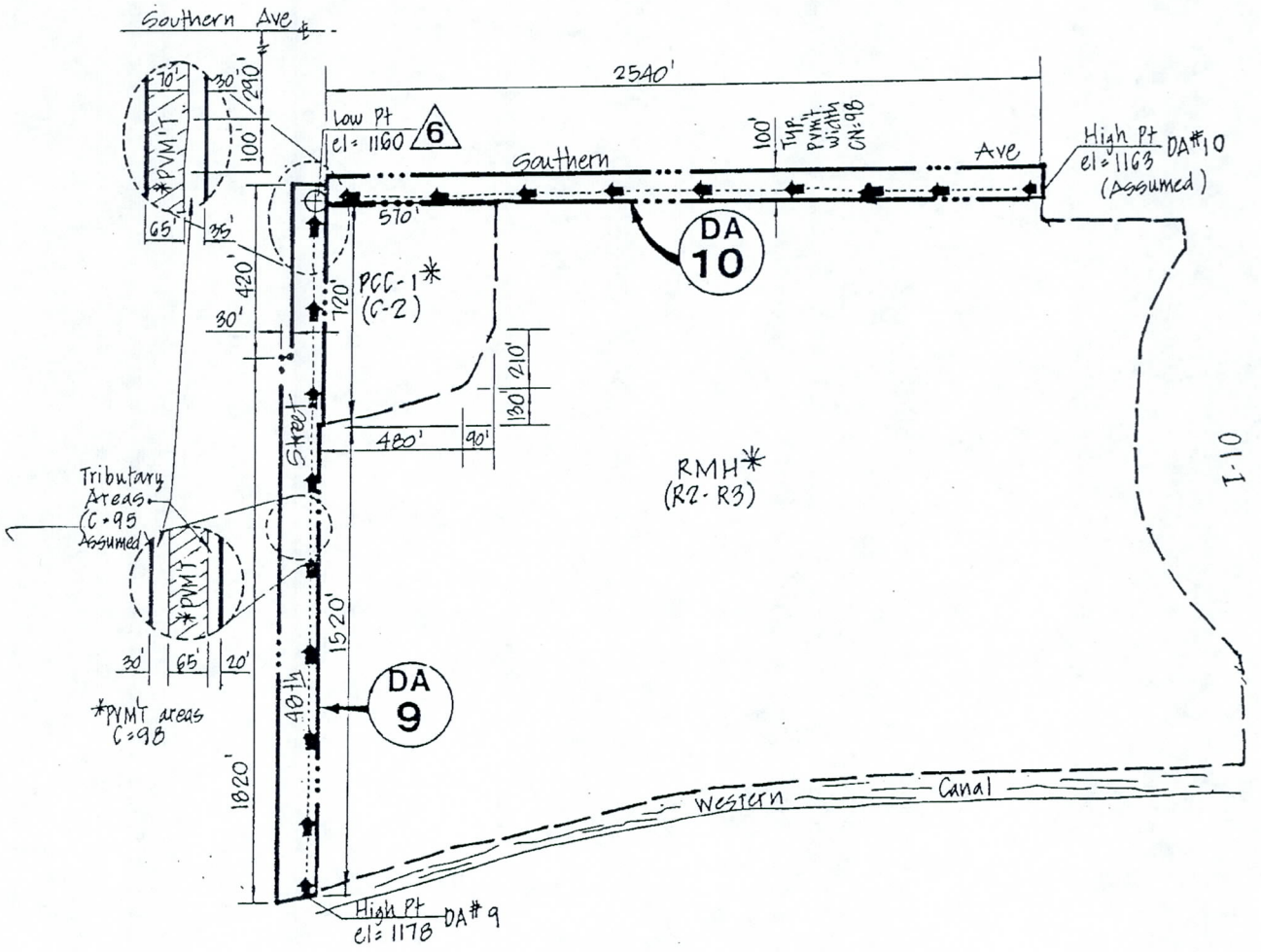
Note: Zoning in parenthesis is nearest City of Phoenix equivalent to City of Tempe Zoning

LEGEND

- Drainage Area Boundary
- Zoning Boundary
- Flow Path
- Point of Concentration
- Soil type "B"
- Soil type "D"

DRAINAGE AREA 8

FIGURE 12



Note: Zoning in parenthesis is nearest City of Phoenix equivalent to City of Tempe Zoning

LEGEND

- Drainage Area Boundary
- Zoning Boundary
- Flow Path
- Point of Concentration
- Soil type "B"
- Soil type "D"

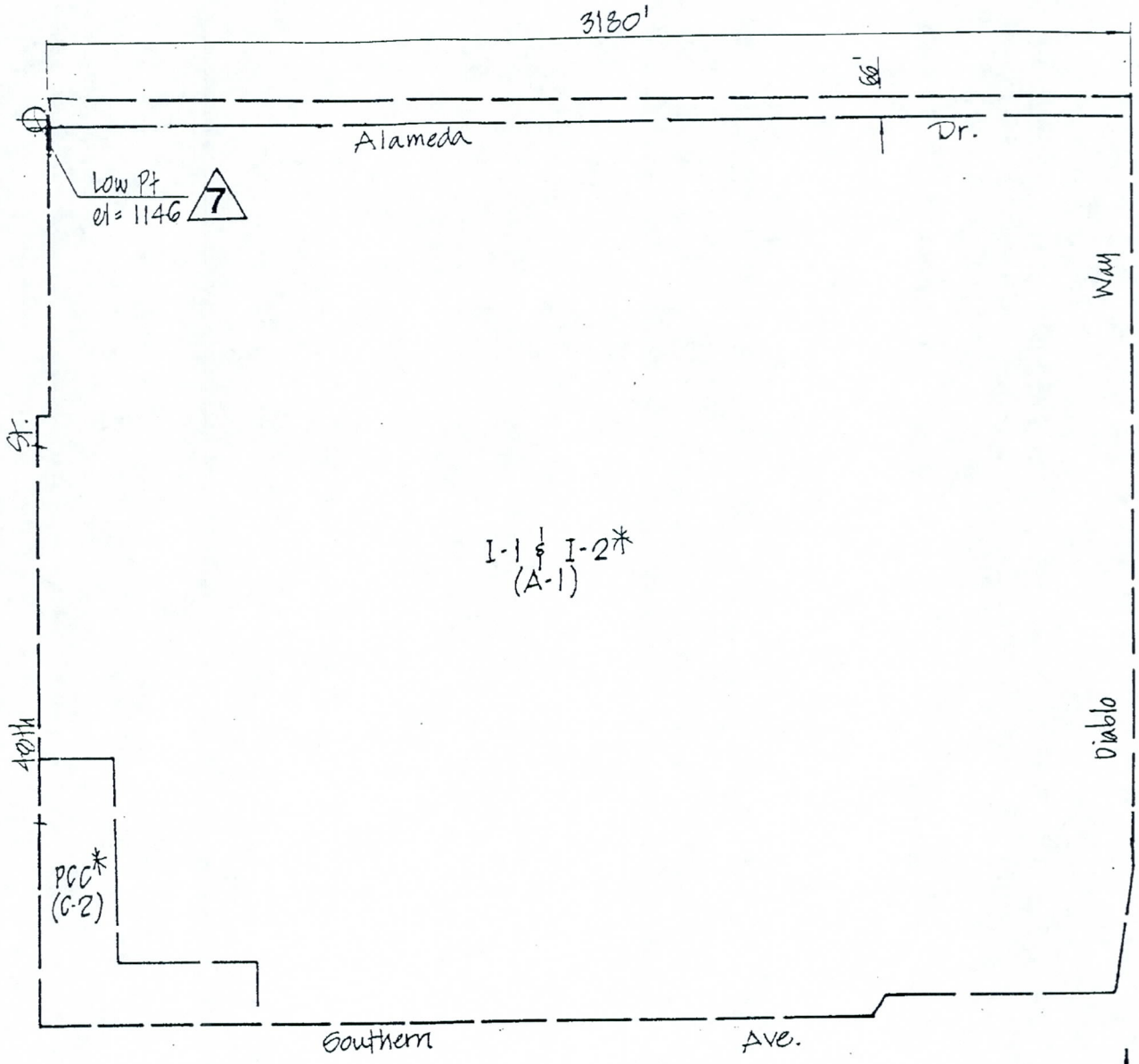
*These areas considered to have 100% Onsite Retention per City of Tempe

N

0 500 1000

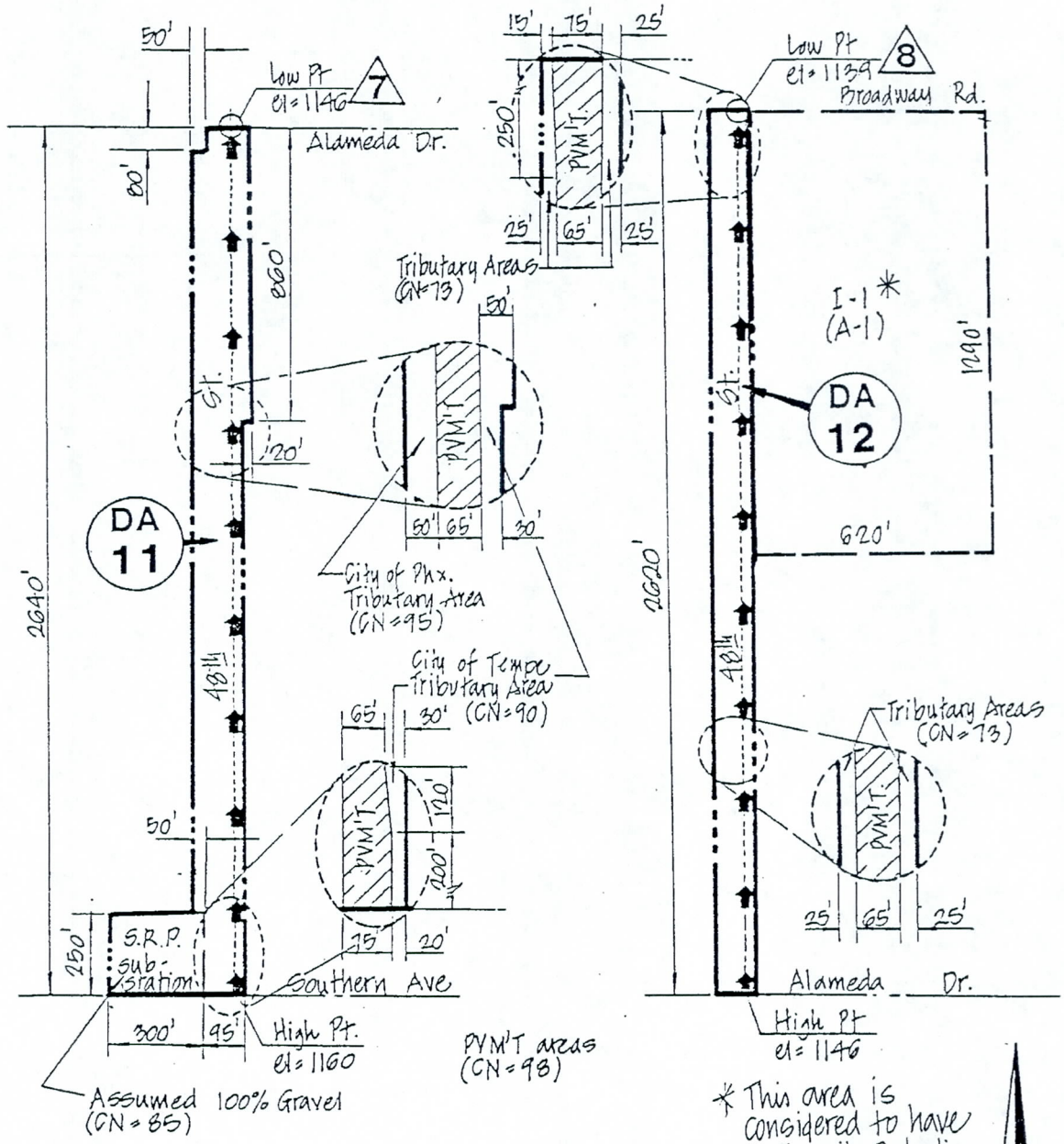
DRAINAGE AREAS 9 & 10

FIGURE 13



EATON FREEWAY INDUSTRIAL PARK

FIGURE 14



LEGEND

- Drainage Area Boundary
- Zoning Boundary
- Flow Path
- Point of Concentration
- Soil type "B"
- Soil type "D"

Note: Zoning in parenthesis is nearest City of Phoenix equivalent to City of Tempe Zoning

DRAINAGE AREAS 11 & 12

FIGURE 15

DA. No.	SUB AREA	ZONING	(1) EQUIV. ZONING	SOIL TYPE	CN	A(ft²)	(2) EFFECT. Ae	CN x Ae	(3) WEIGHTED CN
1	a	Mt. Reg.		D	98	1927111	1927111	188856378	
	b	C-O		D	93	2037111	313067	29115199	
						TOTALS	2240178	217972077	97
							(0.080 mi²)		
2	a	A-1		D	93	1164474	174671	16244412	
	b	C-O		D	93	367737	55461	5157873	
	c	Baseline		Pvm't	98	292900	292900	28704200	
						TOTALS	523,032	50,106,445	96
							(0.019 mi²)		
3	a	C-O		B	88	633450	95018	8361584	
	b	C-O		D	93	361942	54277	5047761	
	c	Baseline		Pvm't	98	121200	121200	11877600	
						TOTALS	270495	25286945	94
							(0.010 mi²)		
4	a	C-O		B	88	324500	48675	4283400	
	b	C-O		D	93	1219737	182961	17015373	
	c	Mt. Rea		D	89	6053947	6053947	538801283	
	d	Baseline		Pvm't	98	55550	55550	5443900	
						TOTALS	6341133	565543956	89
							(0.225 mi²)		

FOOT NOTES:

(1) Nearest City of Phoenix Zoning Equivalent to City of Tempe
(2) Ae = 100% x A for: Mountainous, Agricultural, Pavement and Pavement Tributary Areas
Ae = 15% x A for: Developed Areas with Retention
(3) Weighted CN = TOTAL CN x Ae ÷ TOTAL Ae

WEIGHTED CURVE NUMBER CALCULATIONS

TABLE 8
Sheet 1 of 2

DA. No.	SUB AREA	ZONING	(1) EQUIV. ZONING	SOIL TYPE	CN	A (ft^2)	(2) EFFECT. Ae	CN × Ae	(3) WEIGHTED CN
5	a	C-0		D	93	1119737	167961	15620373	
	b	Mt. Reg.		D	89	3028947	3028947	269576283	
						TOTALS	3196908	285196656	89
							(0.115 mi^2)		
6	a	R1-6		D	90	1203947	180592	16253280	
	b	A-1		B	83	1082237	162336	14235568	
	c	C-0		D	93	238153	35723	3322239	
	d	Baseline		Pvm't	98	256540	256540	25140920	
						TOTALS	635191	59002007	93
							(0.023 mi^2)		
7	a	R1-6		B	84	4441790	666269	55966596	
	b	R-3		B	85	615550	92300	7845500	
	c	A-1		B	88	1037160	155574	13690512	
	d	S-1		B	77	507940	507940	39111380	
						TOTALS	1422083	116613988	82
							(0.051 mi^2)		
8	a	R1-6	R1-6	B	84	74400	74400	6249600	
	b	CCR	R-5	B	86	50150	50150	4312900	
	c	48th St.		Pvm't	98	185900	185900	18218200	
	d	Frontage		Trib.	95	101100	101100	9604500	
						TOTALS	411,550	38385200	93
							(0.015 mi^2)		

FOOT NOTES:

(1) Nearest City of Phoenix Zoning Equivalent to City of Tempe
(2) A_e = 100% × A for: Mountainous, Agricultural, Pavement and Pavement Tributary Areas
A_e = 15% × A for: Developed Areas with Retention
(3) Weighted CN = TOTAL CN × A_e ÷ TOTAL A_e

WEIGHTED CURVE NUMBER CALCULATIONS

TABLE 8
Sheet 2 of 3

DA. No.	SUB AREA	ZONING	① EQUIV. ZONING	SOIL TYPE	CN	A (ft^2)	② EFFECT. Ae	CN x Ae	③ WEIGHTED CN
9	a	48th		Rm't	98	141300	141300	14435400	
	b	48th		Trib.	95	108500	108500	10307500	
						TOTALS	255800	24742900	97
							(0.009 mi^2)		
10	a	Southern		Rm't	98	254000	254000	24892000	
						TOTALS	254000	24892000	98
							(0.009 mi^2)		
11	a	S.R.P.		Gravel	85	75000	75000	6375000	
	b	C.O.P.		Trib.	95	115500	115500	10972500	
	c	C.O.T.		Trib.	90	93800	93800	8442000	
	d	48th		Rm't	98	174200	174200	17071600	
						TOTALS	458500	42361100	94
							(0.016 mi^2)		
12	a	48th		Rm't	98	171550	171550	16811900	
	b	48th		Trib	73	155950	155950	11384350	
						TOTALS	327,500	28,196,250	86
							(0.012 mi^2)		

FOOT NOTES:

① Nearest City of Phoenix Zoning Equivalent to City of Tempe
② A_e = 100% x A for: Mountainous, Agricultural, Pavement and Pavement Tributary Areas
A_e = 15% x A for: Developed Areas with Retention
③ Weighted CN = TOTAL CN x A_e ÷ TOTAL A_e

WEIGHTED CURVE NUMBER CALCULATIONS

TABLE 8
Sheet 3 of 3

DA. No.	LENGTH ft	ELEV. DIFF.	SLOPE 1/1	TYPE OF FLOW	VELOCITY fps	T_c / min	Total T_c / min	Total T_c / hr.
1	1600	193	0.1206	Upland	7.0	6.8		
	1450	30	0.0207	Gutter	6.8	3.6		
						=	(7.4)	0.12
							10.4	(0.17)*
2	4530	40	0.0088	Gutter	4.4	17.1		
						=	17.1	0.29
3	2120	28	0.0132	Gutter	5.4	6.5		
						=	6.5	0.11
								(0.17)*
4	3900	490	0.0551	Upland	4.7	31.6		
	1650	15	0.0079	Gutter	4.2	6.6		
						=	38.2	0.64
5	3600	345	0.0953	Upland	6.2	9.7		
	2690	28	0.0104	Gutter	4.8	9.3		
						=	19.0	0.32
6	1300	101	0.0777	Upland	3.4	6.4		
	850	18	0.0212	Gutter	7.1	1.9		
						=	8.3	0.14
								(0.17)*
7	1118	10	0.0089	Upland	0.85	21.9		
	3390	20	0.0059	Gutter	3.6	15.7		
						=	37.6	0.63
8	2565	33	0.0129	Gutter	5.3	8.1		
						=	8.1	0.14
								(0.17)*

* Minimum Allowable T_c is 10 minutes = 0.17 hour

TIME OF CONCENTRATION CALCULATIONS

TABLE 9
Sheet 1 of 2

DA. No.	LENGTH ft	ELEV. DIFF.	SLOPE ft/ft	TYPE OF FLOW	VELOCITY fps	T_c / min	Total T_c / min	Total T_c / hr.
9	2240	18	0.0080	Gutter	4.2	8.9		
						=	8.9	0.15
								(0.17*)
10	2540	3	0.0012	Gutter	1.6	26.0		
						=	26.0	0.43
11	2640	14	0.0053	Gutter	3.4	12.9		
						=	13.9	0.22
12	2620	7	0.0027	Gutter	2.4	18.2		
						=	18.2	0.30

* Minimum Allowable T_c is 10 minutes = 0.17 hour

TIME OF CONCENTRATION CALCULATIONS

TABLE 9
Sheet 2 of 2

Appendix III

SUMMARY TABLE 1 - SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL INSTRUCTIONS IN THE ORDER PERFORMED
(A STAR(*) AFTER THE PEAK DISCHARGE TIME AND RATE (CFS) VALUES INDICATES A FLAT TOP HYDROGRAPH
A QUESTION MARK(?) INDICATES A HYDROGRAPH WITH PEAK AS LAST POINT.)

SECTION/ STRUCTURE ID		STANDARD CONTROL OPERATION	DRAINAGE AREA (SQ MI)	RAIN TABLE #	ANTEC MOIST COND	MAIN TIME INCREM (HR)	PRECIPITATION BEGIN (HR)	PRECIPITATION AMOUNT (IN)	PRECIPITATION DURATION (HR)	RUNOFF AMOUNT (IN)	PEAK DISCHARGE ELEVATION (FT)	PEAK DISCHARGE TIME (HR)	PEAK DISCHARGE RATE (CFS)	PEAK DISCHARGE RATE (CSM)
ALTERNATE 1 STORM 1 (Q_2)														
XSECTION	1	RUNOFF	0.08	1	2	0.05	0.0	1.44	24.00	1.01	---	12.48	46.37	579.6
XSECTION	3	REACH	0.08	1	2	0.05	0.0	1.44	24.00	1.00	---	12.53	46.32	579.1
XSECTION	2	RUNOFF	0.01	1	2	0.05	0.0	1.44	24.00	0.77	---	12.48	5.13	512.9
XSECTION	3	REACH	0.01	1	2	0.05	0.0	1.44	24.00	0.77	---	12.54	5.06	506.4
XSECTION	3	RUNOFF	0.03	1	2	0.05	0.0	1.44	24.00	0.77	---	12.50	14.87	495.5
XSECTION	3	ADDHYD	0.09	1	2	0.05	0.0	1.44	24.00	0.98	---	12.53	51.38	570.9
XSECTION	3	ADDHYD	0.12	1	2	0.05	0.0	1.44	24.00	0.93	---	12.52	65.87	548.9
XSECTION	5	REACH	0.12	1	2	0.05	0.0	1.44	24.00	0.92	---	12.58	65.90	549.2
XSECTION	4	RUNOFF	0.23	1	2	0.05	0.0	1.44	24.00	0.47	---	12.95	50.97	223.6
XSECTION	4	RUNOFF	0.11	1	2	0.05	0.0	1.44	24.00	0.49	---	12.59	38.13	331.6
XSECTION	4	RUNOFF	0.02	1	2	0.05	0.0	1.44	24.00	0.71	---	12.48	11.22	488.0
XSECTION	4	ADDHYD	0.34	1	2	0.05	0.0	1.44	24.00	0.48	---	12.70	78.21	228.0
XSECTION	4	ADDHYD	0.37	1	2	0.05	0.0	1.44	24.00	0.49	---	12.61	82.66	225.8
XSECTION	5	REACH	0.37	1	2	0.05	0.0	1.44	24.00	0.49	---	12.76	79.85	218.2
XSECTION	5	RUNOFF	0.05	1	2	0.05	0.0	1.44	24.00	0.24	---	12.71	8.49	166.4
XSECTION	5	ADDHYD	0.42	1	2	0.05	0.0	1.44	24.00	0.46	---	12.75	88.19	211.5
XSECTION	5	RUNOFF	0.02	1	2	0.05	0.0	1.44	24.00	0.54	---	12.51	7.61	400.6
XSECTION	5	RUNOFF	0.05	1	2	0.05	0.0	1.44	24.00	0.34	---	12.55	13.73	274.6
XSECTION	5	ADDHYD	0.14	1	2	0.05	0.0	1.44	24.00	0.87	---	12.54	72.99	525.1
XSECTION	5	ADDHYD	0.19	1	2	0.05	0.0	1.44	24.00	0.73	---	12.54	86.72	458.8
XSECTION	5	ADDHYD	0.61	1	2	0.05	0.0	1.44	24.00	0.54	---	12.61	167.35	276.2
XSECTION	6	REACH	0.61	1	2	0.05	0.0	1.44	24.00	0.54	---	12.68	165.55	273.2
XSECTION	6	RUNOFF	0.01	1	2	0.05	0.0	1.44	24.00	1.01	---	12.48	5.24	581.7
XSECTION	6	RUNOFF	0.03 ?	1	2	0.05	0.0	1.44	24.00	0.33	---	12.64	6.57	234.7
XSECTION	6	RUNOFF	0.01	1	2	0.05	0.0	1.44	24.00	1.00	---	12.52	6.11	555.8
XSECTION	6	ADDHYD	0.61	1	2	0.05	0.0	1.44	24.00	0.55	---	12.68	167.12	271.7
XSECTION	6	ADDHYD	0.04	1	2	0.05	0.0	1.44	24.00	0.52	---	12.59	12.43	318.8
XSECTION	6	ADDHYD	0.65	1	2	0.05	0.0	1.44	24.00	0.55	---	12.67	178.70	273.2
XSECTION	7	REACH	0.65	1	2	0.05	0.0	1.44	24.00	0.54	---	12.74	176.77	270.3
XSECTION	7	RUNOFF	0.02	1	2	0.05	0.0	1.44	24.00	0.77	---	12.49	8.09	505.8
XSECTION	7	RUNOFF	0.05	1	2	0.05	0.0	1.44	24.00	0.34	---	12.55	13.73	274.6
XSECTION	7	ADDHYD	0.67	1	2	0.05	0.0	1.44	24.00	0.55	---	12.73	179.13	267.4

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SUMMARY TABLE 1 - SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL INSTRUCTIONS IN THE ORDER PERFORMED
(A STAR(*) AFTER THE PEAK DISCHARGE TIME AND RATE (CFS) VALUES INDICATES A FLAT TOP HYDROGRAPH
A QUESTION MARK(?) INDICATES A HYDROGRAPH WITH PEAK AS LAST POINT.)

SECTION/ STRUCTURE ID	STANDARD CONTROL OPERATION	DRAINAGE AREA (SQ MI)	RAIN TABLE #	ANTEC MOIST COND	MAIN TIME INCREM (HR)	PRECIPITATION BEGIN (HR)	PRECIPITATION AMOUNT (IN)	PRECIPITATION DURATION (HR)	RUNOFF AMOUNT (IN)	PEAK DISCHARGE ELEVATION (FT)	PEAK DISCHARGE TIME (HR)	PEAK DISCHARGE RATE (CFS)	PEAK DISCHARGE RATE (CSM)
ALTERNATE 1 STORM 1 (Q_2)													
XSECTION 7	ADDHYD	0.72	1	2	0.05	0.0	1.44	24.00	0.58	---	12.70	187.69	260.7
XSECTION 8	REACH	0.72	1	2	0.05	0.0	1.44	24.00	0.53	---	12.79	184.80	256.7
XSECTION 8	RUNOFF	0.02	1	2	0.05	0.0	1.44	24.00	0.41	---	12.53	5.14	320.5
XSECTION 8	ADDHYD	0.74	1	2	0.05	0.0	1.44	24.00	0.53	---	12.78	186.74	253.7
ALTERNATE 1 STORM 2													
XSECTION 1	RUNOFF	0.08	1	2	0.05	0.0	2.10	24.00	1.59	---	12.47	69.13	864.2
XSECTION 3	REACH	0.08	1	2	0.05	0.0	2.10	24.00	1.59	---	12.52	69.12	864.0
XSECTION 2	RUNOFF	0.01	1	2	0.05	0.0	2.10	24.00	1.32	---	12.48	8.11	811.0
XSECTION 3	REACH	0.01	1	2	0.05	0.0	2.10	24.00	1.32	---	12.53	8.03	803.5
XSECTION 3	RUNOFF	0.03	1	2	0.05	0.0	2.10	24.00	1.32	---	12.49	23.74	791.4
XSECTION 3	ADDHYD	0.09	1	2	0.05	0.0	2.10	24.00	1.56	---	12.53	77.59	862.2
XSECTION 3	ADDHYD	0.12	1	2	0.05	0.0	2.10	24.00	1.50	---	12.50	100.79	839.9
XSECTION 5	REACH	0.12	1	2	0.05	0.0	2.10	24.00	1.49	---	12.57	100.53	837.7
XSECTION 4	RUNOFF	0.23	1	2	0.05	0.0	2.10	24.00	0.92	---	12.92	97.16	426.2
XSECTION 4	RUNOFF	0.11	1	2	0.05	0.0	2.10	24.00	0.95	---	12.57	69.30	602.7
XSECTION 4	RUNOFF	0.02	1	2	0.05	0.0	2.10	24.00	1.24	---	12.48	18.09	786.7
XSECTION 4	ADDHYD	0.34	1	2	0.05	0.0	2.10	24.00	0.93	---	12.68	149.57	436.1
XSECTION 4	ADDHYD	0.37	1	2	0.05	0.0	2.10	24.00	0.95	---	12.60	157.96	431.6
XSECTION 5	REACH	0.37	1	2	0.05	0.0	2.10	24.00	0.94	---	12.74	152.79	417.5
XSECTION 5	RUNOFF	0.05	1	2	0.05	0.0	2.10	24.00	0.58	---	12.68	19.18	376.1
XSECTION 5	ADDHYD	0.42	1	2	0.05	0.0	2.10	24.00	0.90	---	12.73	171.61	411.5
XSECTION 5	RUNOFF	0.02	1	2	0.05	0.0	2.10	24.00	1.02	---	12.49	13.15	692.1
XSECTION 5	RUNOFF	0.05	1	2	0.05	0.0	2.10	24.00	0.73	---	12.53	26.97	539.4
XSECTION 5	ADDHYD	0.14	1	2	0.05	0.0	2.10	24.00	1.43	---	12.53	113.46	816.3
XSECTION 5	ADDHYD	0.19	1	2	0.05	0.0	2.10	24.00	1.25	---	12.53	140.43	743.0
XSECTION 5	ADDHYD	0.61	1	2	0.05	0.0	2.10	24.00	1.01	---	12.61	300.05	495.1
XSECTION 6	REACH	0.61	1	2	0.05	0.0	2.10	24.00	1.00	---	12.68	297.17	490.4
XSECTION 6	RUNOFF	0.01	1	2	0.05	0.0	2.10	24.00	1.59	---	12.46	7.78	865.0
XSECTION 6	RUNOFF	0.03	1	2	0.05	0.0	2.10	24.00	0.73	---	12.62	13.34	476.5
XSECTION 6	RUNOFF	0.01	1	2	0.05	0.0	2.10	24.00	1.58	---	12.50	9.28	843.3
XSECTION 6	ADDHYD	0.61	1	2	0.05	0.0	2.10	24.00	1.01	---	12.67	299.15	486.4
XSECTION 6	ADDHYD	0.04	1	2	0.05	0.0	2.10	24.00	0.97	---	12.58	22.33	572.7
XSECTION 6	ADDHYD	0.65	1	2	0.05	0.0	2.10	24.00	1.01	---	12.66	320.59	490.2
XSECTION 7	REACH	0.65	1	2	0.05	0.0	2.10	24.00	1.00	---	12.73	317.53	485.5
XSECTION 7	RUNOFF	0.02	1	2	0.05	0.0	2.10	24.00	1.32	---	12.48	12.84	802.8
XSECTION 7	RUNOFF	0.05	1	2	0.05	0.0	2.10	24.00	0.73	---	12.53	26.97	539.4

SUMMARY TABLE 1 - SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL INSTRUCTIONS IN THE ORDER PERFORMED
(A STORM AFTER THE PEAK DISCHARGE TIME AND RATE (CFS) VALUES INDICATES A FLAT TOP HYDROGRAPH
A QUESTION MARK(?) INDICATES A HYDROGRAPH WITH PEAK AS LAST POINT)

SECTION/ STRUCTURE ID		STANDARD CONTROL OPERATION	DRAINAGE AREA (SQ MI)	RAIN TABLE #	ANTEC MOIST COND	MAIN TIME INCREM (HR)	PRECIPITATION BEGIN (HR)	PRECIPITATION AMOUNT (IN)	PRECIPITATION DURATION (HR)	RUNOFF AMOUNT (IN)	PEAK DISCHARGE ELEVATION (FT)	PEAK DISCHARGE TIME (HR)	PEAK DISCHARGE RATE (CFS)	PEAK DISCHARGE MASS (CSM)
ALTERNATE 1 STORM 2 (Q_5)														
XSECTION	7	ADDHYD	0.67	1	2	0.05	0.0	2.10	24.00	1.01	---	12.78	321.40	479.7
XSECTION	7	ADDHYD	0.72	1	2	0.05	0.0	2.10	24.00	0.99	---	12.68	336.90	470.7
XSECTION	8	REACH	0.72	1	2	0.05	0.0	2.10	24.00	0.98	---	12.78	334.13	464.1
XSECTION	8	RUNOFF	0.02	1	2	0.05	0.0	2.10	24.00	0.84	---	12.52	9.51	594.4
XSECTION	8	ADDHYD	0.74	1	2	0.05	0.0	2.10	24.00	0.98	---	12.77	337.77	458.9
ALTERNATE 1 STORM 3 (Q_{10})														
XSECTION	1	RUNOFF	0.08	1	2	0.05	0.0	2.53	24.00	1.98	---	12.46	84.06	1050.8
XSECTION	3	REACH	0.08	1	2	0.05	0.0	2.53	24.00	1.97	---	12.51	84.05	1050.6
XSECTION	2	RUNOFF	0.01	1	2	0.05	0.0	2.53	24.00	1.69	---	12.48	10.04	1003.7
XSECTION	3	REACH	0.01	1	2	0.05	0.0	2.53	24.00	1.69	---	12.53	9.96	995.7
XSECTION	3	RUNOFF	0.03	1	2	0.05	0.0	2.53	24.00	1.69	---	12.48	29.50	983.2
XSECTION	3	ADDHYD	0.09	1	2	0.05	0.0	2.53	24.00	1.94	---	12.52	93.94	1043.7
XSECTION	3	ADDHYD	0.12	1	2	0.05	0.0	2.53	24.00	1.88	---	12.49	123.39	1028.2
XSECTION	5	REACH	0.12	1	2	0.05	0.0	2.53	24.00	1.87	---	12.56	123.12	1026.0
XSECTION	4	RUNOFF	0.23	1	2	0.05	0.0	2.53	24.00	1.24	---	12.91	129.19	566.6
XSECTION	4	RUNOFF	0.11	1	2	0.05	0.0	2.53	24.00	1.28	---	12.56	90.46	786.6
XSECTION	4	RUNOFF	0.02	1	2	0.05	0.0	2.53	24.00	1.60	---	12.48	22.55	980.5
XSECTION	4	ADDHYD	0.34	1	2	0.05	0.0	2.53	24.00	1.25	---	12.67	199.05	580.3
XSECTION	4	ADDHYD	0.37	1	2	0.05	0.0	2.53	24.00	1.27	---	12.59	210.12	574.1
XSECTION	5	REACH	0.37	1	2	0.05	0.0	2.53	24.00	1.26	---	12.73	203.39	555.7
XSECTION	5	RUNOFF	0.05	1	2	0.05	0.0	2.53	24.00	0.85	---	12.67	27.03	530.1
XSECTION	5	ADDHYD	0.42	1	2	0.05	0.0	2.53	24.00	1.21	---	12.72	229.98	551.5
XSECTION	5	RUNOFF	0.02	1	2	0.05	0.0	2.53	24.00	1.36	---	12.49	16.82	885.1
XSECTION	5	RUNOFF	0.05	1	2	0.05	0.0	2.53	24.00	1.03	---	12.53	36.16	723.2
XSECTION	5	ADDHYD	0.14	1	2	0.05	0.0	2.53	24.00	1.80	---	12.53	139.74	1005.3
XSECTION	5	ADDHYD	0.19	1	2	0.05	0.0	2.53	24.00	1.60	---	12.53	175.89	930.7
XSECTION	5	ADDHYD	0.61	1	2	0.05	0.0	2.53	24.00	1.33	---	12.60	391.10	645.4
XSECTION	6	REACH	0.61	1	2	0.05	0.0	2.53	24.00	1.33	---	12.67	386.98	638.6
XSECTION	6	RUNOFF	0.01	1	2	0.05	0.0	2.53	24.00	1.98	---	12.45	9.46	1051.5
XSECTION	6	RUNOFF	0.03	1	2	0.05	0.0	2.53	24.00	1.02	---	12.61	18.13	647.6
XSECTION	6	RUNOFF	0.01	1	2	0.05	0.0	2.53	24.00	1.97	---	12.50	11.32	1029.2
XSECTION	6	ADDHYD	0.61	1	2	0.05	0.0	2.53	24.00	1.34	---	12.66	390.06	634.2
XSECTION	6	ADDHYD	0.04	1	2	0.05	0.0	2.53	24.00	1.28	---	12.58	29.16	747.6
XSECTION	6	ADDHYD	0.65	1	2	0.05	0.0	2.53	24.00	1.33	---	12.66	418.06	639.2
XSECTION	7	REACH	0.65	1	2	0.05	0.0	2.53	24.00	1.33	---	12.73	414.27	633.4
XSECTION	7	RUNOFF	0.02	1	2	0.05	0.0	2.53	24.00	1.69	---	12.48	15.92	994.9

SUMMARY TABLE 1 - SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL INSTRUCTIONS IN THE ORDER PERFORMED
(A STAR(*) AFTER THE PEAK DISCHARGE TIME AND RATE (CFS) VALUES INDICATES A FLAT TOP HYDROGRAPH
A QUESTION MARK(?) INDICATES A HYDROGRAPH WITH PEAK AS LAST POINT.)

SECTION/ STRUCTURE ID		STANDARD CONTROL OPERATION	DRAINAGE AREA (SQ MI)	RAIN TABLE #	ANTEC MOIST COND	MAIN TIME INCREM (HR)	PRECIPITATION BEGIN (HR)	PRECIPITATION AMOUNT (IN)	PRECIPITATION DURATION (HR)	RUNOFF AMOUNT (IN)	PEAK DISCHARGE ELEVATION (FT)	PEAK DISCHARGE TIME (HR)	PEAK DISCHARGE RATE (CFS)	PEAK DISCHARGE RATE (CSM)
ALTERNATE 1 STORM 3 (Q_{10})														
XSECTION	7	RUNOFF	0.05	1	2	0.05	0.0	2.53	24.00	1.03	---	12.53	36.16	723.2
XSECTION	7	ADDHYD	0.67	1	2	0.05	0.0	2.53	24.00	1.34	---	12.72	418.63	624.8
XSECTION	7	ADDHYD	0.72	1	2	0.05	0.0	2.53	24.00	1.31	---	12.67	443.05	615.3
XSECTION	8	REACH	0.72	1	2	0.05	0.0	2.53	24.00	1.31	---	12.78	437.10	607.1
XSECTION	8	RUNOFF	0.02	1	2	0.05	0.0	2.53	24.00	1.15	---	12.51	12.51	781.9
XSECTION	8	ADDHYD	0.74	1	2	0.05	0.0	2.53	24.00	1.30	---	12.76	442.10	600.7

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SUMMARY TABLE 2 - SELECTED MODIFIED ATT-KIN REACH ROUTINGS IN ORDER OF STANDARD EXECUTIVE CONTROL INSTRUCTIONS
(A STAR(*) AFTER VOLUME ABOVE BASE(IN) INDICATES A HYDROGRAPH TRUNCATED AT A VALUE EXCEEDING BASE + 10% OF PEAK
A QUESTION MARK(?) AFTER COEFF.(C) INDICATES PARAMETERS OUTSIDE ACCEPTABLE LIMITS, SEE PREVIOUS WARNINGS)

XSEC ID	REACH LENGTH (FT)	HYDROGRAPH INFORMATION: INFLOW PEAK (CFS)	INFLOW TIME (HR)	OUTFLOW PEAK (CFS)	OUTFLOW TIME (HR)	OUTFLOW+ INTERV. PEAK (CFS)	OUTFLOW+ INTERV. TIME (HR)	BASE-FLOW (CFS)	ROUTING PARAMETERS: VOLUME ABOVE BASE (IN)	MAIN TIME INCR (HR)	ITER-ATION #	Q AND A EQUATION COEFF (X)	Q AND A EQUATION POWER (M)	LENGTH FACTOR (K*)	PEAK RATIO O/I (Q*)	S/Q @PEAK (K) (SEC)	ATT-KIN COEFF (C)	TRAVEL TIME STOR-AGE (HR)	TRAVEL TIME KINE-MATIC (HR)
ALTERNATE 1 STORM 1 (Q_2)																			
3	1300	46	12.5	46	12.5	51	12.5	0	1.01	0.05	1	12.2	1.00	0.030	1.000	107	0.92?	0.05	0.03
5	2680	66	12.5	66	12.6	---	---	0	0.93	0.05	1	14.0	1.00	0.050	1.000	191	0.64	0.10	0.05
5	5070	83	12.6	80	12.8	88	12.8	0	0.49	0.05	1	13.5	1.00	0.070	0.970	376	0.39	0.15	0.10
6	2600	167	12.6	165	12.7	166	12.7	0	0.54	0.05	1	13.5	1.00	0.040	0.990	193	0.64	0.10	0.05
7	2750	178	12.6	177	12.8	179	12.8	0	0.54	0.05	1	12.9	1.00	0.050	0.990	213	0.59	0.10	0.06
8	2670	188	12.7	185	12.8	187	12.8	0	0.53	0.05	1	9.10	1.00	0.060	0.980	293	0.47	0.10	0.08

ALTERNATE 1 STORM 2 (Q_5)

3	1300	69	12.4	69	12.5	77	12.5	0	1.59	0.05	1	12.2	1.00	0.020	1.000	107	0.92?	0.05	0.03
5	2680	101	12.5	100	12.5	---	---	0	1.50	0.05	1	14.0	1.00	0.050	1.000	191	0.64	0.05	0.05
5	5070	158	12.6	153	12.8	171	12.8	0	0.95	0.05	1	13.5	1.00	0.070	0.970	376	0.39	0.15	0.10
6	2600	300	12.6	296	12.7	299	12.6	0	1.01	0.05	1	13.5	1.00	0.040	0.990	193	0.64	0.10	0.05
7	2750	320	12.6	317	12.8	320	12.8	0	1.01	0.05	1	12.9	1.00	0.040	0.990	213	0.59	0.10	0.06
8	2670	339	12.7	334	12.8	338	12.8	0	0.99	0.05	1	9.10	1.00	0.060	0.990	293	0.47	0.10	0.08

ALTERNATE 1 STORM 3 (Q_{10})

3	1300	84	12.4	84	12.5	94	12.5	0	1.98	0.05	1	12.2	1.00	0.020	1.000	107	0.92?	0.05	0.03
5	2680	123	12.5	123	12.5	---	---	0	1.88	0.05	1	14.0	1.00	0.050	1.000	191	0.64	0.05	0.05
5	5070	210	12.6	203	12.8	230	12.7	0	1.27	0.05	1	13.5	1.00	0.070	0.970	376	0.39	0.15	0.10
6	2600	391	12.6	386	12.6	390	12.6	0	1.33	0.05	1	13.5	1.00	0.040	0.990	193	0.64	0.05	0.05
7	2750	418	12.6	414	12.8	418	12.7	0	1.33	0.05	1	12.9	1.00	0.040	0.990	213	0.59	0.10	0.06
8	2670	442	12.6	436	12.8	442	12.8	0	1.31	0.05	1	9.10	1.00	0.060	0.990	293	0.47	0.15	0.08

SUMMARY TABLE 3 - DISCHARGE (CFS) AT XSECTIONS AND STRUCTURES FOR ALL STORMS AND ALTERNATES

XSECTION/ STRUCTURE ID	DRAINAGE AREA (SQ MI)	STORM NUMBERS..... 1 (Q_2)	2 (Q_5)	3 (Q_{10})
o XSECTION 1	0.08			
+ ALTERNATE 1		46.37	69.13	84.06
o XSECTION 2	0.01			
+ ALTERNATE 1		5.13	8.11	10.04
o XSECTION 3	0.12			
+ ALTERNATE 1		65.87	100.79	123.39
o XSECTION 4	0.37			
+ ALTERNATE 1		82.66	157.96	210.12
o XSECTION 5	0.61			
+ ALTERNATE 1		167.35	300.05	391.10
o XSECTION 6	0.65			
+ ALTERNATE 1		178.70	320.59	418.06
o XSECTION 7	0.72			
+ ALTERNATE 1		187.69	338.90	443.05
o XSECTION 8	0.74			
+ ALTERNATE 1		186.74	337.77	442.10

END OF 1 JOBS IN THIS RUN

Appendix I V

FULL SIZE BLUEPRINT – UNABLE TO SCAN

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SEE HARD COPY OF BOOK IN ENGINEERING LIBRARY

Sverdrup

SCALE:

STORM SEWER PROFILE
Sheet 1 of 2

STORM SEWER PROFILE
Sheet 2 of 2