ARIZONA HIGHWAY DEPT.

Drainage Study Along Black Canyon Highway

Project I-17-1-201

June 18, 1964 Our Job #4166

by

Yost and Gardner Engineers

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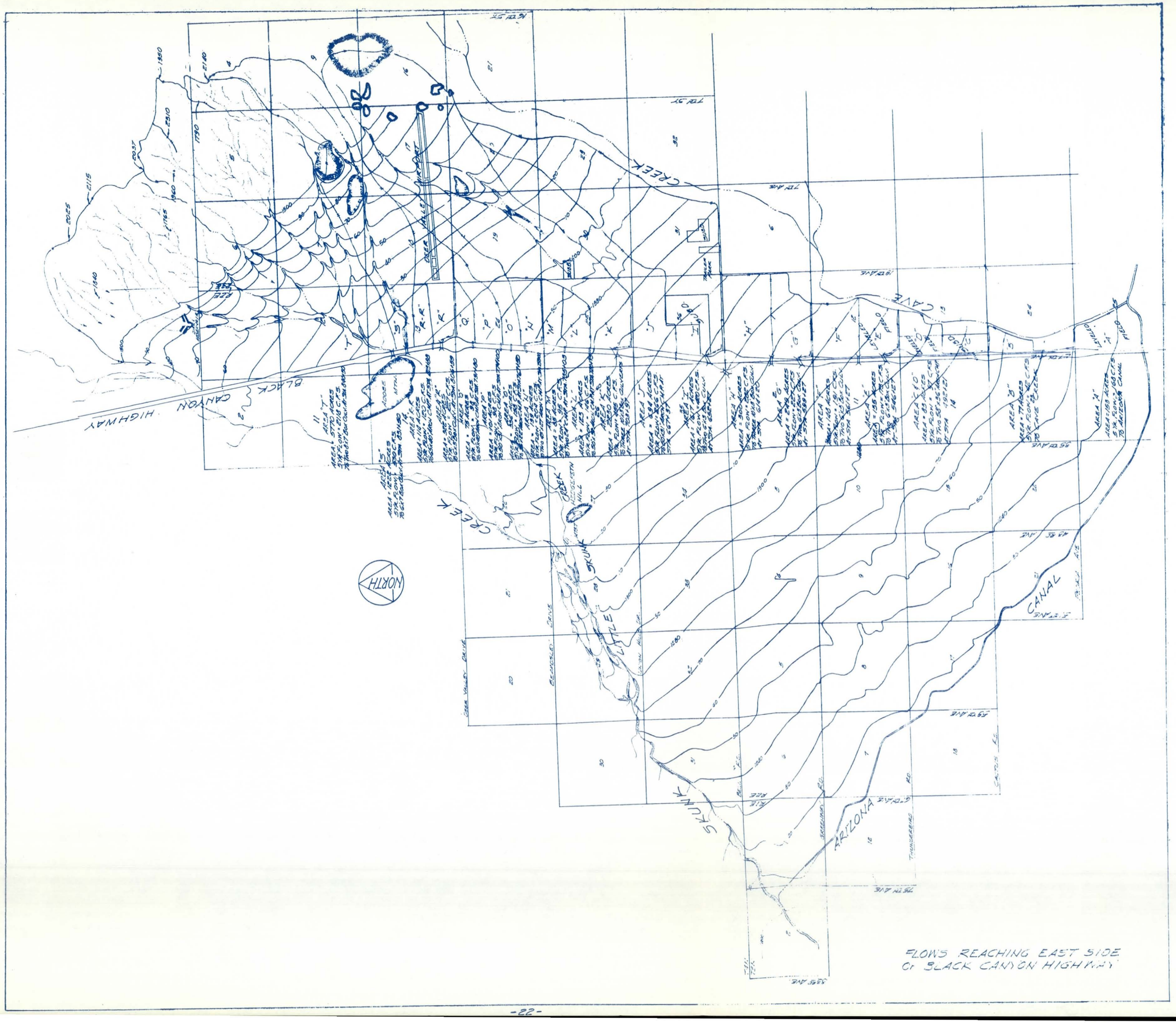

FLOWS REACHING EAST SIDE
OF BLACK CANYON HIGHWAY

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Yost and Gardner Engineers
2619 North 3rd Street
Phoenix 4, Arizona

June 18, 1964

William Price, State Highway Engineer
State Highway Department
1739 West Jackson Street
Phoenix, Arizona

Dear Mr. Price:

In accordance with Agreement #64-9, Project I-17-1-201, herewith our report on Drainage Studies of the Phoenix - Cordes Junction Highway in the Deer Valley Area.

The report discusses hydrology, estimates flows, summarizes flow conditions near the Black Canyon Highway and recommends a drainage program.

Construction of the highway has to some degree changed, or restricted flow, in much of the area. Drainage problems range from mere nuisance to the potential of major damage and some work should be done. The report recommends that some of the structures crossing the Black Canyon Highway be added to - that collecting channels be built along the west side of the highway - that (a) from north of Greenway Road the water be taken to a future channel paralleling the Arizona Canal (b) near Bell Road and Union Hills Drive channels be built west to the Skunk Creek (c) near Beardsley Drive and Deer Valley Drive channels be built west to the Little Skunk Creek.

More particular description is given in the report concerning cost estimates of the recommended work, which aggregates $2,583,000.

Table of contents and list of maps, tables, and appendices follow. Aerial photographs and other material and work sheets not included in the report are available in our office for reference.

It is hoped the report gives you the information upon which you may base the future drainage program for the Black Canyon Highway between the Arizona Canal and Little Skunk Creek.

Respectfully submitted,

YOST AND GARDNER ENGINEERS

By Leigh O. Gardner
Leigh O. Gardner

LOG:vr

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Agreement #64-9
Project I-17-1-201
Our Job #4166

Drainage Studies
Phoenix - Cordes Junction Highway
(Deer Valley Area)

Purpose - This report discusses flood water drainage along the Black Canyon Highway from the Arizona Canal to, but not including, the Skunk Creek. The general area is along the Phoenix - Cordes Junction Highway north of Phoenix and in Deer Valley.

The extent to which construction of the Black Canyon Highway may have affected the drainage pattern in the area was to receive particular comment.

Scope - The work consisted of:

(1) Sufficient field levels and reconnaissance - along with aerial photos furnished by the State - to delineate and define the various existing drainage areas,

(2) General hydrologic studies

(3) Office mapping and calculations to determine the flows of the contributing drainage areas and of the highway itself.

(4) Preparation of a flow sheet (tables) consolidating the above information,

(5) Suggestions as to handling such flows, and

(6) Comment on any diversions, or changes in flow, due to highway construction; comments on areas of possible damage; recommendations for immediate and/ or long range programs which should be undertaken.

The results of the work of items (1) to (4) above are incorporated in the first portion of the report.

HYDROLOGY

General.

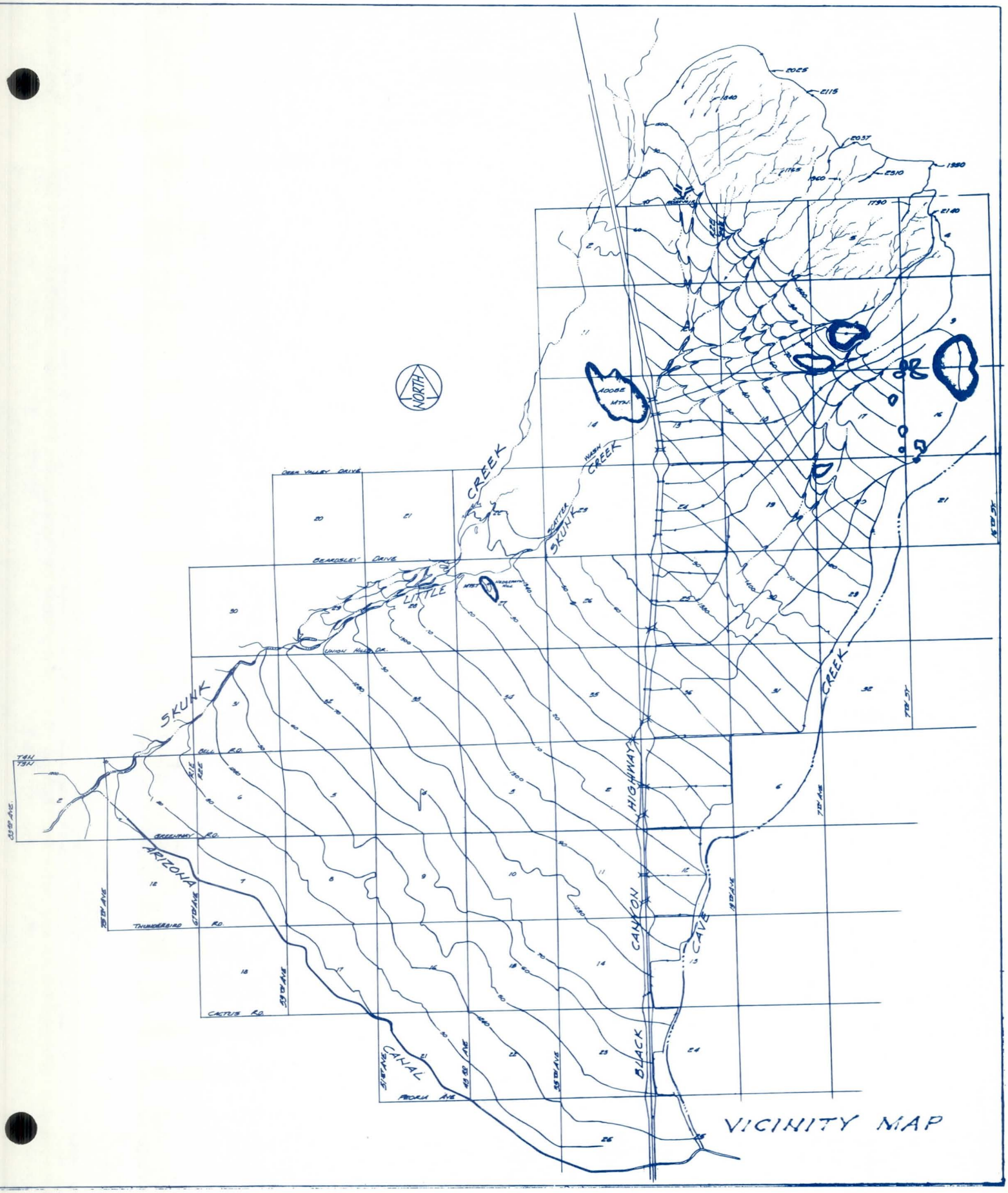
The area studied is about 9 miles long along the highway and extends from the Arizona Canal on the south to near the Skunk Creek on the north. The eastern boundary of the drainage area is the boundary, or divide, of Cave Creek drainage. Area drainage is to Skunk Creek or the New River on the west.

Elevations range from 1,230 feet above sea level in the lower farm and subdivision lands to over 2,300 feet in the foothills defining the northern and northeastern area boundary. Land slopes range from 4' per thousand upward to 20 ft. or more near the hills. A vicinity map follows which shows general features.

Soils range from clay loam to sandy loam near the hills and the foothills are predominately greenstone (metamorphic).

Subdivision, commercial, and industrial development has been rapid over the past 10 years and such developments will continue.

Such documents as the "Interim Report on Survey for Flood Control - Phoenix, Arizona and Vicinity (including New River)" prepared by the U. S. Army Engineer District, Los Angeles, Corps of Engineers dated January 15, 1964, and our own "Flood Control Survey Report for Northeastern Maricopa County - Area III" prepared for the Flood Control District of Maricopa County in September, 1962 should be referred to for discussion of the surrounding areas.


NORTH
ADOBE MTN.
SKUNK CREEK
LITTLE SKUNK CREEK
BLACK CANYON HIGHWAY
CAVE CREEK
ARIZONA CANAL
SKUNK
DEER VALLEY DRIVE
BEARDSLEY DRIVE
UNION HILLS DR.
BELL RD.
GREENWAY RD.
THUNDERBIRD RD.
CACTUS RD.
PEORIA AVE.
19TH AVE.
27TH AVE.
35TH AVE.
43RD AVE.
51ST AVE.
59TH AVE.
67TH AVE.
75TH AVE.
83RD AVE.
91ST AVE.
99TH AVE.
107TH AVE.
T4N
T3N
2025
2115
2037
2510
1990
1960
1790
2140
1840
VICINITY MAP

The above reports also give detail concerning climatology, infiltration in soils, and other hydrologic data. This report will usually discuss such matters only in general.

Rainfall.

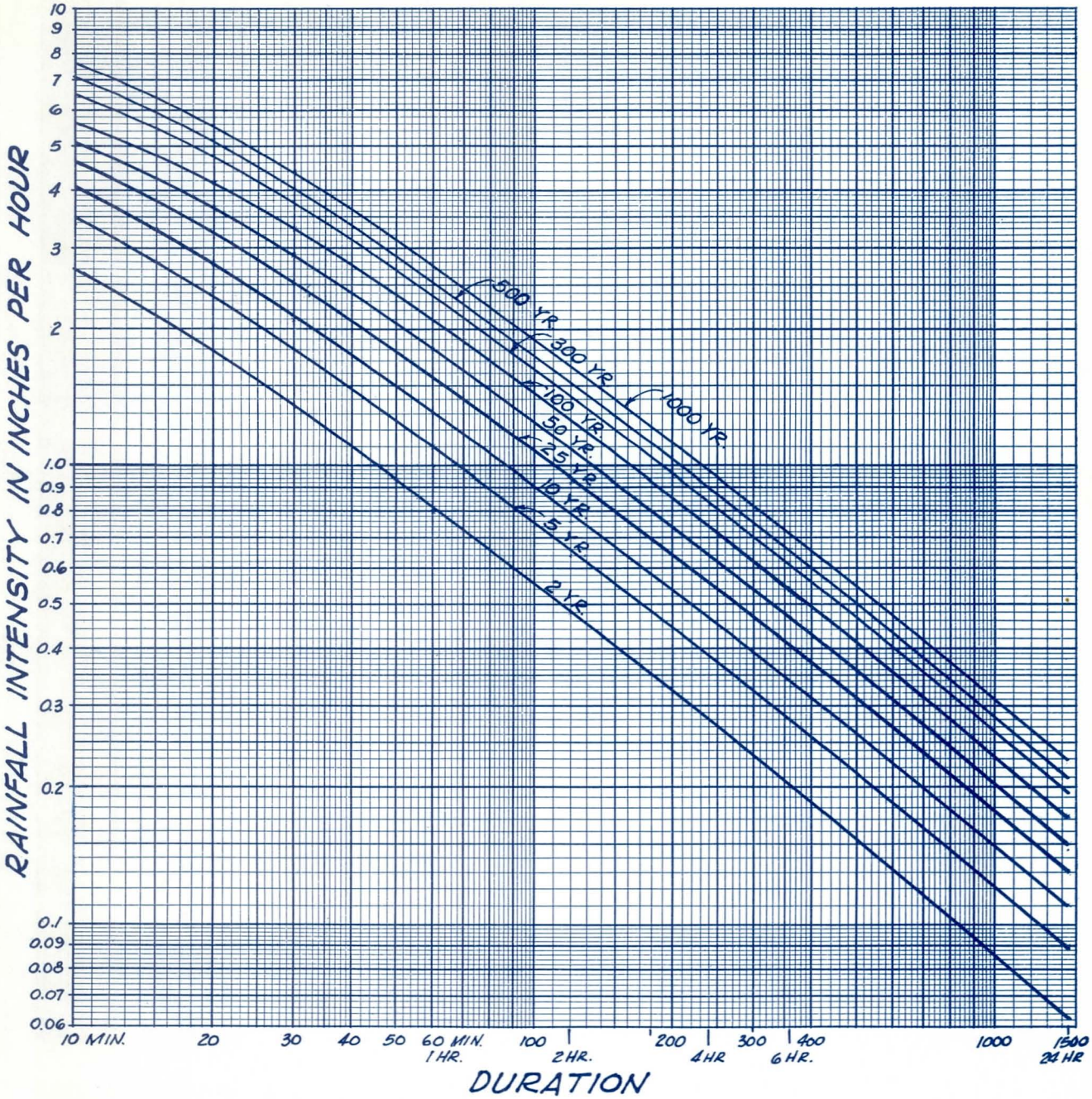
A rainfall intensity-duration-frequency chart is attached applicable to Phoenix, Arizona. Primarily this is from U. S. Weather Bureau Technical Paper No. 28 which also gives data for other areas of the state.

The Arizona Highway Departments "Drainage Table" includes "Isohyetal" charts prepared from the same weather bureau paper and yields essentially the same rainfall results.

In the use of the attached rainfall intensity - duration - frequency chart two points must be kept in mind, first that this is for a point intensity and rainfall would be somewhat less over larger areas and second, that the chart applies to Phoenix and intensities are greater at higher elevations. The first point is minor as shown by curve 1 on the attached chart showing area - depth curves for central Arizona storms. The second point indicates (from Weather Bureau Paper #28) that about 10% higher intensities should be used in the Deer Valley vicinity and both factors have been considered and included in our tables of flow calculations.

Estimates of Flow.

While the U. S. Army Corps of Engineers in their report previously mentioned applies standard project flood isohyetals (a Queen Creek storm of August 19, 1954) to each area under consideration and develops hydrographs considering net rainfall (rain less infiltration), time of travel,



RAINFALL INTENSITY-DURATION-FREQUENCY RELATION FOR PHOENIX, ARIZONA

(Partial Duration Series)

Curves for recurrence intervals of 100 years and less are based on data and methods of U.S. Weather Bureau Technical Paper No. 28. The 300, 500 and 1000 year curves are plotted for Gumbel extreme value distributions after Chow (Transactions, American Geophysical Union Vol. 32, No.2, p 231 ff.)

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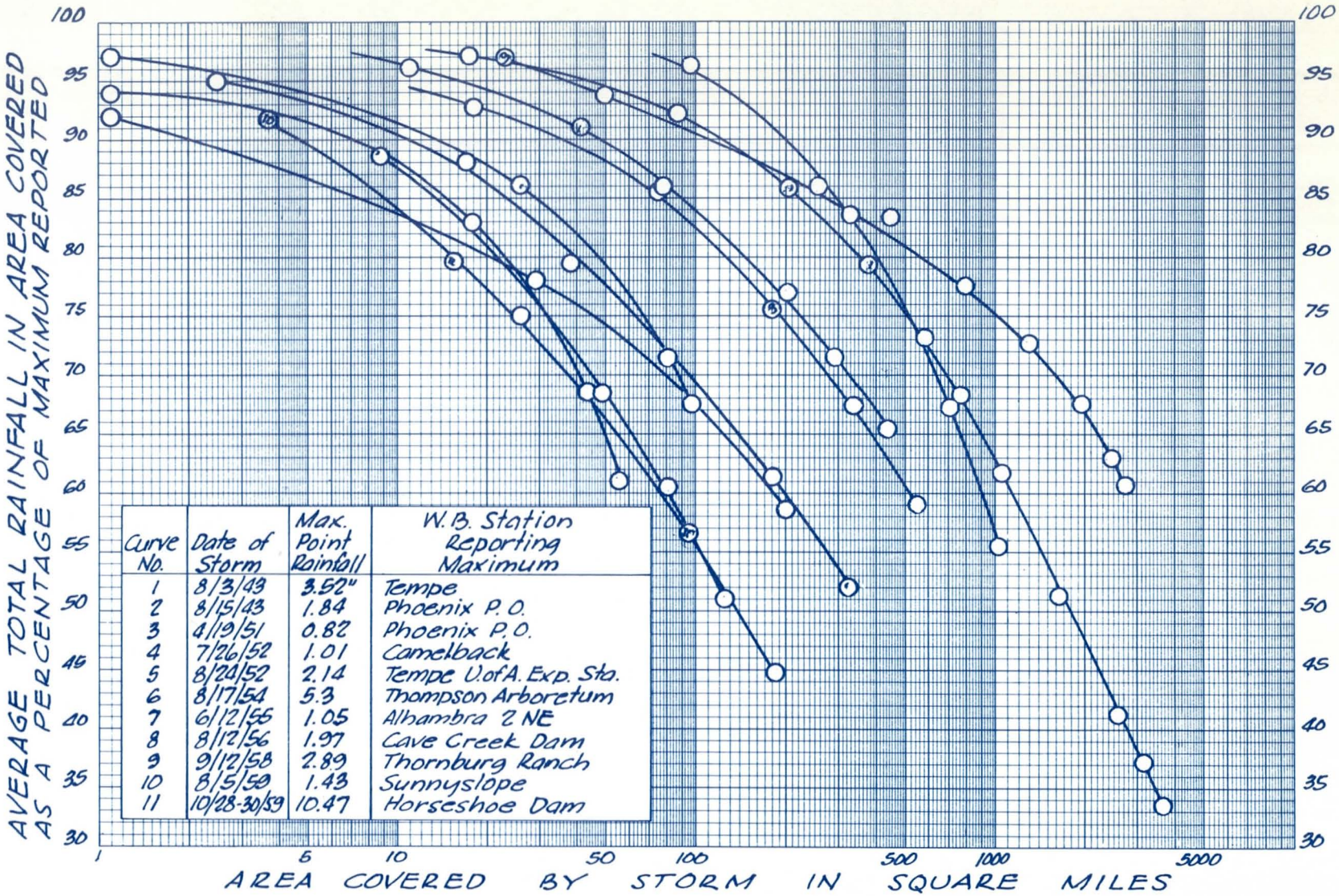


Curve No.	Date of Storm	Max. Point Rainfall	W.B. Station Reporting Maximum
1	8/3/43	3.52"	Tempe
2	8/15/43	1.84	Phoenix P.O.
3	4/19/51	0.82	Phoenix P.O.
4	7/26/52	1.01	Camelback
5	8/24/52	2.14	Tempe U of A. Exp. Sta.
6	8/17/54	5.3	Thompson Arboretum
7	6/12/56	1.05	Alhambra 2 NE
8	8/12/56	1.97	Cave Creek Dam
9	9/12/58	2.89	Thornburg Ranch
10	8/5/59	1.43	Sunnyslope
11	10/28-30/59	10.47	Horseshoe Dam

AREA-DEPTH CURVES FOR CENTRAL ARIZONA STORMS

Computed from isohyetal maps plotted using Climatological Data for Arizona by U.S. Weather Bureau, supplemented by unofficial data from Louis R. Jurwitz, Phoenix, Arizona.

YOST AND GARDNER ENGINEERS Phoenix, Arizona FEBRUARY, 1962

channel storage and other factors we have developed a formula method of estimating run-off.

This formula yields results comparable (usually less) with the Army methods and comparable (usually greater) with the formula included in the Arizona Highway Department "Drainage Table" if appropriate constants are selected from such "Drainage Tables". A comparison of our formula with that of the "Drainage Table" is made later - an explanation of our formula and methods follows:

If the rate of runoff were equal to the rate of supply, that is if there were no losses or storage, the relation between runoff and supply could be expressed by the formula

$$Q = IA$$

Where Q is the rate of runoff in cubic feet per second

I is the rate of rainfall in inches per hour

A is the contributing area in acres

and the constant of proportionality is nearly equal to 1 (difference neglected) with the above stated units. In order to account for losses the sustained infiltration rate of soils, called f_c, is deducted from the supply in the case of pervious areas and a loss rate of 0.2 inches per hour is deducted in impervious areas such as street paving. It is further observed that such things as channel storage, depression storage, evaporation, and surface detention work toward reducing the peak flow rate. Therefore the runoff - rainfall relationship is expressed as

$$Q = 0.8\ A_p\ (Ia - f_c) + 0.9\ Ai\ (Ia - 0.20)$$

where

Q = design runoff rate in cubic feet per second

A_p = pervious portion of the drainage area in acres

A_i = impervious portion of the drainage area in acres

Ia = average rainfall intensity over the area in inches per hour

f_c = final or sustained infiltration capacity of the soil in the pervious area in inches per hour

In any location the pervious and impervious area (present or future types) contributing in a 'time' can be determined. The rainfall rate during the 'time' period is determined for any design recurrence interval or frequency from the Rainfall-Intensity-Duration curves (corrected upward 10% for Deer Valley) and adjusted downward to correct for area coverage versus the point intensity obtained from the rainfall curves.

Infiltration rates are determined from soil maps, comparison with other soils, or by other means.

The storm duration or 'time' period essential to reading the rainfall curves is that least period required for all increments of the area to contribute flow. In many cases portions of a total area being studied will produce greater flows because water can be collected in a shorter 'time of concentration' and the partial area therefore receives greater rainfall intensities. The designer must seek out such areas and this is similar to hydrograph methods of centering the storm where it will produce the greatest rate of outflow.

This collecting period, storm duration, or time above referred to is called 'time of concentration' in this report and was calculated as follows:

In natural drainage basins the time of concentration calculations were made from the formula

$$t_c = 5.75 \left(\frac{L^2}{s}\right)^{1/3}$$

Where t_c = Time of concentration, minutes

L = Channel length, miles

s = Slope, feet per foot

At any point under consideration the means of flow to the point were considered. If travel is over streets or in man made channels and conduits the velocity was estimated and the associated time of concentration arrived at. Future improvements in an area are apt to change flow travel time and thereby time of concentration. The tabular calculations reflect these considerations and show the final chosen times.

It will be very helpful when more actual flood hydrographs or runoff data is collected in the Phoenix area. While both the above formula and synthetic hydrograph methods produce good estimates the proper determination of loss rates such as infiltration is very difficult. On storms of high intensity, such as 2 inches per hour, the choice of an infiltration rate varying between 0.5 and 0.6 inches per hour could only make 8% difference in the result while the same choice of loss rates could make an infinite difference if the storm being considered was one of 0.6 inches per hour intensity. Caution and judgement must be exercised in the determination of design flows but application of basic principles will yield results

more consistent and more truly comparable with similar areas than the use of empirical methods or judgement only. Reference is made to our "Phoenix Storm Drainage Report" for a more detailed description and the studies and observations leading to use of the formula method.

Storage requirements, such as that in the underpasses, have been computed from the entire areas net runoff (total rainfall less total infiltration) without the further reductions to peak flow rates deemed applicable and indicated by the formula.

Appendix I and II are estimates of flow for each area for 50 year and 5 year frequency rainfall intensities. Such tables also show in a few instances calculations for other frequencies of occurrence, change in future conditions such as added subdivision roads, and other minor investigations.

As previously mentioned estimated flows using the above formula and the highway department's "Drainage Table" are comparable. The highway formula is $A = C^4 \sqrt{M^3}$ where

A = Required opening in sq. ft. at 10'/sec. velocity

M = Area in acres

C = "K" x "C"

"K" = The rainfall factor from the Table's Isohyetal Charts

"C" = A factor summing conditions of vegetative cover C_1 and slopes C_2 and shape of drainage area C_3.

Area	Description	Acres	Factor	Rain Factor	Coeff.	Opening
		M	"C"	"K"	C	A
'A'	Arizona Canal to Peoria	153	C_1=0.20 C_2=0.10 C_3=0.20			
	50 year storm		0.50	1.2	0.60	26.1
	10 year storm		0.50	0.9	0.45	19.6

This compares 261 vs. 310 and 196 vs. 213 c.f.s. as determined by us in Appendix I.

'E'	Above Thunderbird	135	C_1=0.20 C_2=0.10 C_3=0.30			
	50 year storm		0.60	1.2	0.72	28.6
	10 year storm		0.60	0.9	0.54	21.5

This compares 286 vs. 316 and 215 vs. 218 c.f.s. as determined by us in Appendix I.

'K'	Above Union Hills	2,230	C_1=0.20 C_2=0.10 C_3=0.10			
	50 year storm		0.40	1.2	0.48	156
	10 year storm		0.40	0.9	0.36	117

This compares 1,560 vs. 1,550 and 1,170 vs. 769 c.f.s. as determined by us in Appendix I.

'T'	Little Skunk Creek	5,770	C_1=0.20 C_2=0.23 C_3=0.20			
(Use Formula $A = 8\ C\ \sqrt{M}$)						
	50 year storm		0.63	1.2	0.76	452
	10 year storm		0.63	0.9	0.57	346

This compares 4,520 vs. 5,660 and 3,460 vs. 3,080 c.f.s. as determined by us in Appendix I.

The above comparisons show the highway tables to usually result in lower flows for the 50 year storm and higher for the 10 year storm. However, if flows are estimated using a highway table C factor of 0.2 (which seems to be allowable practice) then of course the results are only 1/3 to 1/2 of what we consider reasonable estimates of flow.

In passing it is noted that ratio of flow estimates for various periods of occurrence are about as follows:

	Flood Recurrence - Ratio to 50 Year Storm				
Source	100 Yr.	50 Yr. (Base)	25 Yr.	10 Yr.	5 Yr.
Preliminary rept. of Corps of Engrs. (Some North Phx. Areas)	1.35±	1.0	0.70±	0.45±	0.30-
Highway Tables		1.0	0.90+	0.75-	
Appendix I (Y&G)	1.25±	1.0	0.8±	0.6 ±	0.4±

WATERWAYS

Natural Channels.

With the exception of Little Skunk Creek (or Scatter Creek) and an adjacent wash there are no well defined courses crossing the highway.

There are numerous natural waterways near the foothills but then the water spreads over the land and sheet flow occurs. Road, or street building affects the sheet flow depending on the size of roadside ditches or the height of the barrier made by the road itself.

Road systems within the contributing drainage area will usually have little affect on big storms or major flows since most such roads are near natural ground levels. This is not true of the highway itself since it is a distinct barrier.

Conduits.

Appendix III is a table evaluating the conduits crossing the highway. Some of the capacities are difficult to evaluate either because the conduit isn't constructed at this time or final available head is hard to determine.

It is suggested that the "Drainage Table" of the highway department's Head-Velocity Table be revised to base obtainable velocities on the head over the top of the conduit (rather than the center) since this will yield more nearly correct results at low available heads.

Pumps.

Pumps are installed at each of the grade separations to care for interior drainage.

Pumps

Location	Pumps	Discharge Pipe	Total Rated Capacity Pumps - C.F.S.
Peoria	Two 8,000 G.P.M.	16" pipe each	35.6
Cactus (Q)	Two 8,000 G.P.M.	16" pipe each	35.6
Thunderbird	Two 10,000 G.P.M.	18" pipe each	44.5
Greenway	Two 9,000 G.P.M.	18" pipe each	40.0
Bell	Two 12,000 G.P.M.	20" pipe each	53.5
Union Hills	Two 8,000 G.P.M.	16" pipe each	35.6
Beardsley	Two 9,000 G.P.M.	18" pipe each	40.0
Deer Valley	Two 12,000 G.P.M.	20" pipe each	53.5

Summary of Pumps & Conduit Capacities.

Preliminary examination of the flows estimated in Appendix I and II and the conduit capacities in Appendix III indicated that the 5 year storm would provide a good basis of comparison.

In the case of the pumps the high peaks to be expected from short, heavy storms can not be handled. With some storage in the cross-road roadway, only interfering with such traffic and not access ramps or main highway travel, it appears the pumps should handle about the 10 year storm. This is demonstrated in the following table - and storage capacity of 1/2 acre foot or more is reasonably available.

The following analysis is self explanatory except note that net rain or net runoff is gross rain less the average infiltration rate which is considered to be 0.2 inches per hour on impervious surfaces and 0.6 to 0.7 inches per hour on earth or pervious surfaces.

Analysis of Underpasses and Pumps Based On The 10 Year Storm

Underpass & Pumps	Area in Acres	Rainfall Inches Per Hour	Net Rain Runoff	Inflow Rate C.F.S.	Inflow Total Ac. Ft.	Pumped Ac. Ft. (Approx.)	Storage Req'd. (Approx.) Ac. Ft.
Peoria	17 imperv.	10 min. = 4.44	4.14	95.4	1.32	0.49	0.83
35.6 cfs pumps	6 perv.	30 min. = 2.33	2.03	46.7	1.95	1.48	0.47
		60 min. = 1.45	1.15	26.4	2.20	2.96	0
Cactus	18 imperv.	10 min. = 4.44	4.17	91.9	1.28	0.49	0.79
35.6 cfs pumps	4 perv.	30 min. = 2.33	2.06	45.3	1.89	1.48	0.41
		60 min. = 1.45	1.18	26.0	2.16	2.96	0
Thunderbird	15 imperv.	10 min. = 4.44	4.03	129.0	1.79	0.62	1.17
44.5 cfs pumps	17 perv.	30 min. = 2.33	1.92	61.4	2.56	1.85	0.71
		60 min. = 1.45	1.04	33.3	2.78	3.71	0
Greenway	15 imperv.	10 min. = 4.44	4.13	86.9	1.20	0.56	0.64
40 cfs pumps	6 perv.	30 min. = 2.33	2.02	42.4	1.77	1.67	0.10
		60 min. = 1.45	1.14	23.9	1.99	3.33	0
Bell	14 imperv.	10 min. = 4.44	3.91	160	2.22	0.74	1.48
53.5 cfs pumps	27 perv.	30 min. = 2.33	1.80	73.8	3.07	2.23	0.84
		60 min. = 1.45	0.92	37.7	3.14	4.45	0
Union Hills	13 imperv.	10 min. = 4.44	4.12	70	0.97	0.49	0.48
35.6 cfs pumps	4 perv.	30 min. = 2.33	2.01	34.2	1.42	1.48	0
		60 min. = 1.45	0.93	15.8	1.32	2.96	0
Beardsley	16 imperv.	10 min. = 4.44	4.19	75.5	1.05	0.56	0.49
40.0 cfs pumps	2 perv.	30 min. = 2.33	2.08	37.4	1.56	1.67	0
		60 min. = 1.45	1.20	21.6	1.80	3.33	0
Deer Valley	12 imperv.	10 min. = 4.44	3.95	114	1.59	0.74	0.85
53.5 cfs pumps	17 perv.	30 min. = 2.33	1.84	53.3	2.22	2.23	0
		60 min. = 1.45	0.96	27.8	2.32	4.45	0

From the above table it appears the underpasses will handle the approximately 10 year storms with storage (short time of flooding) for the shorter high intensity storms. The northermost three underpasses appear in better shape than the others.

Information in regard to each area is given in the following table, and thereafter further described in the text. Area description, amount of water reaching the east side of the highway, conduit capacity crossing the highway, and situation as flows (in some cases combined with pumps) leave the west side of the highway, all are shown in the table. The table and maps accompanying the descriptions are usually based on the 5 year flow estimates.

This is the preliminary or background information essential to plans of what should be done as discussed in the final sections of the report. The work recommendations are usually based on 10 yr. or greater flows.

Summary of Flow Conditions Adjacent (East and West) to the Black Canyon Highway

	Area Location	Approx. Highway Station	Contrib. Area Acres	Estimated Flow - CFS 50 Yr.	Estimated Flow - CFS 5 Yr.	Outlet Approx. Highway Station	Outlet Description	Outlet Capacity CFS	Remarks
A	Ariz. Canal to Peoria		153	310	168		None		Drains to swale north of Ariz. Canal and will overflow into canal.
	Highway Center Drain		15	53	33		36" pipe to Ariz. Canal	46	
B	Peoria to Cactus		77						Drains east to Cave Creek
	Upper portion (part)		43	108	42		None		Drains south thence east to Cave Creek
	Peoria Underpass		23	106	71		Two 8,000 gpm pumps	35	Ditch west about 500 ft. to end
C&D	Cactus to Thunderbird		83						
	Upper half or 'D' (part)		78	193	97	492+21	Two 58"x36" Arch CMP	108?	CMP capacity may be less not constructed to date
	Cactus Underpass		22	103	69		Two 8,000 gpm pumps	35	
	West side highway		105	210	115		Ditch?		Ditch ends about 550± west
E	Thunderbird to 0.4 mile north		135	316	173	546+27	Two 6x3 Box Culv.	250	
	Thunderbird Underpass		32	139	93		Two 10,000 gpm pumps	44	Ditch to west about 650 ft. to two 6'x3 box culverts then ditch to daylight or into road ditch
F	0.6 mile south to Greenway		148	345	191	561+27	Two 6x3 Box Culv.	120	Culv. limited by head

	Area Location	Approx. Highway Station	Contrib. Area Acres	Estimated Flow - CFS 50 Yr.	5 Yr.	Outlet Approx. Highway Station	Outlet Description	Outlet Capacity CFS	Remarks
	West side highway		152	355	197		None ?		Construction not completed. No ditch west
G	Greenway to 0.4 mile north		249	440	227	599+27	Two 6x3 Box Culv.	204	
	Greenway Underpass		21	96	65		Two 9,000 gpm pumps	40	
	West side highway		270	488	255		Ditch		Ditch to west about 650' then into small road ditch
H	0.6 mile south to Bell Road		300	538	282	614+20	Three 10x3 box culv.	700	Culv. limited by head
	West side highway		304	545	288		None ?		Construction not completed. No ditch west
I	Bell Road, from north and east		1,617	1,175	420	652+27	Two 6x3 box culv.	200	Culv. limited by head
	Bell Road Underpass		41	172	116		Two 12,000 gpm pumps	53	
	West side highway		1,658	1,250	436		Ditch ?		Ditch west about 300 ft. to two 6x3' box culv. that cross Bell Rd. Const. not completed. No ditch south or west.

	Area Location	Approx. Highway Station	Contrib. Area Acres	Estimated Flow - CFS 50 Yr.	5 Yr.	Outlet Approx. Highway Station	Outlet Description	Outlet Capacity CFS	Remarks
J	0.5 mile south to Union Hills and from east		694	670	266	667+37	50"x31" Arch CMP	30	CMP - limited by depth.
	West side highway		696	672	269		None		Construction not completed. No ditch west.
K	Union Hills from north & east		2,230	1,550	455	703+97	Three 10x3 box culv.	500	Culv. limited by head.
	Union Hills Underpass		17	78	53		Two 8,000 gpm pumps	35	
	West side highway		2,255	1,575	469		Concrete ditch		Ditch west about 600 ft. to end.
L	North of Union Hills 0.7 mile	720+93 to 735+03	123	268	146	720+93	50"x31" Arch CMP	10	CMP - limited by depth.
	West side highway		126	276	154		?		Construction not completed. No ditch west.
M	0.2 mile south to Beardsley Drive		85	178	95	735+03	Two 24" CMP	4	CMP limited by depth.
	West side highway		89	189	101				Bladed ditch west to daylight
N	Beardsley Drive to 0.3 mile north		199	387	204	758+00	Two 43"x27" Arch CMP	50	
	Beardsley Drive Underpass		18	85	57		Two 9,000 gpm pumps	40	

	Area Location	Approx. Highway Station	Contrib. Area Acres	Estimated Flow - CFS 50 Yr.	5 Yr.	Outlet Approx. Highway Station	Outlet Description	Outlet Capacity CFS	Remarks
	West side highway		221	443	237		Conc. Ditch		Ditch ends 630' west of pumps.
O	0.3 to 0.5 mile north of Beardsley and northeasterly		336	374	158	767+50	36"x22" Arch CMP	5	CMP limited by depth.
	West side highway		339	377	160		None?		Construction not completed. No ditch west.
P	0.5 to 0.8 mile north of Beardsley Drive		101	189	98	774+00	50"x31" Arch CMP	15	CMP limited by depth.
	West side highway		109	207	108		None?		Construction not completed. No ditch west.
Q	0.2 mile south to Deer Valley Drive		75	180	98	791+80	65"x40" Arch CMP	50	
	West side highway		78	189	103		None?		Dumps into small swale 125' x 1.0 bearing WSW
R	Deer Valley Drive to 0.3 mile north		322	447	227	806+59	6x3 box culv.	160	
	Deer Valley Underpass		29	124	83		Two 12,000 gpm pumps	53	
	West side highway		355	524	287		Conc. Ditch		Ditch ends 350' west of pumps
R-R	0.3 to 0.5 mile north of Deer Valley Drive		114	328	120	813+88	65"x40" Arch CMP	90	CMP limited by depth

	Area Location	Approx. Highway Station	Contrib. Area Acres	Estimated Flow - CFS 50 Yr.	5 Yr.	Outlet Approx. Highway Station	Outlet Description	Outlet Capacity CFS	Remarks
	West side highway		118	237	123		None ?		Construction not completed. Drains into small wash bearing S.W. to Little Skunk Creek.
S	0.5 to 0.7 mile north of Deer Valley Drive		1,222	1,107	530	831+50	6'x7' box culv.	480 maximum	Culv. capacity with major ponding.
	West side highway		1,226	1,117	534				Channel west to Scatter Creek (Little Skunk Creek)
T	Little Skunk Creek (or Scatter Creek)		5,770	5,660	2,118	840+50	Two 8x7 box culv.	1,000	
	West side highway		5,795	5,698	2,130		Creek		
	SEPARATE MINOR HIGHWAY INTERIOR AREAS DRAINING WEST								
		443+00 to	0.7	3	2	443+00	29"x18" Arch CMP	22±	Based on 10 minute storm.
		452+00 to	4.1	18	12	452+00	29"x18" Arch CMP	22±	Based on 10 minute storm.
		461+00 to	1.7	6	4	461+00	29"x18" Arch CMP	22±	Based on 10 minute storm.
		498+50 to	5.0	22	15	498+50	29"x18" Arch CMP	22±	Based on 10 minute storm.
		509+50 to	7.0	21	14	509+50	29"x18" Arch CMP	22±	Based on 16 minute storm.

PRESENT AND PAST CONDITIONS EAST OF HIGHWAY

AREA "A"

Water will flow south along the east side of the northbound access road to the Arizona Canal. When it reaches a depth of about 1.0 ft. it will break over the north bank of the canal at a point about 125 feet east of the northbound access road. However before this happens the water will reach a depth of about six inches (6") along the east toe of the northbound access road and back up to the north and east approximately 400 feet.

The finished grade of the northbound access road at the Arizona Canal is about the same elevation as the old highway completed in 1948.

Before the 1948 construction, flows would reach the north bank of the Arizona Canal at about the same location, then flow west. However; the highway construction has prevented this and caused the water to pond on the east side of the highway. Original drainage area and present drainage area are about the same.

AREA "B"

Water will flow along the east side of the northbound access road, south to Peoria Ave. then east into Cave Creek. Should the water reach a depth of about six inches (6") it will spill over into the grove and then flow east into Cave Creek.

The grove now occupying the land between the highway and Cave Creek drains east. However from aerial photographs taken in 1940 we find that this area originally drained west.

No provisions were made during the 1948 construction for handling flows from the east. The finish grade of the northbound access road is about 1.5 feet higher than the 1948 construction.

Considering that the south half of this area now drains east and the contributing area is small, (even smaller than the original area), it is unlikely that any major flood damage will be caused by the construction of either the old or new highway. However the fact remains that before either highway was built the flows in the upper half of the area were southwesterly and never reached the lower half of the area, therefore any flood damage caused, might be charged to the highway construction.

AREA "C & D"

The water will flow along the east side of the northbound access road, south to two 58" x 36" arch culverts at Sta. 492 + 21, approximately 1,000 feet north of Avenue Q (Cactus Road).

The subdivision, north of Avenue Q, and between the highway and Cave Creek, now drains east into Cave Creek. However this was not the natural condition. From aerial photographs taken in 1940, a fair sized wash crossed the area now occupied by the highway about 2,000 feet north of Ave. Q. Under the 1948 construction a 66"x38" arch culvert was installed at the intersection of Avenue Q and the Black Canyon Highway, and was fed from an open ditch from the east. Due to the fact that in 1948 Area C & D had about twice the contributing area - that is the area now occupied by the subdivision was then contributing - this culvert was undoubtedly inadequate. However flood waters could sheet flow south across Avenue Q and even west across the Black Canyon Highway before any appreciable damage was done.

Considering that the paved street on the north side of the subdivision drains east into Cave Creek, probably a considerable amourt of the flows from area "D" will be taken care of in this street although some will go south through the subdivision.

Even though the construction of the Black Canyon Highway has caused a change in the natural flows from the north and east in this area, the size of the area, combined with the revised fall of the land, indicates that no appreciable damage should be caused by flooding.

AREA "E"

Water will flow along the east side of the northbound access road south to two 6' x 3' box culverts at Sta. 546 + 27. Due to the fact that these culverts are located approximately 1,300 feet north of the south end of the drainage area, (Thunderbird Road), part of the water will reach the culverts by its natural flow and part of the water will reach the culverts through a channel constructed along the east side of the northbound access road, from Thunderbird Road north. A dike is to be constructed between the channel and the access road. Should the water reach a height of approximately 2.5 feet above the inside top of the culverts, it will overflow the dike at the N.E. corner of Black Canyon Highway and Thunderbird Road. Some of this overflow water will go into the underpass and some of it will flow across Thunderbird Road and into area "C" and "D". Before this condition occurs however a considerable area will be under water.

AREA "F"

Water will flow along the east side of the northbound access road, south to two 6' x 3' box culverts at Sta. 561 + 27. When the water reaches a height of approximately the same elevation as the inside top of the culverts, it will break over the existing field road about 100 feet south and flow into area "E". However, before this occurs, an area approximately 600 feet north and 600 feet east of the culvert will be under water.

During the 1948 construction, an 8' x 3' box culvert was installed to handle the flows from the north and east. The finished grade of the highway was raised about 1.5 feet above the existing road. The finish grade of the new highway will be another 2 feet higher.

From 1940 aerial photographs, a wash from the north east crossed the area now occupied by the highway at approximately Sta. 561 + 00. It is apparent from the photographs that the original drainage area for this wash was considerably larger.

The construction of the old highway definitely restricted flood flows in this area. The new construction can only add to this condition as it will be even higher.

AREA "G"

Water will flow along the east side of the northbound access road, south to two 6' x 3' box culverts at Sta. 599 + 27. Due to the fact that these culverts are located approximately 1,200 feet north of the south end of the drainage area (Greenway Road), part of the water will reach the culverts by its natural flow and part will reach the culverts through a channel to be constructed along the east side of the northbound access road, from Greenway Road north. A dike is to be constructed between the channel and the access road.

Under the 1948 construction an 8' x 3' box culvert was installed near the intersection to handle the flows from the north and east. The finished grade of the highway at that time was raised about 1.5 feet above the existing ground. The finish grade of the new construction will be approximately the same elevation.

The 1948 construction as well as the new construction has definitely restricted flood flows in this area.

Should the water reach a height of about 2.5 feet above the inside top of the culverts it will overflow the dike at the N.E. corner of Black Canyon Highway and Greenway Road. Some of this overflow water will go into the underpass and some of it will flow across Thunderbird Road and into area "F".

Before this condition occurs however, an area approximately 1,300 feet north and 800 feet east of the dike along the access road and along Greenway Road will be under water.

AREA "H"

Water will flow south and west to three 10' x 3' box culverts at Sta. 614 + 20. Should the water reach a height of about 1 foot above the inside top of the culverts it will break over the existing farm road about 50 feet south of the culverts.

Before this happens however, an area about 500' x 200' will be under water.

During the 1948 construction two 10' x 3' box culverts were installed to handle flows from the north and east. At that time the finished grade of the road was raised about 2 feet above the existing ground. The finished grade of the new highway will be about the same elevation.

It is quite possible that a good portion of the flows from area "I" could overflow Bell Road and reach this area.

The construction of the old as well as the new highway has definitely restricted the flood flows in this area.

AREA "I"

Water will flow along the east side of the northbound access road south to two 6' x 3' box culverts at Sta. 652 + 27. Due to the fact that the culverts are located about 1,100 feet north of the south end of the drainage area, (Bell Road), part of the water will reach the culverts by its natural flow and part will reach the culverts through a comparatively small channel constructed east of the northbound access road.

No dike will be built between channel and access road. Water will flow over Bell Road into area "H" and will also overflow into Bell Road underpass.

During the 1948 construction an 8' x 3' box culvert was installed at the intersection to handle the flows from the north and east. The old highway was raised about 2.0 feet higher than the existing ground. The finished grade of the new highway will be approximately another 1.0 foot higher.

The old as well as the new highway has definitely restricted flood flows in this area.

AREA "J"

Water will flow from the northeast to a 50" x 31" arch culvert at Sta. 667 + 37. The flow line of the culverts is about 1.5 feet below natural ground. Without some provisions made at the culvert to create a ponding area the majority of the flows from this area will continue south to area "I".

During the 1948 construction a 52" x 30" arch culvert was installed to handle flows from the north and east. Also a dike extending 100 feet east was was installed to keep the water from going on south. The finished grade of the old highway was raised about 2 feet above the existing ground. The finished grade of the new highway will be about another 1.0 foot higher.

The construction of both the old and the new highways has restricted the natural flood flows in this area.

AREA "K"

Water will flow from the north and east to three 10' x 3' box culverts at Sta. 703 + 97. Because these culverts are located about 1,000 feet north of the south end of the drainage area, part of the water will reach the culverts by its natural flow and part will reach the culverts through a channel constructed east of the northbound access road. A dike is to be constructed between the channel and the northbound access road.

Should the water reach a height of about the same elevation as the top inside of the culvert it will break over into Union Hills Drive about 900 feet east of the Black Canyon Highway, (around the east end of the dike), and go into the underpass.

Before this happens however an area of about 800' x 900' will be under water.

During the 1948 construction two 10' x 3' box culverts were installed at Sta. 694 + 60 to handle the flows from the east. Also a dike was installed extending 400 feet east to keep the water from going on south. The finished grade of the old highway was raised about 3 feet above the existing ground at Sta. 694 + 00. The finished grade of the new highway will be about another 2.0 feet higher.

The construction of both the old and new highways has restricted the natural flood flows in this area.

AREA "L"

Water will flow from the northeast to a 50" x 31" arch culvert at Sta. 720 + 93. East of this culvert there is an approach ditch.

Should the water reach a height of about 1.7 feet below the top of the culvert it will break over the field road just south of the culvert and go into area "K". Before this happens however an area about 200' x 200' will be under water.

During the 1948 construction a 52" x 30" arch culvert was installed at Sta. 720 + 95 to handle flows from the east. Also a dike was installed extending 100 feet east to keep the water from going on south. The finished grade of the old highway was raised about 2.0 feet above the existing ground. The new highway will be about another 2.0 feet higher.

The construction of both the old and new highways has restricted the flood flows in this area.

AREA "M"

Water will flow from the north and east to two 24" culverts at Sta. 735 + 03. Unless provisions are made to create a ponding area, water will flow on south into area "L".

During the 1948 construction two 24" culverts were installed to handle flows from the east. Also a dike extending 100 feet east was installed to keep the water from going on south. The finished grade of the old highway was raised about 2.0 feet above the existing ground. The finished grade of the new highway will be about another 1.0 foot higher.

The construction of both the old and new highway has restricted the flood flows in this area.

AREA "N"

Water will flow from the north and east to two 43" x 27" culverts at Sta. 758 + 00. Because the culverts are located about 1,100 feet north of the south end of the drainage area, part of the water will reach the culverts by its natural flow and part will reach the culverts through a channel constructed east of the northbound access road. A dike is to be built between this channel and the northbound access road.

Should the water reach a height of about 1.0 foot above the top of the culvert, it will break over the dike at the N.E. corner of Black Canyon Highway and Beardsley Road and go into the underpass. Before this happens however, an area of about 800' x 800' will be under water.

Under the 1948 construction a 52" x 30" arch culvert was installed to handle the flows from the north and east. Also a dike was installed extending 100 feet east to keep the water from going on south. The finished grade of the old highway was raised about 2.5 feet above the existing ground. The finished grade of the new highway will be about the same elevation.

The construction of both the old and the new highways have restricted the natural flood flows in this area.

AREA "O"

Water will flow from the east to a 36" x 22" arch culvert at Sta. 767 + 50. Unless provisions are made to create a ponding area of the east end of this culvert the water will flow south into area "N".

Under the 1948 construction a 30" culvert was installed to handle the flows from the east. Also a dike running 100 feet east was built to keep the water from going on south.

In 1948 the finished grade of the old road was raised about 2.5 feet above the existing ground. The finished grade of the new highway will be about another 2.0 feet higher.

The construction of both the old and new highway has restricted the natural flood flows in this area.

AREA "P"

Water will flow from the north and east to a 36" x 22" arch culvert at Sta. 774 + 00. Should the water reach a height of about 0.7 foot below the top of the culvert it will break across the existing road about 30 feet south of the culvert and flow into area "O" However before this happens an area of about 200' x 300' will be under water.

Under the 1948 construction a 52" x 30" arch culvert was installed to handle the flows from the east. Also a dike running 100 feet to the east was installed to keep the water from flowing on south. The finished grade of the old highway was raised about 3.0 feet above the existing ground. The finished grade of the new highway will be about another 2.0 feet higher.

The construction of both the old and the new highway has restricted the natural flood flows in this area.

AREA "Q"

Water will flow from the north and east to a 65" x 40" arch culvert at Sta. 791 + 80. Should the water reach a height of about 0.4 foot below the top of the culvert it will break over a natural ridge about 300 feet south of the culvert. However, before this happens an area of about 200' x 200' will be under water.

Under the 1948 construction a 66" x 38" arch culvert was installed to handle the flows from the east. Also a dike running 100 feet east was built to keep the water from running south. The finished grade of the old highway was raised about 1.0 foot above the existing ground and about 3.0 feet above the bottom of the existing channel that crossed the highway at this station. The finish grade of the new highway will be about another 2.0 feet higher.

The construction of both the old and new highway has restricted natural flood flows in this area.

AREA "R"

Water will flow from the north and east to a 6' x 3' box culvert at Sta. 806 + 59. Because the culvert is located about 600 feet north of the south end of the drainage area (Deer Valley Drive), part of the water will reach the culvert by its natural flow and part will reach the culvert from the south through a channel constructed east of the northbound access road. No dike is to be constructed. The top of the concrete lined ditch is flush with the natural ground.

There is little or no ponding area. Should the ditch fill up and overflow it will spill over into the underpass. The water level will be about 2 feet above inside top of culvert when this occurs.

Under the 1948 construction, a 66" x 38" arch culvert was installed at Sta. 799 + 00 to handle the flows from the east. Also a dike was built extending 100 feet east to keep the water from going on south. The finished grade of the old highway was raised about 2.0 feet above the existing ground and about 4 feet above the bottom of the existing wash that crossed the highway at Sta. 799 + 00. The finished grade of the new highway will be about another 2 feet higher.

The construction of both the old and the new highway has restricted the natural flood flows in this area.

AREA "R-R"

Water will flow from the north and east to a 65" x 40" arch culvert at Sta. 813 + 88. Should the water reach a height of about the same elevation as the top of the culvert, it will break across the existing road about 40 feet south of the culvert and into area R. Before this happens however, an area of about 200' x 300' will be under water.

Under the 1948 construction, a 66" x 38" arch culvert was installed at Sta. 813 + 88 to handle the flows from the east. Also a dike was built extendint 100 feet to the east to restrict the flows from going on south. The finished grade of the old highway was raised about 2.0 feet above the existing ground and about 4 feet above the bottom of the existing wash that crossed the highway at this station. The finished grade of the new highway will be about another 3.5 feet higher.

The construction of both the old and the new highway has restricted the natural flood flows in this area.

AREA "S"

Water will flow from the north and east, through an existing wash from the east to a 6' x 7' box culvert at Sta. 831 + 50. Should the water reach a height of about 3 feet above the top inside of the culvert the water will break over a natural ridge about 350 feet south of the culvert and flow into area "R-R". Before this happens however, the water will be already breaking over the natural ridge about 750 feet to the north between this area and area "T".

Should this condition occur, considerable land will be under water.

During the 1948 construction the finished grade was raised above 4 feet above the existing ground and about 11 feet above the bottom of the existing wash that crossed the highway at this station. The new construction will be about another 2 feet higher.

The construction of the old highway as well as the new has restricted the natural flood flows in this area.

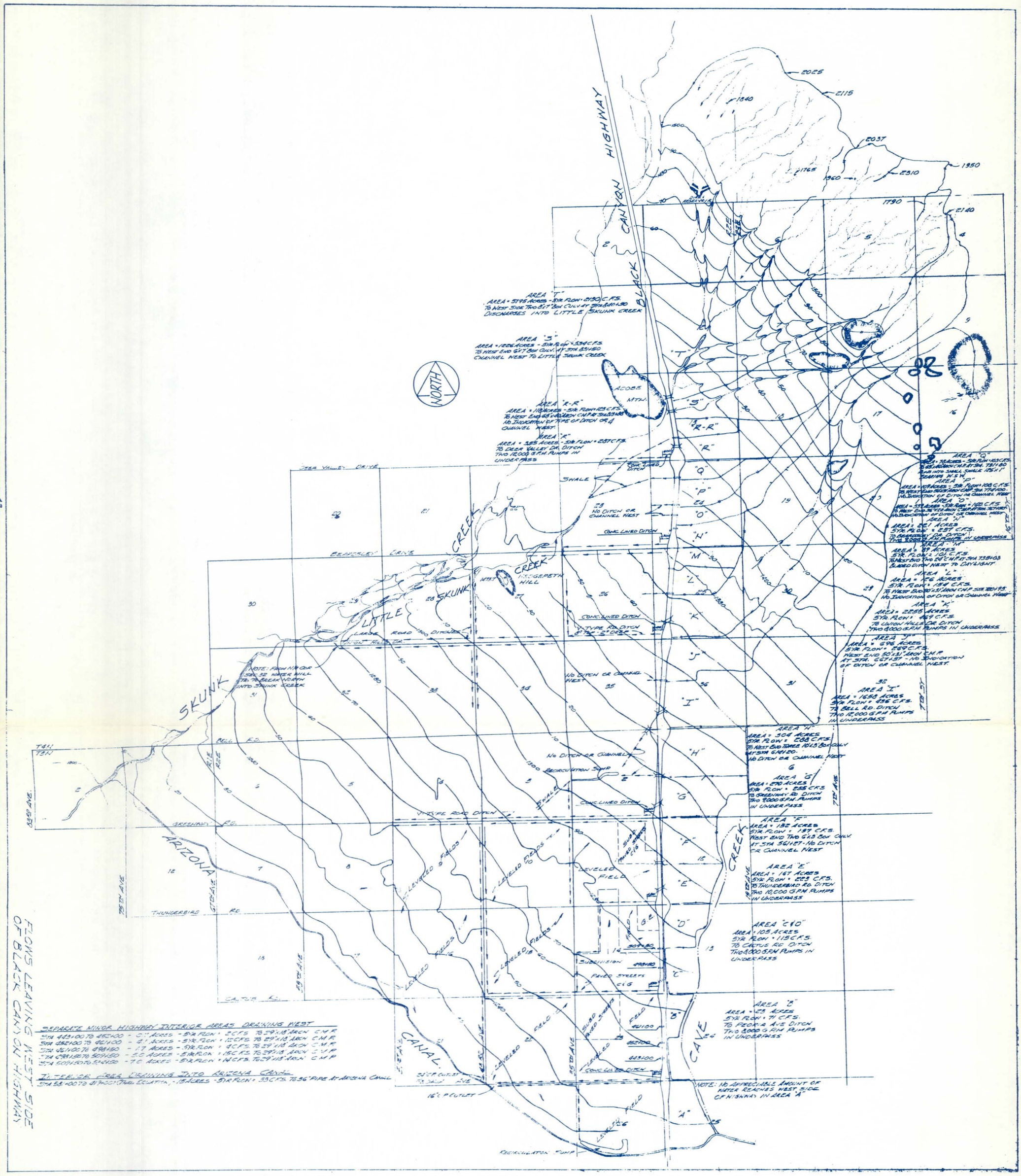
AREA "T"

Water will flow from the north and east to two 8' x 7' box culverts at Sta. 840 + 50. This station is the natural channel of Little Skunk Creek (Scatter Creek). An approach ditch from the north is to be constructed east of the northbound access road to collect the water and facilitate the flows to the culvert.

Should the water reach a height of about 1 foot above the top inside of the culvert, it will break over the natural ridge about 300 feet south of culvert. However, before this happens a considerable area will be under water.

During the 1948 construction the box culverts were installed to handle the flows from this wash. The finished grade of the old highway was raised about 4.0 feet above the existing ground and about 8 feet above the bottom of the existing channel. The finished grade of the new highway will be about another 2 feet higher.

The construction of both the old and the new highway has restricted the natural flood flows in this area.


FLOWS LEAVING WEST SIDE OF BLACK CANYON HIGHWAY
BLACK CANYON HIGHWAY
NORTH
AREA "T"
AREA = 5795 ACRES - SYR. FLOW = 2130 C.F.S.
TO WEST SIDE TWO 8'x7' BOX CULV. AT STA. 8+00 & 10+30
DISCHARGES INTO LITTLE SKUNK CREEK
AREA "S"
AREA = 1826 ACRES - SYR. FLOW = 534 C.F.S.
TO WEST END 6'x7' BOX CULV. AT STA. 83+50
CHANNEL WEST TO LITTLE SKUNK CREEK
AREA "R-R"
AREA = 112 ACRES - SYR. FLOW = 125 C.F.S.
TO WEST END 8'x8' ARCH CMP AT STA. 83+80
NO INDICATION OF TYPE OF DITCH OR CHANNEL WEST
AREA "R"
AREA = 385 ACRES - SYR. FLOW = 287 C.F.S.
TO DEER VALLEY DR. DITCH
TWO 12,000 G.P.M. PUMPS IN UNDERPASS
AREA "Q"
AREA = 78 ACRES - SYR. FLOW = 135 C.F.S.
TO 8'x8' ARCH CMP AT STA. 79+60
RUNS INTO SMALL SWALE 1750' x 1' DRAINS N.E.W.
AREA "P"
AREA = 47 ACRES - SYR. FLOW = 108 C.F.S.
TO WEST END 30"x30" ARCH CMP STA. 77+00.
NO INDICATION OF DITCH OR CHANNEL WEST
AREA "O"
AREA = 317 ACRES - SYR. FLOW = 160 C.F.S.
TO WEST END 36" ARCH CMP AT STA. 76+00
NO INDICATION OF DITCH OR CHANNEL WEST
AREA "N"
AREA = 221 ACRES
SYR. FLOW = 237 C.F.S.
TO BEARDSLEY DR. DITCH
TWO 8000 G.P.M. PUMPS IN UNDERPASS
AREA "M"
AREA = 39 ACRES
SYR. FLOW = 101 C.F.S.
TO WEST END TWO 24" C.M.P. AT STA. 73+00
BLOCKED DITCH WEST TO DAYLIGHT
AREA "L"
AREA = 56 ACRES
SYR. FLOW = 134 C.F.S.
TO WEST END 30"x31" ARCH CMP STA. 70+95
NO INDICATION OF DITCH OR CHANNEL WEST
AREA "K"
AREA = 2295 ACRES
SYR. FLOW = 469 C.F.S.
TO UNION HILLS DR. DITCH
TWO 8000 G.P.M. PUMPS IN UNDERPASS
AREA "J"
AREA = 696 ACRES
SYR. FLOW = 269 C.F.S.
WEST END 50"x31" ARCH CMP
AT STA. 66+87 - NO INDICATION
OF DITCH OR CHANNEL WEST.
AREA "I"
AREA = 1658 ACRES
SYR. FLOW = 436 C.F.S.
TO BELL RD. DITCH
TWO 12,000 G.P.M. PUMPS
IN UNDERPASS
AREA "H"
AREA = 304 ACRES
SYR. FLOW = 223 C.F.S.
TO WEST END TWO 10'x3' BOX CULV.
AT STA. 61+20.
NO DITCH OR CHANNEL WEST
AREA "G"
AREA = 270 ACRES
SYR. FLOW = 225 C.F.S.
TO GREENWAY RD. DITCH
TWO 8000 G.P.M. PUMPS
IN UNDERPASS
AREA "F"
AREA = 132 ACRES
SYR. FLOW = 187 C.F.S.
WEST END TWO 6'x3' BOX CULV.
AT STA. 56+27 - NO DITCH
OR CHANNEL WEST
AREA "E"
AREA = 167 ACRES
SYR. FLOW = 223 C.F.S.
TO THUNDERBIRD RD. DITCH
TWO 10,000 G.P.M. PUMPS
IN UNDERPASS
AREA "C & D"
AREA = 105 ACRES
SYR. FLOW = 115 C.F.S.
TO CACTUS RD. DITCH
TWO 8,000 G.P.M. PUMPS IN
UNDERPASS
AREA "B"
AREA = 23 ACRES
SYR. FLOW = 71 C.F.S.
TO PEORIA AVE. DITCH
TWO 8000 G.P.M. PUMPS
IN UNDERPASS
NOTE: NO APPRECIABLE AMOUNT OF WATER REACHES WEST SIDE OF HIGHWAY IN AREA "A"
NOTE: FROM NW COR SEC. 32 WATER WILL TRY TO BREAK NORTH INTO SKUNK CREEK
SEPARATE MINOR HIGHWAY INTERIOR AREAS DRAINING WEST
STA. 443+00 TO 465+00 - 0.1 ACRES - SYR. FLOW = 2 C.F.S. TO 24"x18" ARCH C.M.P.
STA. 482+00 TO 501+00 - 0.1 ACRES - SYR. FLOW = 1.5 C.F.S. TO 24"x18" ARCH C.M.P.
STA. 461+00 TO 499+50 - 1.7 ACRES - SYR. FLOW = 4 C.F.S. TO 24"x18" ARCH C.M.P.
STA. 499+50 TO 509+50 - 5.0 ACRES - SYR. FLOW = 15 C.F.S. TO 24"x18" ARCH C.M.P.
STA. 509+50 TO 524+50 - 7.0 ACRES - SYR. FLOW = 14 C.F.S. TO 24"x18" ARCH C.M.P.
INTERIOR AREA DRAINING INTO ARIZONA CANAL
STA. 58+00 TO 81+00 (THRU EQUATION) - 15 ACRES - SYR. FLOW = 33 C.F.S. TO 36" PIPE AT ARIZONA CANAL
ARIZONA CANAL
LITTLE SKUNK CREEK
SKUNK CREEK
CAVE CREEK
DEER VALLEY DRIVE
BEARDSLEY DRIVE
BELL RD.
GREENWAY RD.
THUNDERBIRD RD.
CACTUS RD.
PEORIA AVE.
CONC. LINED DITCH
TYPE RD. DITCH
SWALE
NO DITCH OR CHANNEL WEST
RECIRCULATION PUMP
LEVELED FIELDS
SUBDIVISION
PAVED STREETS
16" C.P. OUTLET
24" C.P. OUTLET

EXISTING CONDITIONS WEST SIDE OF HIGHWAY
AREA "A"

No appreciable amount of water will reach the west side of the highway. Water that falls on the highway will be carried into the Arizona Canal by pipes installed in the median.

AREA "B"

No flows from the east will reach the west side of the highway. The only water reaching the west side is what is collected and pumped out of the underpass and water that falls on the highway for about 3,200 feet north. This water will be discharged into a concrete lined ditch running from the pumps about 500 feet west. There it will flow into the existing inadequate road ditches and be carried west. There is a 16" outlet into the Arizona Canal at 43rd Avenue that may help dissipate some of this water.

There are 29" x 18" arch culverts placed about 1,400 feet north, 2,300 feet north, and 3,200 feet north of Peoria Avenue to handle water falling between the southbound lane and the southbound access road. These culverts discharge west and principal flow will be south along the west side of the southbound access road and enter the north end of the concrete lined ditch, mentioned above, at Sta. 439 + 50.

AREAS "C" & "D"

The combined flows of the east side and what is pumped out of the underpass will be carried west through a concrete lined ditch that runs from the pump discharge about 550 feet west. At this point it will go into the existing subdivision frontage road, will be carried west to 35th Avenue and then dumped into the existing road ditch. Because the water on the east side of the highway drains into Cave Creek, the amount of flows reaching the west side are less as compared to similar underpasses.

The existing road ditches will not handle the combined flood flows of the east and west sides of the highway, however, it does not seem as though the highway has added much beyond its pumps to the condition. They are responsible for water that will be pumped out of the underpass.

There are 29" x 18" arch culverts placed about 1,600 feet north and about 2,800 feet north of Avenue "Q" to handle water that falls between the southbound road and the southbound access road. These culverts discharge west into fields and commercial property. Because of the size of the drainage area, it is doubtful if they would cause much damage, but at least it is a nuisance.

AREA "E"

Combined flows from the east and what is pumped out of the underpass will be carried west through a concrete lined channel that runs from the pump discharge about 650 feet west. At this point it will go into the existing inadequate road ditch. The water will continue west to about 31st Avenue and beyond and then it will enter the old natural swale and flow south and west through the existing subdivision.

The drainage study indicates that the highway has not added much to, or changed this condition appreciably, but probably will get blamed for it anyway particularly on account of pumping from the underpass.

AREA "F"

Water from the east will reach the west side of the highway through two 6' x 3' box culverts at Sta. 561 + 27. No ditch or channel has been constructed west from the west end of the culvert. However, should it be left in its present condition considerable damage could be done to the subdivision west of this culvert. At the present it discharges into the back yards of two houses about 150 feet away.

It is understood the Highway Department is to turn the water south in a channel and dump it into the alley on the south side of the subdivision then "let it go where it wants to".

AREA "G"

The flows from the east side of the highway together with water that is pumped out of the underpass will be carried west through a concrete lined ditch. This ditch runs from the pump discharge approximately 600 feet west. At this point the water will enter the inadequate existing road ditches and will probably cross the road and flood a few houses.

AREA "H"

Flows from the east side together with that which falls on the highway itself will reach the west side through three 10' x 3' box culverts at Sta. 614 + 20. At the present there is no indication of how the flows are to be carried west away from the highway. There is a large recirculation sump about 1/2 mile west that can handle quite a bit of water. However, flows from Area "I" will probably drain into this sump also (see map of flows leaving west side of highway). Part of the water will be stored in this sump and part will go west into the natural swale, then south and west into inadequate existing road ditches on Greenway Road. It is possible that at this point the flows from Area "G", "H", and "I" might combine. Under the present construction no provision is made for a ditch or channel running west to handle the flows from this culvert.

AREA "I"

Flows from the east side together with water is pumped out of the underpass will reach the west side through a concrete lined channel. This channel runs south and west to two 6' x 3' box culverts that cross Bell Road about 900 feet west of the centerline median of the Black Canyon Highway. From here the water is dumped into an open field and then flows southwest to the recirculation sump described in Area "H". The field (above the sump) that this water will flow through, has been leveled. However a natural wash some 1,300 feet west of the Black Canyon Highway did run through this area as indicated by the 1940 aerials. It looks like considerable damage could be caused to the field if it is left in its present condition. It is understood that the Highway Department was to run a channel from the south end of the box culvert crossing Bell Road, west about 600 feet to the natural swale. However, as yet they don't have any R/W so they can't do anything except let the water go out into the field.

The County submitted a plan to run the water from the box culvert crossing Bell Road back southeasterly and thence south for 1/2 mile thence west (see area "N").

AREA "J"

Flows from the east, together with water that falls on the highway for about 1/2 mile north, will reach the west side of the highway, through a 50" x 31" arch culvert located at Sta. 667 + 37.

Under the present contract no ditch or channel to the west has been provided to handle these flows. There is no indication of a natural channel. However this water should sheet flow south and west about 1/4 mile and enter a natural swale. It will then be carried southwest and join with the flows from Area "I".

There is no development in this area at present.

AREA "K"

Flows from the east together with water that is pumped out of the underpass will discharge to the west through a concrete lined channel that ends about 600 feet west of the pump discharge. The existing road ditch from the end of the concrete lined ditch cannot possibly handle the expected flows in this area. Unless provisions are made to carry this west to Little Skunk Creek extensive damage could be done to fields, groves and farm houses.

AREA "L"

Flows from the east together with water that falls on the highway for about 1/4 mile north will reach the west side through a 50" x 31" arch culvert located at Sta. 720 + 93. Under this contract no channel or ditch is to be provided to handle the flows from the west end of the culvert. The water will flow west along the north side of an existing concrete lined irrigation ditch. This ditch is about a foot or so above the existing fields and runs about 600 feet west. At this point the water will sheet flow south and west across open fields and probably eventually reach Union Hills Road.

AREA "M"

Flows from the east, together with water that falls on the highway for about 1/4 mile north, will reach the west side through two 24" corrugated metal pipes located at Sta. 735 + 03.

The water will discharge directly into an old inadequate irrigation ditch and be carried west about 800 feet. There it will dump out next to the concrete lined irrigation ditch described in area "N" and be taken south possibly as far as Union Hills.

The land west of the highway at one time was under cultivation. Consequently there is a low area adjacent to the concrete lined ditch as a result of terraced fields.

There is no development at present in this area.

AREA "N"

Flows from the east together with water that falls on the highway will be discharged to the west through a concrete lined ditch that ends about 650 feet west of the pump discharge. There it will go into the inadequate existing road ditches and be carried west to Little Skunk Creek. Unless some provisions are made to keep the water in the road ditches on Beardsley Drive, it will break over into a low area on the south side of Beardsley Drive, at the west end of the concrete lined ditch and flow south along the east side of a concrete lined irrigation ditch.

The existing road ditches will handle some of the water from this area, but they can not handle the combined flows from areas "N", "O" and "P" and this condition could quite conceivably happen.

AREA "O"

Flows from the east together with water that falls on the highway for about 700 feet north, will reach the west side through a 36" x 22" arch culvert at Sta. 767 + 50.

Water will sheet flow across the open fields to the west. Under the present construction no ditch or channel is to be built to handle the flows from this area.

Fields to the west were at one time under cultivation so water will probably seek its way south and west to Beardsley Drive. There is no development at present west of the highway in this area.

AREA "P"

Flows from the east together with the water that falls on the highway for about 800 feet north will reach the west side of the highway through a 50" x 31" arch culvert at Sta. 774 + 00.

There is no indication of a ditch or channel west.

Flows will be turned south at the west end of the culvert and taken south through a grader ditch along the west side of the southbound access road to Beardsley Drive. Some of the water however, will probably break out across the open fields to the west before it reaches Beardsley Drive. The only purpose of the grader ditch is to protect the motel just north and west of the west end of the culvert.

AREA "Q"

Flows from the east together with water that falls on the highway for about 800 feet north will reach the west side through a 65" x 40" arch culvert at Sta. 791 + 80. From there it will be carried west through a natural swale to Little Skunk Creek. The swale is of sufficient size so that should easily handle the flows in this area. There is no development at present through the swale but eventually this would have to be channeled.

AREA "R"

Flows from the east together with the water that is pumped out of the underpass will reach the west side of the highway through a concrete lined channel that ends about 600 feet west of the pump discharge. From here it will flow on west by the inadequate road ditches about 1/4 mile to a natural swale, then southwest into Little Skunk Creek. That which does not get into the swale will stay in the road ditches and be carried west directly into Little Skunk Creek. The road ditches are probably big enough to handle average flows but heavy flows could cause some flooding before they reach Little Skunk Creek. There is no development in this area at present.

AREA "R-R"

Flows from the east, together with the water that falls on the highway for about 1,700 feet north, will reach the west side through a 65" x 40" arch culvert at Sta. 813 + 88. The flows will discharge directly into a natural swale that runs southwest into Little Skunk Creek. However, in order to reach Little Skunk Creek, this swale runs through the Phoenix Trailer Park. The main channel, although small has been filled with dirt in a number of places and trailers are parked over the channel. Should flows of a large quantity reach this area, considerable damage could be done.

AREA "S"

Flows from the east together with water that falls on the highway for about 900 feet north will reach the west side through a 6' x 7' box culvert at Sta. 831 + 50. From here the water will flow through a channel west, no more than 100 feet and into Little Skunk Creek.

AREA "T"

Flows from the east, together with water that falls on the highway for about 4,500 feet north will reach the west side through two 8' x 7' box culverts at Sta. 840 + 50. Here it will discharge directly into Little Skunk Creek.

RECOMMENDED WORK

General:

It is apparent from the previous area descriptions that drainage problems exist at practically every point. The problems range from merely a nuisance to the potential of serious damage. In some cases highway construction has only added minor amounts to flows but in practically every case there has been a restriction, diversion, incremental addition, or change to natural flows.

While it has not been particularly described in the previous "conditions east of the highway" it should be noted that bigger storms will flow to the east side of the highway (as a dyke) and water will travel south, in some cases through buildings, into other drainage areas.

There are many alternative possibilities.

1. Little work need be done (except at a few locations) and the risk can be taken on damages. As the area further develops this alternative becomes less attractive.

Immediate work should be at least, (1) temporarily close the east end of the existing 6' x 3' box culverts about midway between Thunderbird and Greenway Roads, (2) direct the flow south along the west right-of-way of Black Canyon Highway from the existing 50" x 31" C.M.P. arch about 1/2 mile south of Deer Valley Drive.

2. A complete job of taking care of the estimated 50 year flows can be accomplished. This would be very expensive and is not warranted.

3. There are innumerable alternatives between the above two plans. One such plan is herein recommended for general guidance and discussion. When a general decision has been reached by the Highway Department on what should be done - then more engineering work should be done on possible right-of-ways, best routing of channels, revaluation of flows for such routing, and better general design criteria. All of this preliminary to detail construction plans.

For example the alternates of carrying all the water from areas A through G south to the Arizona Canal or building a Thunderbird Road channel for part of the area should be more thoroughly studied - also more study should be made of utilizing the area between the frontage and southbound main roads as a channel. When general decision has been reached as to a program - these alternative possibilities should be investigated in accordance with the program and design criteria selected.

Work of Other Agencies

The Maricopa County Flood Control District proposes a channel along the north side of the Arizona Canal and a channel about 1,500 feet north of Union Hills Drive both picking up waters east of the Black Canyon Highway and running westerly to the Skunk Creek.

These channels will be very helpful but at present depend on a proposed County bond election and further on participation by the U. S. Army Corps of Engineers through Congressional approval.

We feel eventually such jobs will be accomplished even if only by local interests - such as the City of Phoenix and the County - but there is no immediate or definite assurance as to time of accomplishment.

The Recommended Work

The method herein selected is as follows - in general the 10 year flow is the design criteria:

1. Areas A,B,C,D. Gather the water along the west side of the highway from the pumps at Peoria and Cactus and part of the water from areas C and D east of the highway and take this water to a future Arizona Canal Channel.

Buy right-of-way along the Arizona Canal and store flows as a temporary measure until the Arizona Canal flood channel is built by the County.

2. Areas E,F,G. Gather the water along west side of highway from Thunderbird pumps and Greenway pumps and from areas E,F, and G east of the highway and take this water along or near Thunderbird Road westerly to the Arizona Canal and Skunk Creek. Add culverts crossing the highway north of Greenway underpass and 1/2 mile north of Thunderbird.

Buy right-of-way along Thunderbird and the Arizona Canal as required.

In connection with such right-of-way along Thunderbird Road the two best possibilities are:

a. build a divided roadway with a center gently sidesloped channel or

b. build about 200 feet, or one tier of lots, away from the road so that future developments can back-up against the channel.

1 and 2 Alternate. Areas A through G. Gather the water along the west side of the highway and do other work as noted above but eliminate the unlined channel west on Thunderbird Road.

3. Areas H,I,J. Gather the water along the west side of the highway from the pumps at Bell Road and from areas H, I, J east of the highway and take this water along or near the midsection line south of Bell Road westerly to the Skunk Creek.

Add a culvert crossing north of the Bell Road underpass and do some channel work along the east side of the highway north of such crossing.

4. Areas K,L,M. Gather the water along the west side of the highway from the pumps at Union Hills Drive from areas K,L, and M east of the highway and take this water along Union Hills Drive westerly to the Skunk Creek.

Assume the County's proposed Union Hills diversion will be built and take care of the water as best possible until then. After the County's Union Hills diversion is built it would be possible to reroute the pumps discharge north to such channel and to abandon the westerly route along Union Hills Drive.

Some channel work along and east of the highway is also required.

Some additional right-of-way along Union Hills Drive is required at least until the County diversion channel is built.

5. Areas N,O,P. Gather the water along the west side of the highway from the pumps at Beardsley Drive and from areas N,O,P, east of the highway and take this water westerly along Beardsley Drive to the Little Skunk Creek.

Add a culvert crossing the Black Canyon Highway north of Beardsley Drive underpass.

Buy right-of-way along Beardsley Drive as required.

6. Area Q. Take this water westerly along the existing swale to the Little Skunk Creek.

Add a culvert crossing about 1/4 mile south of Deer Valley Drive.

Improve the swale as required and this will require right-of-way or permission from owners in the area.

7. Area R and R-R. Gather this water along the west side of the highway from the pumps at Deer Valley Drive and from areas R and R-R east of the highway and take this water westerly along Deer Valley Drive to the Little Skunk Creek.

Add culverts crossing the Black Canyon Highway north of the Deer Valley underpass.

Buy right-of-way along Deer Valley Drive as required.

8. Areas S, and T. Add to the crossings at or near Little Skunk Creek (Scatter Wash) to provide for the 25 year estimated flow.

Whether this is done by separate culverts makes little difference hydraulically. We show the excess flow from the main crossing being carried south into the smaller wash and the required highway crossing provided here.

Buy some right-of-way east of the highway for channel purposes.

The flow estimates are given in the table following and a plan is attached showing flows and general features of the proposed work. Appendix V shows the size and kind of conduit and channel appropriate to the work recommended.

ESTIMATED FLOWS FOR THE RECOMMENDED WORK

EXPECTED FLOWS 10 year rainfall intensity and duration unless noted

Present Conditions of Subdivision Development

Assume Ariz. Canal and Union Hill Channels Constructed

LOCATION	AREA IN ACRES Total Area A	Pervious Area A_p	Imperv's Area A_i	Infiltr'n (final) in/hr f_c	Concentration Time Street Slope	Min. t_c	RAIN Point Intensity I	Average Intensity Ia	RUNOFF Pervious $(Ia-f_c)0.8$ = Inches	IxA_p = CFS	Impervious $(Ia-0.2)0.9$ = Inches	IxA_i =CFS	Total Flow CFS	DESIGN FLOW AND REMARKS
Area A, B, C, D, combined														
Test pumps & west drainage	77±	32	45	0.6	Channel	50	1.65	1.63	0.84	27	1.29	58	85	Not a maximum
Total Area														Use structure capacity
Test below pumps at Cactus	110	98	22	0.6		38	2.00	1.98	1.11	108	1.60	35	143	150 use
Area E, F, G combined														
Area G - E. side highway	249	248	1	0.6		36	2.07	2.05	1.16	288	1.67	1	289	
Area G - including pumps	270	254	16	0.6		36	2.07	2.05	1.16	295	1.67	27	322	
Area F - W. side highway	151.7	147.7	4	0.6		25	2.64	2.61	1.61	238	2.17	9	247	
Area F & G	424	403	21	0.6		41	1.87	1.85	1.02	411	1.49	31	442	Not a maximum
Part area trial	300	279	21	0.6		25	2.64	2.61	1.61	449	2.17	46	495	500 use
Area E - W. side highway incl. pumps	167	150	17	0.6		25	2.64	2.61	1.61	227	2.17	37	264	250 use existing
Area E, F, G	593	454	39	0.6		44	1.80	1.78	0.95	431	1.42	55	486	
Part area trial	340	301	39	0.6		25	2.64	2.61	1.61	485	2.17	85	570	Use 560 to 590 from pumps
One mile west on Thunderbird	700	660	40	0.8		36	2.07	2.05	1.02	673	1.66	66	739	
Two mile west on Thunderbird	1,100	1,060	40	0.9		47	1.70	1.67	0.62	657	1.32	53	710	Not a maximum
Area H, I, J combined														
Area J - Part area trial	300	294	6	0.7		33	2.20	2.17	1.18	347	1.77	10	357	Use 350
Area I & J - E. side highway	1,486	1,437	49	0.7		57	1.51	1.49	0.63	905	1.16	57	962	Use 960
Area I & J - W. side highway & pumps	1,529	1,465	64	0.7		58+	1.47	1.45	0.60	879	1.12	72	951	Not a maximum
Area H, I & J	1,834	1,765	69	0.7		62	1.41	1.39	0.55	971	1.07	74	1,045	Use 1,050
One mile west on midsection	2,236	2,166	70	0.75		71	1.29	1.27	0.46	996	0.96	67	1,063	Use 1,070
Area K, L, M combined														
Area K - Without Union Hills	2,230	2,210	20	0.7		82	1.15	1.14	0.43	950	0.85	17	967	Not applicable
(E. side) With U.H. Diversion built	151	151	0	0.7		28	2.43	2.40	1.36	205	1.98	0	205	Temporarily build to culv. capacity 500 cfs
See plan for K, L, M														
Area M - E. side highway	85	85	0	0.7		27	2.51	2.49	1.43	122	2.06	-	122	
Area M & L - E. side highway	208	207	1	0.7		29	2.40	2.37	1.34	277	1.95	2	279	
Area N, O, P combined														
Area P - E. of highway	101	100	1	0.7		32	2.24	2.22	1.22	122	1.82	2	124	
Area O & P - E. of highway	437	429	8	0.7		56	1.52	1.51	0.73	313	1.18	9	322	Not a maximum
Trial part area	320	312	8	0.7		34	2.16	2.14	1.15	359	1.75	14	373	
Area N, O, & P (part area)	520	510	10	0.7		35	2.10	2.08	1.18	602	1.69	17	619	

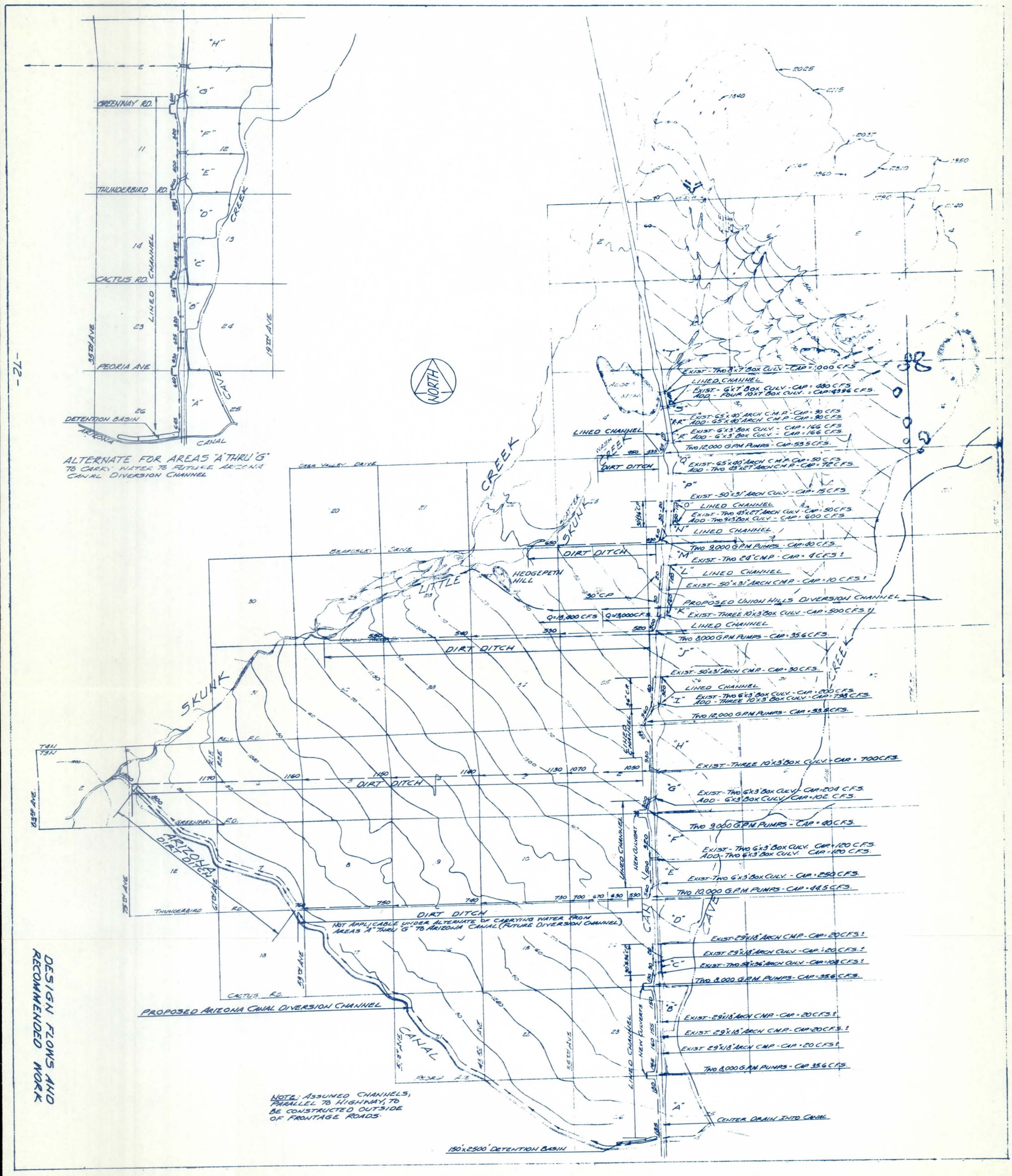
ESTIMATED FLOWS FOR THE RECOMMENDED WORK

EXPECTED FLOWS 10 **year rainfall intensity and duration unless noted**

Present Conditions of Subdivision Development

Assume Ariz. Canal and Union Hill Channels Constructed

LOCATION	AREA IN ACRES Total Area A	Pervious Area A_p	Imperv's Area A_i	Infiltr'n (final) in/hr f_c	Concentration Time Street Slope	Min. t_c	RAIN Point Intensity I	Average Intensity Ia	RUNOFF Pervious $(Ia-f_c)0.8$ = Inches	$InxA_p$ = CFS	Impervious $(Ia-0.2)0.9$ = Inches	$InxA_i$ =CFS	Total Flow CFS	DESIGN FLOW AND REMARKS
Area Q	75	74	1	0.7		23	2.77	2.74	1.63	121	2.29	2	123	
Area R and R-R combined														
Area R-R - E. side highway	114	113	1	0.7		29	2.40	2.38	1.35	153	1.96	2	155	
Area R - E. side highway	322	298												Not a maximum
Trial - lower part	280	258	22	0.7		38	2.00	1.98	1.02	263	1.60	35	298	
Area R and pumps Trial - lower part	313	278	35	0.7		38	2.00	1.98	1.02	284	1.60	56	340	
Area R and R-R and pumps	431	393	38	0.7		40	1.93	1.90	0.96	377	1.53	58	435	
Area S and T combined														
Area T - E. of highway	5,770	5,762	8	0.8		56	1.52	1.47	0.54	3,111	1.14	9	3,120	10 yr. storm
Area T - E. of highway	5,770	5,762	8	0.8		56	1.80	1.75	0.76	4,379	1.39	11	4,390	25 yr. storm
Area S - Central portion	660	660	0	0.8		34	2.16	2.14	1.07	706	1.75	0	706	10 yr. storm
Area S & T - Part dr. in 56 min.	6,700	6,692	8	0.8		56	1.52	1.47	0.54	3,614	1.14	9	3,623	10 yr. storm
Area S & T - Part dr. in 56 min.	6,700	6,692	8	0.8		56	1.80	1.75	0.76	5,086	1.39	11	5,097	25 yr. storm
Area "A" through "G" combined														
Area E, F, G														
Part area trial	340	301	39	0.6		25	2.64	2.61	1.61	485	2.17	85	570	
C - D incl. pumps	105	85	20											
Total	445	386	59	0.6		33	2.20	2.17	1.18	455	1.77	104	559	Not a maximum



DESIGN FLOWS AND RECOMMENDED WORK

COST ESTIMATES

Appendix VI gives the detail cost estimate of the proposed work.

The work proposed aggregates $2,583,000.

In general this will take care of storms on the order of 10 year recurrence and should prove both economic and satisfactory. The costs at various locations are:

Areas, Location	Description	Amount
A,B,C,D. From South of Thunderbird to Arizona Canal	Conduit and lined channel west of Highway to future Arizona Canal channel	($338,000) See Alternate
E,F,G From North of Greenway Road to Thunderbird	Conduit and lined channel west of Highway. Unlined channel on Thunderbird to Arizona Canal channel and thence to Skunk Creek	($757,000) See Alternate
A through G (Alternate) North of Greenway Road to Arizona Canal	Channel along west side of Highway to future Arizona Canal channel	$861,000
H,I,J Below Union Hills to 1/2 mile south of Bell Road	Conduit and lined channel east and west of Highway. Unlined channel 1/2 mile south of Bell Road westerly to Skunk Creek	$782,000
K,L,M Below Beardsley Drive to Union Hills Drive	Conduit and lined channel east and west of Highway. Unlined channel along Union Hills Drive westerly to Skunk Creek	$381,000
N,O,P 3/4 mile north of Beardsley Drive to Beardsley Drive	Conduit and channel east and west of Highway. Unlined channel along Beardsley Drive westerly to Little Skunk Creek	$236,000

Areas, Location	Description	Amount
Q Below Deer Valley Drive	Improve swale westerly to Little Skunk Creek	$ 21,000
R and R-R North of Deer Valley Drive	Channel along west side of Highway and unlined channel westerly along Deer Valley Drive to Little Skunk Creek	$109,000
S and T Little Skunk Creek or Scatter Wash	Add box culverts crossing the Highway. Some channel work east of Highway	$193,000
	Total	$2,583,000

EXPECTED FLOWS 50 year rainfall intensity and duration unless noted

LOCATION		AREA IN ACRES Total Area A	Pervious Area A_p	Imperv's Area A_i	Infiltr'n (final) in/hr f_c	Concentration Time Street Slope	Min. t_c	RAIN Point Intensity I (10%)	Average Intensity Ia	RUNOFF Pervious $(Ia-f_c)0.8$ = Inches	$InxA_p$ = CFS	Impervious $(Ia-0.2)0.9$ = Inches	$InxA_i$ =CFS	Total Flow CFS	DESIGN FLOW AND REMARKS
Area 'A'		153	151	2	0.6		30	3.16	3.13	2.02	305	2.64	5	310	
	10 yr.	153	151	2	0.6		30	2.34	2.32	1.38	209	1.91	4	213	
	5 yr.	153	151	2	0.6		30	1.98	1.96	1.09	165	1.58	3	168	
Highway Center Drain	50 yr.	15	4.4	10.6	0.6		17	4.4	4.38	3.02	13	3.76	40	53	In Pipe into Canal 36" at
Highway Center Drain	5 yr.	15	4.4	10.6	0.6		17	2.86	2.85	1.81	8	2.38	25	33	" " 4'/1000
Area 'B'		77	75	2	0.6		35	2.87	2.85	1.80	135	2.38	5	-	Part drains east to Cave Creek
Upper Half		42.4	41.4	1	0.6		22	3.80	3.76	2.53	105	3.20	3	108	
	5 yr.	42.4	41.4	1	0.6		22	1.85	1.83	0.98	41	1.47	1	42	
Peoria Underpass		23	6	17	0.6		10	5.60	5.54	3.95	24	4.81	82	106	
(Area B - West side Highway)		67	49	18	0.6		22	3.80	3.76	2.53	124	3.20	57	181	(If upper portion contributes)
Area 'C' and 'D'		83	81	2	0.6		35	2.87	2.85						Not a maximum
Upper half or 'D' only	50 yr.	78	77	1	0.6		23	3.72	3.69	2.47	190	3.17	3	193	
	10 yr.				0.6		23	2.78	2.76	1.73	133	2.20	2	135	
	5 yr.				0.6		23	2.37	2.35	1.24	95	1.93	2	97	
Cactus Road Underpass		22	4	18	0.6		10	5.60	5.54	3.95	16	4.81	87	103	
Area C & D - West side Highway		105	85	20	0.6		35	2.87	2.85	1.80	153	2.38	48	201	Use 210 (193 plus 1 pump)
Area 'E'	100 yr.	135	133	2	0.6		25	4.00	3.96	2.69	358	3.38	7	365	
	50 yr.	135	133	2	0.6		25	3.54	3.51	2.33	310	2.98	6	316	
	25 yr.	135	133	2	0.6		25	3.10	3.07	1.97	262	2.59	5	267	
	10 yr.	135	133	2	0.6		25	2.64	2.61	1.61	214	2.17	4	218	
	5 yr.	135	133	2	0.6		25	2.22	2.20	1.28	170	1.80	3	173	
	2 yr.	135	133	2	0.6		25	1.68	1.66	0.85	113	1.33	3	116	
'E' Future Conditions															
	100 yr.	135	100	35	0.9	.0023 to .005	28	3.76	3.72	2.25	225	3.17	111	336	
	50 yr.	135	100	35	0.9		28	3.30	3.27	1.89	189	2.76	96	285	
	25 yr.	135	100	35	0.9		28	2.90	2.87	1.57	157	2.40	84	241	
	10 yr.	135	100	35	0.9		28	2.44	2.42	1.21	121	2.00	70	191	
	5 yr.	135	100	35	0.9		28	2.07	2.05	0.92	92	1.66	58	150	
	2 yr.	135	100	35	0.9		28	1.56	1.54	0.51	51	1.21	42	93	
Thunderbird Underpass		32	17	15	0.6		10	5.60	5.54	3.95	67	4.81	72	139	
Area E - West side Highway		167	150	17	0.6		25	3.54	3.51	2.33	350	2.98	51	401	
Area 'F'		148	146	2	0.6		25	3.54	3.51	2.32	339	2.98	6	345	
	10 yr.						25	2.64	2.61	1.61	235	2.17	4	239	
	5 yr.						25	2.22	2.20	1.28	187	1.80	4	191	
Area F - West side Highway		151.7	147.7	4	0.6		25	3.54	3.51	2.32	343	2.98	12	355	
Area 'G'		249	248	1	0.6		36	2.83	2.81	1.77	438	2.35	2	440	
	10 yr.						36	2.08	2.06	1.17	290	1.67	2	292	
	5 yr.						36	1.76	1.74	0.91	226	1.39	1	227	
Greenway Road Underpass		21	6	15	0.6		10	5.60	5.54	3.95	24	4.81	72	96	
Area 'G' - West side Highway		270	254	16	0.6		36	2.83	2.81	1.77	450	2.35	38	488	
Area 'H'		300	298	2	0.6		35	2.87	2.84	1.79	533	2.38	5	538	
	10 yr.						35	2.12	2.10	1.20	358	1.70	3	361	
	5 yr.						35	1.78	1.76	0.93	278	1.40	3	281	
Area 'H' - West side Highway		303.7	299.8	3.9	0.6		35	2.87	2.84	1.79	536	2.38	9	545	

EXPECTED FLOWS 50 year rainfall intensity and duration unless noted

LOCATION		AREA IN ACRES Total Area A	Pervious Area A_p	Imperv's Area A_i	Infiltr'n (final) in/hr f_c	Concentration Time Street Slope	Min. t_c	RAIN Point Intensity I(10%)	Average Intensity Ia	RUNOFF Pervious $(Ia-f_c)0.8$ = Inches	$InxA_p$ = CFS	Impervious $(Ia-0.2)0.9$ = Inches	$InxA_i$ =CFS	Total Flow CFS	DESIGN FLOW AND REMARKS
Area 'I'	100 yr.	1,617	1,573	44	0.7		81	1.88	1.86	0.85	1,374	1.50	66	1,440	
Area 'I'	50 yr.	1,617	1,573	44	0.7		81	1.61	1.59	0.71	1,120	1.25	55	1,175	Not a maximum
Lower Portion		1,470	1,426	44	0.7		73	1.73	1.71	0.81	1,150	1.36	60	1,210	
	25 yr.	1,470	1,426	44	0.7		73	1.50	1.48	0.62	880	1.15	50	930	
	10 yr.	1,470	1,426	44	0.7		73	1.24	1.23	0.42	600	0.93	40	640	
	5 yr.	1,470	1,426	44	0.7		73	1.05	1.04	0.27	385	0.76	35	420	
Bell Road Underpass		41	27	14	0.7		10	5.60	5.54	3.87	105	4.81	67	172	
Area I - West of Highway (part)		1,511	1,453	58	0.7		73	1.73	1.71	0.81	1,171	1.36	79	1,250	
'I' Future Conditions	50 yr.	1,470	1,100	370	0.9	.0055	105	1.32	1.30	0.32	353	0.99	367	720	
	25 yr.	1,470	1,100	370	0.9		105	1.13	1.12	0.18	198	0.83	307	505	
	10 yr.	1,470	1,100	370	0.9		105	0.94	0.93	0.02	22	0.66	243	265	
	5 yr.	1,470	1,100	370	0.9		105	0.80	0.79	-	0	0.53	196	196	
	2 yr.	1,470	1,100	370	0.9		105	0.59	0.58	-	0	0.34	125	125	
Area 'J'		694	689	5	0.7		63	1.92	1.90	0.96	662	1.53	8	670	
	10 yr.	694	689	5	0.7		63	1.40	1.39	0.55	379	1.06	5	384	
	5 yr.	694	689	5	0.7		63	1.18	1.17	0.38	262	0.87	4	266	
Area J - West of Highway		696.3	690	6.3	0.7		63	1.92	1.90	0.96	662	1.53	10	672	
Area 'K'		2,230	2,210	20	0.7		82	1.58	1.56	0.69	1,525	1.22	25	1,550	
	10 yr.	2,230	2,210	20	0.7		82	1.14	1.12	0.34	752	0.83	17	769	Upper area might be greater
	5 yr.	2,230	2,210	20	0.7		82	0.96	0.95	0.20	442	0.67	13	455	Upper area might be greater
Union Hills Underpass		17	4	13	0.7		10	5.60	5.54	3.87	16	4.81	62	78	
Area K - West of Highway		2,255	2,218	37	0.7		82	1.58	1.56	0.69	1,530	1.22	45	1,575	
Area 'L'		123	122	1	0.7		26	3.44	3.41	2.17	265	2.89	3	268	
	10 yr.	123	122	1	0.7		26	2.56	2.54	1.47	179	2.11	2	181	
	5 yr.	123	122	1	0.7		26	2.19	2.17	1.18	144	1.77	2	146	
Area L - West of Highway		126.2	123.5	2.7	0.7		26	3.44	3.41	2.17	268	2.89	8	276	
Area 'M'		85	85	0	0.7		27	3.36	3.33	2.10	178	2.82	0	178	
	10 yr.	85	85	0	0.7		27	2.52	2.50	1.44	122	2.07	0	122	
	5 yr.	85	85	0	0.7		27	2.12	2.10	1.12	95	1.71	0	95	
Area M - West of Highway		89	87	2	0.7		27	3.36	3.33	2.10	183	2.82	6	189	
Area 'N'		199	197	2	0.7		30	3.16	3.13	1.94	382	2.63	5	387	
	10 yr.	199	197	2	0.7		30	2.34	2.32	1.30	256	1.91	4	260	
	5 yr.	199	197	2	0.7		30	1.98	1.97	1.02	201	1.60	3	204	
Beardsley Drive Underpass		18	2	16	0.7		10	5.60	5.54	3.87	8	4.81	77	85	
Area N - West of Highway		221	201	20	0.7		30	3.16	3.13	1.94	390	2.63	53	443	
Area 'O'		336	329	7	0.7		56	2.09	2.07	1.10	362	1.68	12	374	
	10 yr.	336	329	7	0.7		56	1.51	1.50	0.64	211	1.17	8	219	
	5 yr.	336	329	7	0.7		56	1.29	1.28	0.46	151	0.97	7	158	
Area O - West of Highway		339	330.5	8.5	0.7		56	2.09	2.07	1.10	363	1.68	14	377	

EXPECTED FLOWS 50 **year rainfall intensity and duration unless noted**

LOCATION	AREA IN ACRES Total Area A	Pervious Area A_p	Imperv's Area A_i	Infiltr'n (final) in/hr f_c	Concentration Time Street Slope	Min. t_c	RAIN Point Intensity I (10%)	Average Intensity Ia	RUNOFF Pervious $(Ia-f_c)0.8$ = Inches	$InxA_p$ = CFS	Impervious $(Ia-0.2)0.9$ = Inches	$InxA_i$ =CFS	Total Flow CFS	DESIGN FLOW AND REMARKS
Area 'P'	101	100	1	0.7		32	3.05	3.02	1.86	186	2.54	3	189	
10 yr.	101	100	1	0.7		32	2.23	2.21	1.22	122	1.81	2	124	
5 yr.	101	100	1	0.7		32	1.90	1.89	0.96	96	1.52	2	98	
Area 'P' - West of Highway	109.2	104.2	5	0.7		32	3.05	3.02	1.86	194	2.54	13	207	
Area 'Q'	75	74	1	0.7		23	3.72	3.70	2.40	177	3.15	3	180	
10 yr.	75	74	1	0.7		23	2.77	2.76	1.65	122	2.30	2	124	
5 yr.	75	74	1	0.7		23	2.34	2.33	1.30	96	1.92	2	98	
Area 'Q' - West of Highway	77.9	75.4	2.5	0.7		23	3.72	3.70	2.40	181	3.15	8	189	
Area 'R'	322	298	24	0.7		43	2.40	2.38	1.34	400	1.96	47	447	
Lower Portion	280	258	22	0.7		38	2.73	2.70	1.60	413	2.25	50	463	
10 yr.	280	258	22	0.7			2.00	1.98	1.02	263	1.60	35	298	
5 yr.	280	258	22	0.7			1.68	1.66	0.77	198	1.31	29	227	
Deer Valley Underpass	29	17	12	0.7		10	5.60	5.54	3.87	66	4.81	58	124	
Area 'R' - West of Highway (part)	313	278	35	0.7		38	2.73	2.70	1.60	445	2.25	79	524	
Area 'R-R'	114	113	1	0.7		29	3.22	3.19	1.99	225	2.69	3	228	
10 yr.	114	113	1	0.7		29	2.40	2.38	1.34	151	1.96	2	153	
5 yr.	114	113	1	0.7		29	2.01	2.00	1.04	118	1.62	2	120	
Area R-R - West of Highway	118	115	3	0.7		29	3.22	3.19	1.99	229	2.67	8	237	
Area 'S'	1,222	1,221	1	0.8		73	1.73	1.70	0.72	878	1.35	1	879	
Central Portion	660	660	0	0.8		34	2.93	2.90	1.68	1,107	2.47	0	1,107	
10 yr.	660	660	0	0.8		34	2.16	2.13	1.06	700	1.74	0	700	
5 yr.	660	660	0	0.8		34	1.82	1.80	0.80	530	1.44	0	530	
Area S - West of Highway (part)	664	662	2	0.8		34	2.93	2.90	1.68	1,112	2.47	5.0	1,117	
Area 'T' 100 yr.	5,770	5,762	8	0.8		56	2.42	2.39	1.27	7,314	1.98	16	7,330	
Area 'T' 50 yr.	5,770	5,762	8	0.8		56	2.09	2.03	0.98	5,647	1.65	13	5,660	
Partial 50 yr.	4,800	4,792	8	0.8		50	2.27	2.21	1.13	5,416	1.81	14	5,430	Not a maximum
25 yr.	4,800	4,792	8	0.8		50	1.96	1.90	0.88	4,220	1.53	12	4,230	
10 yr.	4,800	4,792	8	0.8		50	1.65	1.60	0.64	3,070	1.26	10	3,080	
5 yr.	4,800	4,792	8	0.8		50	1.39	1.35	0.44	2,110	1.03	8	2,118	
2 yr.	4,800	4,792	8	0.8		50	1.02	1.00	0.16	767	0.72	6	783	
Area T - West of Highway	5,795	5,782	13	0.8		56	2.09	2.03	0.98	5,676	1.65	22	5,698	

EXPECTED FLOWS 50 year rainfall intensity and duration unless noted

LOCATION		AREA IN ACRES Total Area A	Pervious Area A_p	Imperv's Area A_i	Infiltr'n (final) in/hr f_c	Concentration Time Street Slope	Min. t_c	RAIN Point Intensity I (10%)	Average Intensity Ia	RUNOFF Pervious $(Ia-f_c)0.8$ = Inches	Pervious $IaxA_p$ = CFS	Impervious $(Ia-0.2)0.9$ = Inches	Impervious $IaxA_i$ =CFS	Total Flow CFS	DESIGN FLOW AND REMARKS
Station 443 + 00		0.74	0.74		0.8		10	5.60	5.04	3.39	2.5			2.5	
	5 yr.	0.74	0.74		0.8		10	3.85	3.81	2.41	1.8			1.8	
Station 452 + 00		4.13	1.81	2.32	0.8		10	5.60	5.04	3.39	6.1	5.26	12.2	18.3	
	5 yr.	4.13	1.81	2.32	0.8		10	3.85	3.81	2.41	4.4	3.25	7.5	11.9	
Station 461 + 00		1.67	1.67		0.8		10	5.60	5.04	3.39	5.7	5.26		5.7	
	5 yr.	1.67	1.67		0.8		10	3.85	3.81	2.41	4.0	3.25		4.0	
Station 498 + 50		5.06	2.29	2.77	0.8		10	5.60	5.04	3.39	7.8	5.26	14.6	22.4	
	5 yr.	5.06	2.29	2.77	0.8		10	3.85	3.81	2.41	5.5	3.25	9.0	14.5	
Station 509 + 50		7.02	4.0	3.02	0.8		16	4.50	4.05	2.60	10.4	3.47	10.5	20.9	
	5 yr.	7.02	4.0	3.02	0.8		16	2.97	2.94	1.71	6.8	2.47	7.5	14.3	

Notes regarding time of concentration

(1) Some of the underpasses and smaller highway areas drain in less than 10 minutes and higher flows would thus be indicated. We used a minimum 10 minutes in all cases.

(2) Estimates of travel time in pipes, or regular sections such as the highway medians was made from Scobey's charts. Most of the 'time' calculations were made from the text formula.

(3) 'Time' was considered the same at east or west side of highway although there is up to a minutes difference.

A sample calculation using the formula $tc = 5.75 \left(\frac{L^2}{S}\right)^{\frac{1}{3}}$ - see text

Area	Acres	L	S	$\frac{L^2}{S}$	$\left(\frac{L^2}{S}\right)^{\frac{1}{3}}$	tc
'H'	300	1.07	.0053	216	6.0	35
'T'	5770	3.7	.015	913	9.72	56

EXPECTED FLOWS 5 **year rainfall intensity and duration unless noted**

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Area 'A'	153	151	2	0.6		30	1.98	1.96	1.09	165	1.58	3	168	No outlet
Highway Center to Canal	15	4.4	10.6	0.6		17	2.86	2.85	1.81	8	2.38	25	33	
Area 'B' (part drains east)	77	75	2											Not applicable
Upper half	42.4	41.4	1	0.6		22	1.85	1.83	0.98	41	1.47	1	42	
Peoria Underpass	23	6	17	0.6		10	3.85	3.83	2.58	15	3.27	56	71	
(Area 'B' - West of Highway)	67	49	18	0.6		22	1.85	1.83	0.98	48	1.47	27	75	If upper half contributed
Area 'C' & 'D'	83	81	2	0.6		35	1.78	1.77	0.94	76	1.41	3	79	Not a maximum
Upper half or 'D' only	78	77	1	0.6		23	2.37	2.35	1.24	95	1.93	2	97	
Cactus Road Underpass	22	4	18	0.6		10	3.85	3.83	2.58	10	3.27	59	69	
Area 'C & D'- West of Highway	105	85	20	0.6		35	1.78	1.77	0.94	80	1.41	28	108	Use 115 (97 plus 1 pump)
Area 'E'	135	133	2	0.6		25	2.22	2.20	1.28	170	1.80	3	173	
Thunderbird Underpass	32	17	15	0.6		10	3.85	3.83	2.58	44	3.27	49	93	
Area 'E' - West of Highway	167	150	17	0.6		25	2.22	2.20	1.28	192	1.80	31	223	
Area 'F'	148	146	2	0.6		25	2.22	2.20	1.28	187	1.80	4	191	
Area 'F' - West of Highway	151.7	147.7	4	0.6		25	2.22	2.20	1.28	190	1.80	7	197	
Area 'G'	249	248	1	0.6		36	1.76	1.74	0.91	226	1.39	1	227	
Greenway Road Underpass	21	6	15	0.6		10	3.85	3.83	2.58	16	3.27	49	65	
Area 'G' - West of Highway	270	254	16	0.6		36	1.76	1.74	0.91	231	1.39	22	255	
Area 'H'	300	298	2	0.6		35	1.78	1.76	0.93	279	1.40	3	282	
Area 'H' - West of Highway	303.7	299.8	3.9	0.6		35	1.78	1.76	0.93	282	1.40	6	288	

EXPECTED FLOWS 5 **year rainfall intensity and duration unless noted**

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Area 'I'	1,617	1,573	44	0.7		81								Not a maximum
Lower Portion (part)	1,470	1,426	44	0.7		73	1.05	1.04	0.27	385	0.76	35	420	
Bell Road Underpass	41	27	14	0.7		10	3.85	3.83	2.58	70	3.27	46	116	
Area 'I' - West of Highway (part)	1,511	1,453	58	0.7		73	1.05	1.04	0.27	392	0.76	44	436	
Area 'J'	694	689	5	0.7		63	1.18	1.17	0.38	262	0.87	4	266	
Area 'J' - West of Highway	696.3	690	6.3	0.7		63	1.18	1.17	0.38	263	0.87	6	269	
Area 'K'	2,230	2,210	20	0.7		82	0.96	0.95	0.20	442	0.67	13	455	
Union Hills Underpass	17	4	13	0.7		10	3.85	3.83	2.58	10	3.27	43	53	
Area 'K' - West of Highway	2,255	2,218	37	0.7		82	0.96	0.95	0.20	444	0.67	25	469	
Area 'L'	123	122	1	0.7		26	2.19	2.17	1.18	144	1.77	2	146	
Area 'L' - West of Highway	126.2	123.5	2.7	0.7		26	2.19	2.17	1.18	149	1.77	5	154	
Area 'M'	85	85	0	0.7		27	2.12	2.10	1.12	95	1.71	0	95	
Area 'M' - West of Highway	89	87	2	0.7		27	2.12	2.10	1.12	98	1.71	3	101	
Area 'N'	199	197	2	0.7		30	1.98	1.97	1.02	201	1.59	3	204	
Beardsley Dr. Underpass	18	2	16			10	3.85	3.83	2.58	5	3.27	52	57	
Area 'N' - West of Highway	221	201	20	0.7		30	1.98	1.97	1.02	205	1.59	32	237	
Area 'O'	336	329	7	0.7		56	1.29	1.28	0.46	151	0.97	7	158	
Area 'O' - West of Highway	339	330.5	8.5	0.7		56	1.29	1.28	0.46	152	0.97	8	160	

EXPECTED FLOWS 5 year rainfall intensity and duration unless noted

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Area 'P'	101	100	1	0.7		32	1.90	1.89	0.96	96	1.52	2	98	
Area 'P' - West of Highway	109.2	104.2	5.0	0.7		32	1.90	1.89	0.96	100	1.52	8	108	
Area 'Q'	75	74	1	0.7		23	2.34	2.33	1.30	96	1.92	2	98	
Area 'Q' - West of Highway	77.9	75.4	2.5	0.7		23	2.34	2.33	1.30	98	1.92	5	103	
Area 'R'	322	298	24	0.7		43	1.53	1.52	0.66	195	1.19	29	224	
Lower Portion (part)	280	258	22	0.7		38	1.68	1.66	0.77	198	1.31	29	227	
Deer Valley Interchange	29	17	12	0.7		10	3.85	3.83	2.58	44	3.27	39	83	
Area 'R' - West of Highway (part)	313	278	35	0.7		38	1.68	1.66	0.77	241	1.31	46	287	
Area 'R-R'	114	113	1	0.7		29	2.01	2.00	1.04	118	1.62	2	120	
Area 'R-R' - West of Highway	118	115	3	0.7		29	2.01	2.00	1.04	118	1.62	5	123	
Area 'S'	1,222	1,221	1	0.8		73								Not a maximum
Central Portion (part)	660	660	0	0.8		34	1.82	1.80	0.80	530	1.44	0	530	
Area 'S' - West of Highway (part)	664	662	2	0.8		34	1.82	1.80	0.80	531	1.44	3	534	
Area 'T'	5,770	5,762	8	0.8		56	1.28	1.25	0.36	2,070	0.94	8	2,078	Not a maximum
Part area	4,800	4,792	8	0.8		50	1.39	1.35	0.44	2,110	1.03	8	2,118	
Area 'T' - West of Highway (part)	4,825	4,812	13	0.8		50	1.39	1.35	0.44	2,117	1.03	13	2,130	
Area G & H combined	549	546	3	0.6		36	1.76	1.74	0.91	497	1.39	4	501	
Area N, O & P combined	636	626	10	0.7		56	1.29	1.28	0.46	288	0.97	10	298	
Area K, L & M combined	2,441	2,440	21	0.7		82	0.96	0.95	0.20	488	0.67	14	502	
Area I & J combined	2,311	2,262	49	0.7		73	1.05	1.04	0.27	611	0.76	37	648	

AREA DESCRIPTION Black Canyon Highway

Existing Conduit Crossings

(Flows per Scobey chart)

n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor
n= 0.021 Corrugated Metal Pipe

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	P=WET. PER. $r = \frac{A}{P}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
C & D 492+21	Two 58" x 36" Arch CMP	0.021	5.75'	11.4 ea.	0.9	4.8	54x2=108
	Not installed - head conditions unknown						
E 546+27	Two 6'x3' Box Culv.	0.012	1.0	18 ea.	1.0	4.0	72x2=144
	improved by head (2.3 available)		3+			7+	126x2=250
F 561+27	Two 6x3 Box Culv.	0.012	1.0	18 ea.	1.0	4.0	74x2=148
	Limited by head of 0.1 ft.			15			120
G 599+27	Two 6 x 3 Box Culv.	0.012	2.0	18 ea.		5.7	102x2=204
H 614+04	Three 10'x3' Box Culv.	0.012	7.7	30 ea.	1.15	12.5	375x3=1125
	Limited by 0.8 head available						230x3=700 est.
I 652 +72	Two 6x3 Box Culv.	0.012	5	18	1.0	9.1	164x2=328
	Limited by 0.1 head available			12	1.2	8	100x2=200 est
J 667+37	50"x31" Arch CMP	0.021	2	8.7	0.8	4.9	42
	Limited by depth 1.6 ft.						30

AREA DESCRIPTION Black Canyon Highway

Existing Conduit Crossings

(Flows per Scobey Chart)

n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor
n= 0.021 Corrugated Metal Pipe

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r = \frac{A}{p}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
K 703 +80	Three 10'x3' Box Culv.	0.012	6.5	30 ea.	1.15	10.8	324x3=972
	Limited by head (0.2 available)			20	1.4	8	160x3=480 500 est.
L 720+93	50"x31" ArchCMP	.021	4.0	8.7	0.8	3.6	31
	Limited by depth 0.9 ft.						10 est.
M 735+03	Two 24" CMP	.021	1.0	3.14ea.	0.5	1.3	5x2=10
	Limited by depth 0.7 ft.						4
N 758+00	Two 43"x27" Arch CMP	.021	3.6	6.4 ea.	0.7	3.0	19x2=38
	Improved by head (1.7' available)		6 ±			4	25x2=50
O 767+50	36"x22" Arch CMP	.021	13(part)	4.4	0.5	4.6	20
	Limited by depth 0.5 ft.						5 est.
P 774+00	50"x31" Arch CMP	.021	12(part)	8.7	0.8	6.5	56
	Limited by depth 0.8 ft.						15 est.

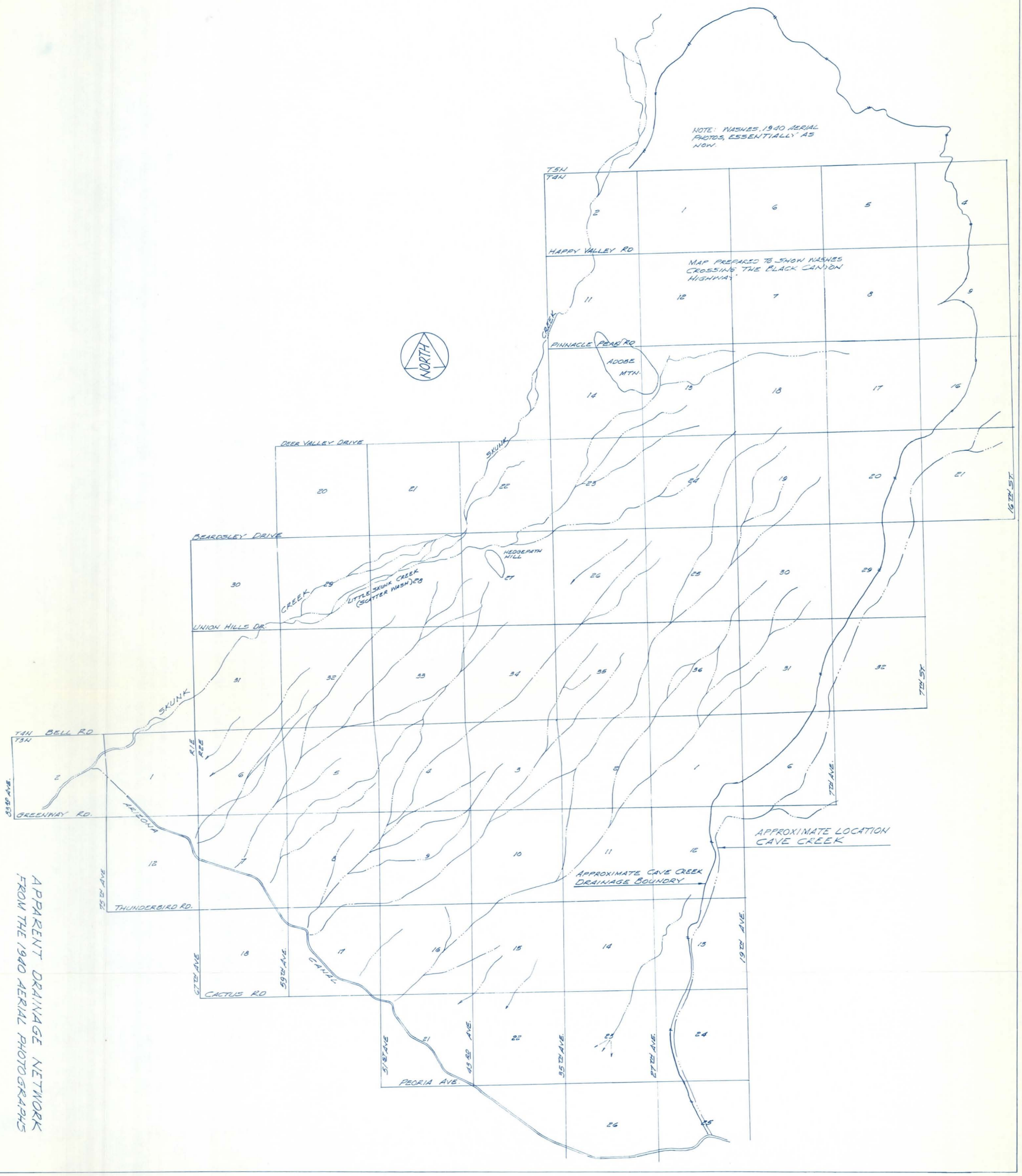
AREA DESCRIPTION Black Canyon Highway

Existing Conduit Crossings

(Flows per Scobey chart)

n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor
n= 0.021 Corrugated Metal Pipe

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	P=WET. PER. $r = \frac{A}{P}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
Q 791+80	65"x40" Arch CMP	0.021	3.4	14.3	1.0	4.0	57
	Limited by head available						50 est.
R 806+59	6'x3' Box Culv.	0.012	5.0	18	1.0	9.2	166
	Head available 1.3 ft.						
RR 813+88	65"x40" Arch CMP	0.021	16.0	14.3	1.0	8.7	125
	Limited by depth 0.2 below top culvert						90 est.
S 831+50	6' x 7' Box Culv.	0.012	4.2	42	1.6	11.5	480
T 840+50	Two 8' x 7' Box Culv.	0.012	2.8	56 ea.	1.8+	10	560x2=1120
	Limited by head available 1.1					8	450x2=900
							500 =1000 est.
Various	29" x 18" Arch CMP	0.021	15 ±	2.8	0.9	8	22
	Head available varies						



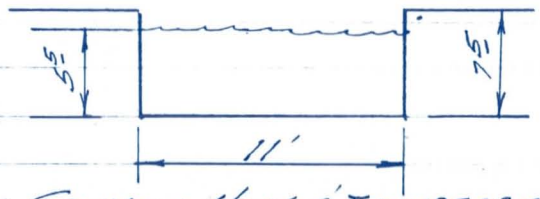
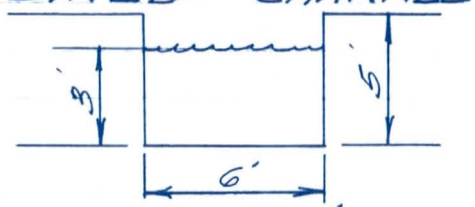
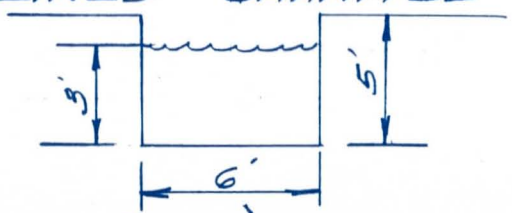
APPARENT DRAINAGE NETWORK FROM THE 1940 AERIAL PHOTOGRAPHS

APPENDIX IV

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

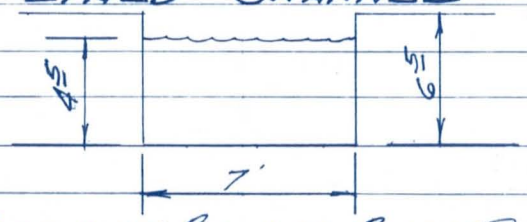
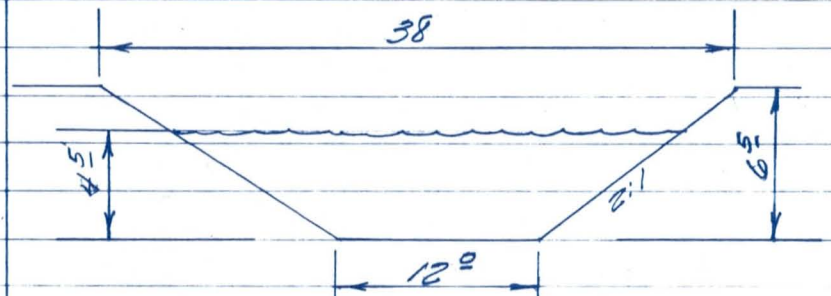
n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r=\frac{A}{p}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
N.W. COR. BLACK CANYON HWY. & THUNDERBIRD RD (CHANNEL FROM HIGHWAY CROSSING TO PUMPS)	LINED CHANNEL 	0.015	3.0	55	2.6	10.2	560
N.W. COR. BLACK CANYON AND ARIZONA CANAL	LINED CHANNEL 	0.015	6	18	1.5	10.5	190
AREA "A" - (WEST SIDE)	LINED CHANNEL 	0.015	4	18	1.5	8.4	150

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

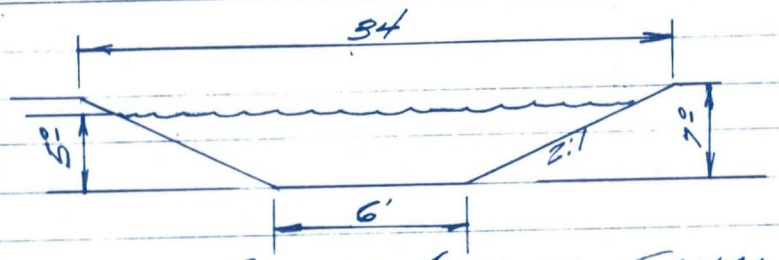
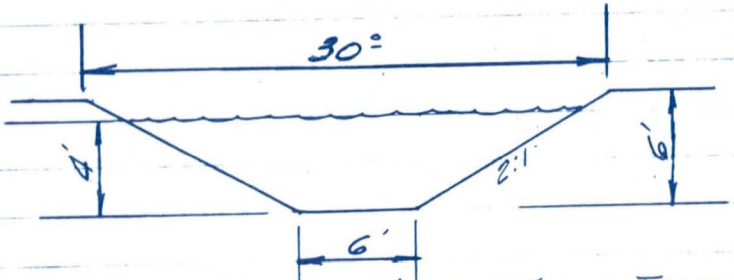
n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r=\frac{A}{p}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
	LINED CHANNEL 	0.015	7.0	31.5	2.0	10.0	315
N.W. CORNER GREENWAY RD. AND BLACK CANYON HWY.							
		0.020	3.3	95	3.0	12.0	1140
67TH AVE and 1/2 mile south of BELL RD.							

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

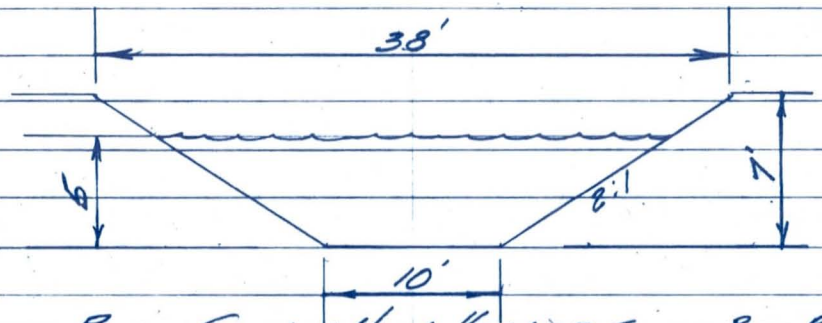
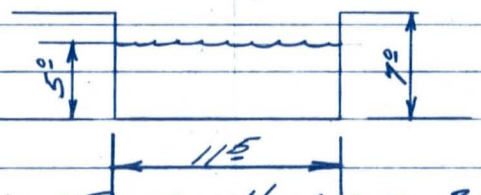
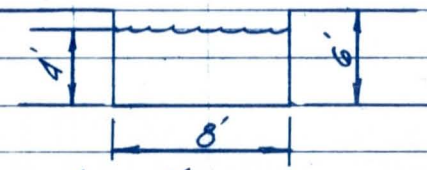
n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r=\frac{A}{p}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
	 THUNDERBIRD RD. AT ARIZONA CANAL	0.020	2.5	80.0	2.85	10.0	800
	 N.W. CORNER BLACK CANYON HIGHWAY AND THUNDERBIRD RD (DITCH TO WEST)	0.020	3.5	56	2.3	10.6	595

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

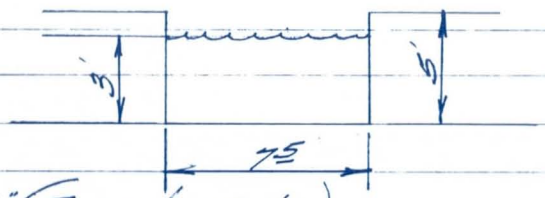
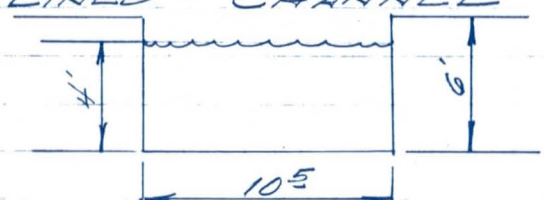
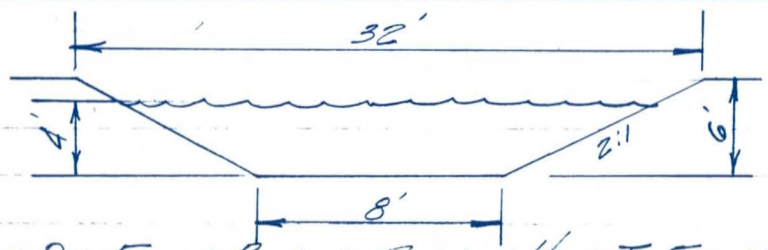
n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth - Brushy - Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS n	SLOPE FT. PER. 1000	AREA SQ.FT. A	P = WET. PER. $r = \frac{A}{P}$	VEL. FT./SEC. V	QUANT. C.F.S. Q
WEST SIDE BLACK CANYON HWY 1/2 MILE SO. OF BELL RD		0.020	3.0	100	3.1	10.6	1060
N.W. CORNER OF BLACK CANYON HWY. AND BELL RD.	LINED CHANNEL 	0.015	7.5	57.5	2.7	17.1	980
E. SIDE BLACK CANYON HWY 1/2 MILE NO. OF BELL RD	LINED CHANNEL 	0.015	4.0	32	2.0	10.2	326

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

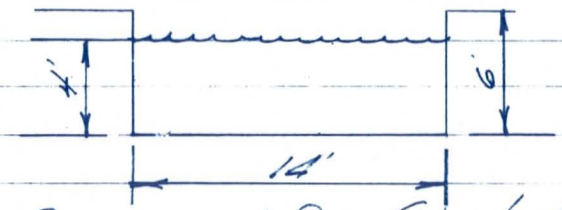
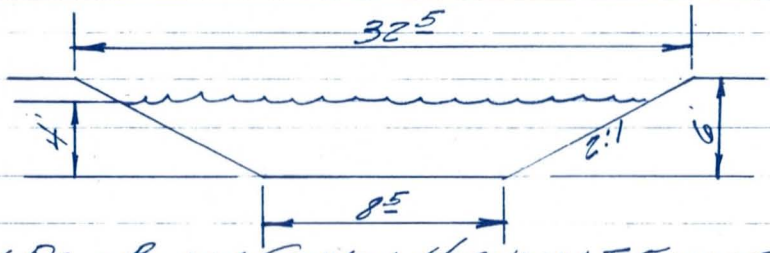
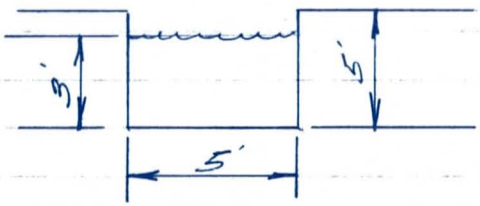
n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	P=WET. PER. $r=\frac{A}{P}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
AREA "L" TO "K" (East Side)	LINED CHANNEL 	0.015	6.7	22.5	1.7	12	270
AREA "K" TO UNION HILLS DR - (West Side)	LINED CHANNEL 	0.015	5	42	2.3	12.8	540
UNION HILLS DR FROM BLACK CANYON HWY. TO SKUNK CREEK		0.020	3.9	64	2.5	8.7	555
(Can reduce bottom to 7½ at Highway.)		0.020	3.9	62	2.4+	8.5	525

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

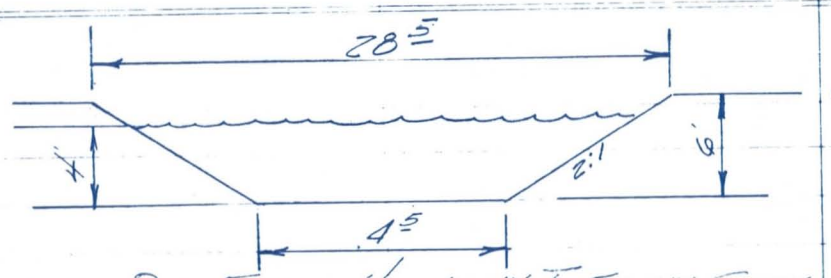
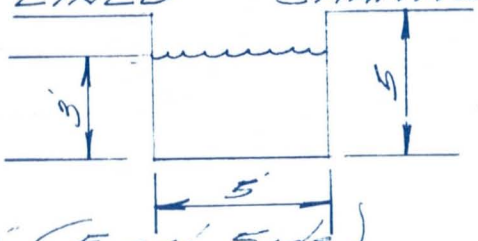
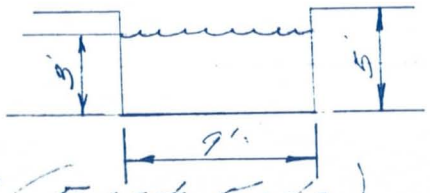
n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth - Brushy - Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r=\frac{A}{p}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
	LINED CHANNEL 	0.015	3.3	56	2.5+	10.9	613
AREA "K" TO BEARDSLEY DR (West Side)							
		0.020	5.1	66	2.5	10	660
BEARDSLEY DR. - BLACK CANYON HIGHWAY TO SKUNK CREEK (Can Reduce bottom to 8° at Highway)		0.020	5.1	64	2.5	10	640
	LINED CHANNEL 	0.015	4.0	15	1.35	8	120
AREA "M" TO "L" (East side)							

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

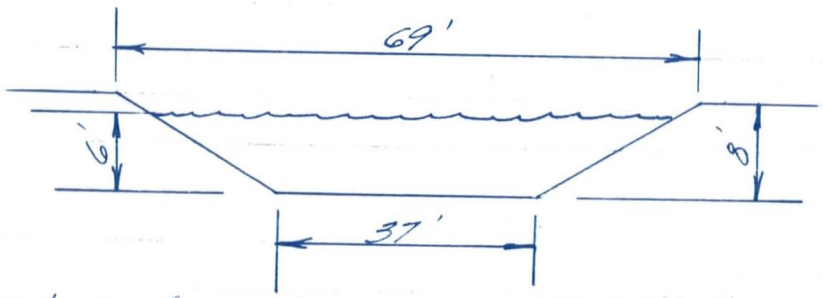
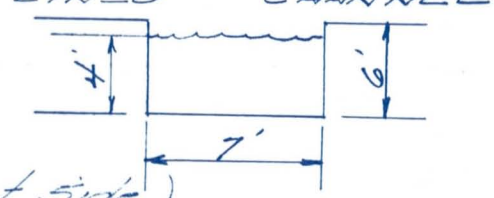
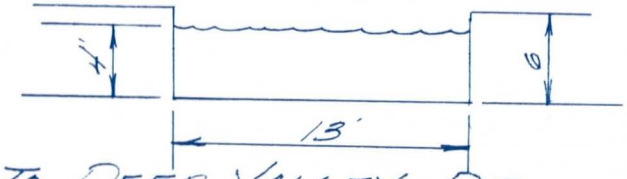
n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth - Brushy - Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r=\frac{A}{p}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
DEER VALLEY DR FROM HIGHWAY TO SKUNK CREEK		0.020	5.0	50	2.2	9	450
AREA "P" TO "O" (East Side)	LINED CHANNEL 	0.015	3.3	15	1.4	7.3	110
AREA "O" TO "N" (East Side)	LINED CHANNEL 	0.015	3.4	27	1.8	9	243

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

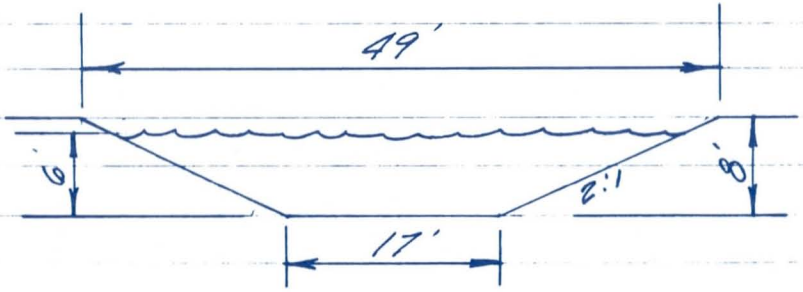
n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r=\frac{A}{P}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
AREA "T&S" (East side Highway)		0.020	3.1	294	4.6	11.7	3440
"R-R"-To "R" (West Side)	LINED CHANNEL 	0.015	2.0	28	1.9	6.9	193
AREA "L" To DEER VALLEY DR.	LINED CHANNEL 	0.015	2.2	50	2.5	8.8	457

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r=\frac{A}{p}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
		0.020	0.6	174	4.2	4.6	790
NORTH SIDE ARIZONA CANAL FROM THUNDERBIRD RD TO 1/2 MILE NO. OF GREENWAY RD							

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor

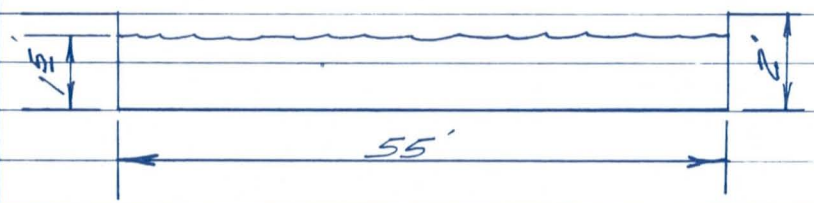
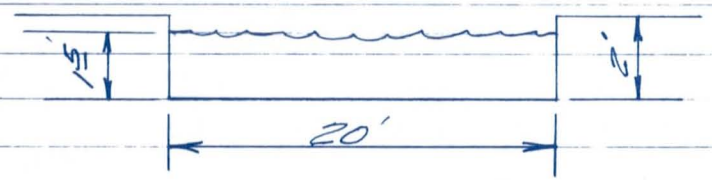
STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r=\frac{A}{p}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
AREA	"P" TO "O": Q=20 C.F.S S=3.3 = 30"	Ø C.P					
AREA	"O" TO "N": Q=30 C.F.S. - S=3.3 = 36"	Ø C.P.					
AREA	"M" TO "L": Q=20 C.F.S - S=4.6 = 30"	Ø C.P					
AREA	"L" TO "K": Q=30 C.F.S. - S=5.9 = 30"	Ø C.P.					
AREA	"J" TO "I": Q=40 C.F.S - S=5.0 = 36"	Ø C.P					
AREA	"D" TO "C": Q=20 C.F.S - S=3.0 = 30"	Ø C.P.					
AREA	"D" TO "C": Q=30 C.F.S - S=3.0 = 36"	Ø C.P					

AREA DESCRIPTION BLACK CANYON HIGHWAY

RECOMENDED CONDUITS & CHANNELS

(ALTERNATE)

n=0.011 Big Concrete Culverts
n=0.012 Pipe Culverts 21" & Larger
n=0.015 Street Paving
Concrete Lined Waterway
n=0.020 Earth-Best
n=0.030 Earth-Brushy-Poor

STA. OR LOCATION	WATERWAY DESCRIPTION	ROUGHNESS =n	SLOPE FT. PER. 1000	AREA SQ.FT. =A	p=WET. PER. $r=\frac{A}{p}$	VEL. FT./SEC. =V	QUANT. C.F.S. =Q
		0.015	3.75	82.5	1.42	7.8	645
							
WEST SIDE HIWAY FROM ARIZONA CANAL 2000 FT. NORTH							
		0.015	3.0	30	1.3	6.5	195
							
WEST SIDE HIWAY FROM ARIZONA CANAL 1000 FT. NORTH							

COST ESTIMATE

LOCATION Areas A,B,C,D Arizona Canal to Sweetwater Road

	Quantity & Unit	Unit Cost	Total Cost
Land & Right-of-Way			
10' along Highway for 13,000'	3 Acres	$8,000	$24,000
150' wide along Arizona Canal 2,500'	8.6 Acres	4,000	35,000
Houses and Buildings, etc.	None	- -	- -
Utility Relocation, Irrigation Crossing		L.S.	5,000
Other Construction Costs			
Pipe as Channel 30" and 36"	2,000 L.F.	17.00	34,000
Earth Channels	None	- -	- -
Lined Channels Q = 130 c.f.s. to 185 c.f.s.	13,000 L.F.	10.00	130,000
Bridges or Culverts on Channel	Two Each	10,000	20,000
Corrug. Culvert Crossing B.C.	None	- -	- -
Bridges or Box culvert crossing B.C.	None	- -	- -
Appurtenances		L.S.	4,000
Fencing 13,000' Single Cable @ 0.50 1,000' Reconstruct Chain Link @ 0.50	14,000 L.F.	0.50	7,000
Detention Basin	One Each	L.S.	23,000
Subtotal			$282,000
Engineering & Miscellaneous 10%			28,000
Contingencies 10%			28,000
	GRAND TOTAL		$338,000

General Project Description

Consists of 1,200 L.F. of 30" concrete pipe, 800 L.F. of 36" pipe, a lined waterway 11,000 feet in length from about 700 feet north of Cactus Road southerly to the Arizona Canal; all on the west side of Black Canyon Highway. A detention Basin west of Black Canyon Highway and north of and adjacent to the Arizona Canal, about 150 feet in width and 2,500 feet in length. Capacity of the pipes are 20 and 30 c.f.s. The lined channel is designed for 130 c.f.s. north of Cactus Road to 185 c.f.s. at the Arizona Canal.

COST ESTIMATE

LOCATION - Areas E,F,G. Thunderbird Road & Greenway Road

	Quantity & Unit	Unit Cost	Total Cost
Land & Right-or-Way			
10' along Highway for 7,000 feet	1.6 Acres	$8,000	$13,000
40' along Thunderbird for 21,400 feet	20 Acres	5,000	100,000
60' along Arizona Canal for 13,000 feet.	18 Acres	4,000	72,000
Utility Relocation		L.S.	2,000
Other Construction Costs			
Pipe as Channel	None	- - -	- - -
Earth Channels Q = 590 to 800 c.f.s.	34,400 L.F.	5.00	172,000
Lined Channels Q = 300 to 560 c.f.s.	7,000 L.F.	14.00	98,000
Bridges or Culverts on Channel	Ten Ea.	7,500	75,000
Corrug. Culvert Crossing B.C.	None	- -	- - -
Bridges or Box Culvert Crossing B.C. 6' x 3' Box Culverts	Three Ea.	20,000	60,000
Appurtenances		L.S.	4,000
Fencing 7,000' Single Cable @ $0.50	82,800 L.F.	0.42	35,000
Reconstruct 7,000' @ $0.50			
42,800' New 4-Strand @ $0.40			
26,000' New 4-Strand @ $0.40			
Subtotal			$631,000
Engineering & Miscellaneous 10%			63,000
Contingencies 10%			63,000
GRAND TOTAL			$757,000

General Project Description

Consists of one 6' x 3' box culvert across the Highway about 900 feet north of Greenway Road, and two 6' x 3' box culverts across the Highway about 2,600 feet south of Greenway Road. A lined waterway 7,000 feet in length from about 900 feet north of Greenway Road with a capacity of 300 c.f.s. to Thunderbird Road where the capacity is 560 c.f.s. A trapezoidal section dirt waterway from the Highway westerly along Thunderbird Road to Skunk Creek, with capacities varying from 590 c.f.s. to 790 c.f.s., a distance of about 34,400 feet.

COST ESTIMATE

LOCATION Areas A,B,C,D & E,F,G Combined (Alternate)
Arizona Canal to Greenway Road.

	Quantity & Unit	Unit Cost	Total Cost
Land & Right-of-Way			
10' along Highway for 24,000 feet	5.5 Acres	$8,000	44,000
200' wide along Arizona Canal for 4,000'	18.4 Acres	4,000	74,000
Houses and Building, etc.	None	- - -	- - -
Utility Relocation		L.S.	9,000
Other Construction Costs			
Pipe as Channel	None	- - -	- - -
Earth Channels	None	- - -	- - -
Lined Channels Q = 300 c.f.s. to 645 c.f.s.	23,000 L.F.	16.00	368,000
Bridges or Culverts on Channel	Eight Each	10,000	80,000
Corrug. Culvert Crossing B.C.	None	- - -	- - -
Bridges or Box Culverts Crossing B.C. 6' x 3' box culverts	Three Each	20,000	60,000
Appurtenances		L.S.	10,000
Fencing 8,000' Reconstruct Chain Link @ 0.50	43,000 L.F.	0.49	21,000
25,000' Single Cable @ 0.50			
10,000' Four Strand @ 0.40			
Detention Basin along Arizona Canal	One Each	51,000	51,000
Subtotal			$717,000
Engineering & Miscellaneous 10%			72,000
Contingencies 10%			72,000
GRAND TOTAL			$861,000

General Project Description

Consists of two 6' x 3' box culverts with a combined capacity of 120 c.f.s. across the Black Canyon Highway about 2,600 feet south of Greenway Road. One 6' x 3' box culvert with a capacity of 102 c.f.s. across the highway about 900 feet north of Greenway Road. A lined waterway on the west side of Black Canyon Highway from about 700' north of Greenway Road southerly to the Arizona Canal with capacities of 300 c.f.s. to 645 c.f.s. A detention basin north of and adjacent to the Arizona Canal and west of Black Canyon Highway, 4,000 feet in length and 200 feet in width.

COST ESTIMATE

LOCATION Areas H, I, J Bell Road

	Quantity & Unit	Unit Cost	Total Cost
Land & Right-or-Way 10' Along Highway for 3,000'	0.7 Acres	$8,000	$ 6,000
50' along Midsection Line 1/2 Mile south of Bell Road for 32,000'	37 Acres	5,000	185,000
Houses and Buildings, etc.	None	- -	- - -
Utility Relocation		L.S.	2,000
Other Construction Costs			
Pipe as Channel Q = 40 c.f.s. 36" Diameter	2,000 L.F.	18.00	36,000
Earth Channels Q = 1,050 to 1,120 c.f.s.	32,000 L.F.	5.00	160,000
Lined Channels Q = 320 to 980 c.f.s.	5,800 L.F.	15.00	87,000
Bridges or Culverts on Channel	Seven Each	7,500	53,000
Corrug. Culvert Crossing B.C.	None	- -	- -
Bridges or Box Culvert Crossing B.C. Triple 10'x3' Box Culvert	One Job	L.S.	89,000
Appurtenances		L.S.	3,000
Fencing 5,500 L.F. Single Cable @ $0.50	75,000 L.F.	0.41	31,000
New 4 Strand - 5,500' @ 0.40			
64,000 L.F. new 4-Strand @ 0.40			
Subtotal			$652,000
Engineering & Miscellaneous 10%			65,000
Contingencies 10%			65,000
	GRAND TOTAL		$782,000

General Project Description

Consists of three 10'x3' box culverts across Black Canyon Highway about 1,200 feet north of Bell Road; a lined waterway designed for 320 c.f.s. on the east side of the Highway from about 2,900 feet north of Bell Road to 1,200 feet north of Bell Road; 2,000 L.F. of 36" concrete pipe designed for 40 c.f.s. on the west side of the Highway from about 3,000 feet north of Bell Road to 1,000 feet north of Bell Road. A lined waterway 4,000 feet in length designed for 960 c.f.s. north of Bell Road to 980 c.f.s. at the midsection line between Bell Road and Greenway Road. A trapezoidal section dirt waterway westerly from the Highway just north of the midsection line between Bell Road and Greenway Road to Skunk Creek with capacities from 1,050 c.f.s. to 1,120 c.f.s., a distance of about 32,000 feet.

COST ESTIMATE

LOCATION Areas K,L,M. Union Hills Drive

	Quantity & Unit	Unit Cost	Total Cost
Land & Right-of-Way 10' along Highway for 4,000'	1 Acre	$8,000	$8,000
40' along Union Hills Drive for 20,000'	18.4 Acres	5,000	92,000
Houses and Buildings, etc.	None	- -	- -
Utility Relocation		L.S.	3,000
Other Construction Costs			
Pipe as Channel Q = 20 to 30 c.f.s., 30" and 36" Diameter	3,300 L.F.	17.00	56,000
Earth Channels Q = 520 to 550 c.f.s.	20,000 L.F.	3.30	66,000
Lined Channels Q = 120 to 500 c.f.s.	4,000 L.F.	10.00	40,000
Bridges or Culverts on Channel	Four Each	7,500	30,000
Corrug. Culvert Crossing B.C.	None	- -	- -
Bridges or Box Culverts Crossing B.C.	None	- -	- -
Appurtenances		L.S.	2,000
Fencing 4,000' Single Cable @ 0.50	48,000 L.F.	0.42	20,000
Reconstruct 4,000' 4-Strand @ 0.40			
40,000' New 4-Strand @ 0.40			
Subtotal			$317,000
Engineering & Miscellaneous 10%			32,000
Contingencies 10%			32,000
GRAND TOTAL			$381,000

General Project Description

Consists of a lined waterway designed for 120 c.f.s. to 260 c.f.s. on the east side of the Highway from 4,000 feet to 2,000 feet north of Union Hills Drive. 1,500 L.F. of 30" concrete pipe and 1,800 L.F. of 36" pipe on the west side of the Highway from 4,200 feet north to 900 feet north of Union Hills Drive. A lined channel designed for 500 c.f.s. from 900 feet north of to Union Hills Drive along the west side of the Highway. A trapezoidal section dirt waterway along the north side of Union Hills Drive from the Highway to Skunk Creek, with capacities from 520 c.f.s. to 550 c.f.s., a distance of about 20,000 L. F.

COST ESTIMATE

LOCATION Areas N, O, P. Beardsley Drive

	Quantity & Unit	Unit Cost	Total Cost
Land & Right-of-Way 15' along Highway for 1,000'	0.4 Acres	$8,000	$3,000
10' along Highway for 1,400'	0.3 Acres	8,000	3,000
40' along Beardsley Drive for 8,000'	7.4 Acres	4,000	30,000
Houses and Buildings, etc.	None	- -	- -
Utility Relocation		L.S.	2,000
Other Construction Costs			
Pipe as Channel Q = 20 to 30 c.f.s. 30" diameter & 36" diameter	1,500 L.F.	17.00	26,000
Earth Channels Q = 630 to 650 c.f.s.	8,000 L.F.	3.50	28,000
Lined Channels Q = 110 to 610 c.f.s.	2,500 L.F.	12.50	32,000
Bridges or Culverts on Channel	One Each	8,000	8,000
Corrug. Culvert Crossing B.C.	None	- -	- - -
Bridges or Box Culverts Crossing B.C. Double 9'x3' box culvert	One Each	53,000	53,000
Appurtenances		L.S.	2,000
Fencing Reconstruct 2,500' 4-strand @ 0.40	21,000 L.F.	0.43	9,000
16,000' New 4-Strand @ 0.40			
2,500 Single Cable @ 0.50			
Subtotal			$196,000
Engineering & Miscellaneous 10%			20,000
Contingencies 10%			20,000
	GRAND TOTAL		$236,000

General Project Description

A lined waterway on the east side of the Highway from 2,600 L.F. to 1,100 L.F. north of Beardsley Drive with a capacity from 110 c.f.s. to 250 c.f.s. 600 L.F. of 30" concrete pipe and 900 L.F. of 36" pipe on the west side of the Highway from 2,700 L.F. north to 1,200 L.F. north of Beardsley Drive with capacities of 20 c.f.s. and 30 c.f.s. Two 9'x3' box culverts across Black Canyon Highway about 1,200 L.F. north of Beardsley Drive with a combined capacity of 600 c.f.s. A lined waterway from about 1,200 L.F. north of to Beardsley Drive on the west side of the Highway with a capacity of 610 c.f.s. A trapezoidal section dirt waterway along the north side of Beardsley Drive from the Highway to Little Skunk Creek with capacities of 630 c.f.s. to 650 c.f.s., a distance of about 8,000 L.F.

COST ESTIMATE

LOCATION Area Q Below Deer Valley Drive

	Quantity & Unit	Unit Cost	Total Cost
Land & Right-of-Way 15' along Natural swale for 5,000'	1.7 Acres	$1,000	$2,000
Houses and Buildings, etc.	None	- - -	- - -
Utility Relocation	None	- - -	- - -
Other Construction Costs			
Pipe as Channel	None	- - -	- - -
Earth Channels Swale Improvement for 122 c.f.s.	5,000 L.F.	0.60	3,000
Lined Channels	None	- - -	- - -
Bridges or Culverts on Channel	None	- - -	- - -
Corrug. Culvert Crossing B.C. Two 43"x27" C.M.P. Arches	Two Each	6,000	12,000
Bridges or Box Culvert Crossing B.C.	None	- - -	- - -
Appurtenances	None	- - -	- - -
Fencing	None	- - -	- - -
Subtotal			$ 17,000
Engineering & Miscellaneous 10%			2,000
Contingencies 10%			2,000
	GRAND TOTAL		$21,000

General Project Description

Consists of two new 43"x27" C.M.P. arches across Black Canyon Highway about 4,300 L.F. north of Beardsley Drive with a combined capacity of 72 c.f.s. Some excavation in the natural swale area west of Black Canyon Highway to Little Skunk Creek to accommodate 122 c.f.s.

COST ESTIMATE

LOCATION Areas R-R, R Deer Valley Drive

	Quantity & Unit	Unit Cost	Total Cost
Land & Right-of-Way 10' along Highway for 1,500'	0.4 Acres	$8,000	3,000
Houses and Buildings, etc.	None	- -	- - -
Utility Relocation		L.S.	2,000
Other Construction Costs			
Pipe as Channel	None	- - -	- - -
Earth Channels Q = 435 to 450 c.f.s.	4,000 L.F.	2.75	11,000
Lined Channels Q = 170 to 415 c.f.s.	1,350 L.F.	14.00	19,000
Bridges or Culverts on Channel	Two Each	7,500	15,000
Corrug. Culvert Crossing B.C. 65"x40" C.M.P. Arch	One Each	11,000	11,000
Bridges or Box Culvert Crossing B.C. 6'x3' Box Culverts	One Each	23,000	23,000
Appurtenances		L.S.	2,000
Fencing 1,400' Single Cable @ 0.50	10,800 L.F.	0.46	5,000
Reconstruct 1,400' 4-Strands @ 0.40			
8,000' New 4-Strand @ 0.40			
Subtotal			$91,000
Engineering & Miscellaneous 10%			9,000
Contingencies 10%			9,000
	GRAND TOTAL		$109,000

General Project Description

Consists of a new 65"x40" C.M.P. arch across Black Canyon Highway with a capacity of 90 c.f.s. about 1,400 L.F. north of Deer Valley Drive. A 6'x3' box culvert with a capacity of 166 c.f.s. crossing the Highway about 900 L.F. north of Deer Valley Drive. A lined waterway on the west side of the Highway from 1,400 feet north of to Deer Valley Drive with capacities of 170 c.f.s. to 415 c.f.s. A trapezoidal section dirt waterway along the north side of Deer Valley Drive from the Highway to Little Skunk Creek with capacities of 435 c.f.s. to 450 c.f.s., a distance of about 4,000 L.F.

COST ESTIMATE

LOCATION Areas S and T, North of Deer Valley Road

	Quantity & Unit	Unit Cost	Total Cost
Land & Right-of-Way 80' along East side of Highway for 800'	1.5 Acres	$4,000	$6,000
Houses and Buildings, etc.	None	- -	- -
Utility Relocation	None	- -	- -
Other Construction Costs			
Pipe as Channel	None	- -	- -
Earth Channels Q = 3,400 c.f.s.	800 L.F.	16.00	13,000
Lined Channels	None	- -	- -
Bridges or Culverts on Channel	None	- -	- -
Corrug. Culvert Crossing B.C.	None	- -	- -
Bridges or Box Culvert Crossing Quadruple 10'x7' Box Culvert	One Each	139,000	139,000
Appurtenances		L.S.	2,000
Fencing 1,600' 4-Strand @ 0.40	1,600 L.F.	0.40	1,000
Subtotal			$161,000
Engineering & Miscellaneous 10%			16,000
Contingencies 10%			16,000
	GRAND TOTAL		$193,000

General Project Description

Consists of four new 10'x7' box culverts with a combined capacity of 3,700 c.f.s. across Black Canyon Highway about 3,000 L.F. north of Deer Valley Drive. A trapezodial section dirt waterway along the east side of the Highway from 3,800 L.F. north of to 3,000 L.F. north of Deer Valley Drive with a capacity of 3,400 c.f.s. Also some channel work on west side of Highway to Little Skunk Creek.