

FLOOD REPORT
BUCKHORN MESA WATERSHED
MARICOPA AND PINAL COUNTIES, ARIZONA

FOR

"STORM OF JULY 17 & 18, 1984"



BY

THE USDA SOIL CONSERVATION SERVICE

NOVEMBER 21, 1984

SIGNAL BUTTE FLOODWAY CONSTRUCTION PLUG

The responsibility for water control lies with a contractor in accordance with de-watering provision of the contract. The contractor must develop and implement a plan for the contract period spelling out those strategies by which he will accomplish these water control contractual requirements.

The construction plug in the Signal Butte Floodway was a water control measure selected by the contractor during construction. Neither Soil Conservation Service designs nor construction requirements called for specific measures. Contractors have the sole responsibility, according to the contract provisions which they signed, to carry out construction functions or operations in such a manner so as to construct and complete the project within the specifications set forth in the contract.

REPORT ON
STORM OF
JULY 17 AND 18, 1984
BUCKHORN MESA WATERSHED
MARICOPA AND PINAL COUNTIES, ARIZONA

PREPARED BY

ROBIN McARTHUR, HYDRAULIC ENGINEER
HARRY MILLSAPS, HYDRAULIC ENGINEER

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Phoenix, Arizona

Timothy E. Sutko
Maricopa County Flood Control District
Phoenix, Arizona

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Buckhorn Mesa Watershed

Storm of July 17 & 18, 1984

Introduction

The Buckhorn Mesa Watershed is an arid watershed located in East Maricopia and West Pinal Counties, Arizona. The watershed heads in the Utery Mountains, Goldfield Mountains and western flank of the Superstition Mountains and drains onto a wide alluvial fan on which valuable improvements, including subdivisions and commercial developments, have been established. Since portions of the watershed lie within the Town of Apache Junction and the City of Mesa, pressure for urban development has increased. Many new developments are being constructed each year with subsequent increases in potential flood damages.

Because of previous flood problems, an application was received and a watershed work plan was developed for the watershed in the early 1960's pursuant to Public Law 83-566, 83rd Congress, 68 Statue 666 as amended and supplemented. This plan consisted of a series of floodwater retarding structures (FRS) and floodways which provided a 100-year level of protection to the area located immediately downstream of the planned measures. Although the plan has since been revised and supplemented, its basic format remains unchanged. The present plan consist of four floodwater retarding structures (Spook Hill FRS, Signal Butte FRS, Apache Junction FRS and Weekes Wash FRS), two floodways (Signal Butte Floodway and Bulldog Wash Floodway) and a diversion (Pass Mountian Diverson). See Project Map located at end of this report. During the present analysis, only a portion of the Buckhorn Mesa

project was studied. This includes all contributing drainage areas lying north of the Central Arizona Project Canal from Signal Butte Road west to the east end of the Spook Hill FRS. (See Drainage Area Map located at the back of this report.)

At the time of the storm, only the first increment of the project, the Spook Hill Dam, was installed. The second increment, the Signal Butte Floodway, was under construction. This latter structure consists of an east-west, earth channel located 1/4-mile north of Brown Road and begins about 500 feet east of Signal Butte Road and empties into a concrete lined channel at an inlet structure (Station 96+74) located about 2500 feet west of Crismon Road. (See Signal Butte Floodway Layout located at back of this report.) From this point the floodway flows in a south-southwest direction to its outlet immediately upstream of the east end of the Spook Hill FRS. At the time of the storm, both the earth and concrete lined portions of the channel were nearing completion, but the inlet structure had not been constructed. As a result, an earth construction plug was installed by the Contractor in the earth portion of the channel at Station 95+00 to protect the construction site of the inlet structure and to provide some protection to the concrete lined channel, since the retaining walls of the channel had not been back-filled at that time. Overflow from the floodway occurred upstream of the plug. The floodway, including the inlet structure has since been completed and was dedicated on August 16, 1984. Other project increments, except Weekes Wash Dam, are scheduled to be completed by Fiscal Year 1987. The Weekes Wash Dam will be completed at a later date. Once completed, the designated structures will provide a high degree of flood protection to many of the areas flooded during

the subject storm. Even with the structures installed, local drainage may still cause some residual flooding within washes and in low-lying, water-ponding areas.

Another construction project which was on-going at the time of the storm was Reach 1B of the Central Arizona Project (CAP) Canal. The excavation on the canal was nearing completion, but proposed concrete lining and drainage facilities had not been installed. Collector channels located along the north (and/or east) O&M road were in various stages of construction; as were overchutes, which are designed to carry local runoff across the CAP and discharge it into downstream channels. Only two openings in the north O&M road were known to exist within the study reach at the time of the storm. These were at proposed overchute locations near Station 345+50 (located west of Ellsworth Road) and Station 456+60 (located south of Apache Trail near Broadway). There are other locations where overchutes are proposed, but generally construction had not yet begun. At two of these latter locations water did enter the CAP by ponding and overtopping the embankment of the north O&M road.

The overchute at Station 397+00 was nearing completion. The outlet for this overchute, however, had not been constructed, therefore, it did not function as designed. On the other hand, the new University Drive Bridge, although not designed as an overchute, did function as one during the flood.

Other construction activities along the CAP which had some effect on passage of the flood were the presence of five construction plugs within the CAP canal and an opening in the south O&M Road at the downstream overchute location (i.e. Station 456+60) where water exited the CAP. The first plug was located near Station 383+00 just upstream of University Drive. The second plug was in place at Station 398+00 east of 96th Street. The next two plugs were located upstream and downstream of Apache Trail, and the final plug was located at Signal Butte Road. The Signal Butte Road plug prevented any contribution of flow from the east and effectively defined the eastern boundary of the Study area. The exact reason for these plugs is not known but could have been for the purpose of flood protection, equipment crossing, or to carry highway traffic during the construction of bridges. In most cases the top of the plugs were below the elevation of the south O&M road and generally caused no overtopping of the CAP on its south side.

Although the water which exited the CAP at Station 456+60 caused flooding downstream of the CAP, it was not evaluated as part of this study. This analysis indicates that little or no overflow from the Signal Butte Floodway was discharged from the CAP at this location.

METHODS OF ANALYSIS

The methods used to analyze the subject storm are those outlined in the Soil Conservation Services's (SCS) National Engineering Handbook, Section 4, Hydrology. This section gives procedures for analyzing both the hydraulic and hydrologic parameters of a watershed. The hydraulic parameters were further

defined using the SCS's WSP-2 Computer Program, which is a step-backwater program used to compute water surface profiles.

Water surface profiles were calculated for the earth portion of the Signal Butte Floodway for both "with" and "without" the construction plug in place, and for the collector channels and overflow sections located along the north embankment of the CAP Canal from University Drive upstream to Station 345+50. The collector channel profiles actually were run in two segments, using surveyed cross section data. The starting point for the first segment was at University Drive (and/or 95th Place), and the second starting point was at Station 345+50. Both of these profiles ran toward and ended at Ellsworth Road since this road served as a divide between the two channel segments.

The purpose of the water surface profile calculations was to estimate the carrying capacities of the various channels and/or overflow sections and to determine the peak flows for the subject storm. Peak discharges were based on the profiles and surveyed high water marks for selected locations in the watershed. Volumes of water stored in the Signal Butte Floodway and the CAP Canal were also calculated. The peak discharges, volumes and elevations were then used to calibrate the hydrologic model.

The hydrologic model used in the analysis is that described in the SCS Technical Release No. 21, i.e. the TR-20 Computer Program. The TR-20 model simulates surface runoff response to precipitation on a watershed by computing sub-basin hydrographs and systematically combining these with other appropriate hydrographs to obtain total runoff discharges and volumes at select points in the watershed.

Sub-basins used in the TR-20 model are shown on the "Drainage Area Map" located in the back of this report. Three major watershed parameters required as input to the model are also shown on the map. These are drainage areas in square miles; times of concentration in hours, and runoff curve numbers. Drainage areas were planimetered from USGS 7 1/2 - minute quadrangle maps. Methods of obtaining both the times of concentration and runoff curve numbers are given in Section 4, of the SCS National Engineering Handbook.

There were 35 separate sub-basins used to model the July 1984 storm. Many of these are the same sub-areas used in modeling the Buckhorn Mesa Watershed for design purposes.

There were four separate watershed alternatives analyzed during this study. These are:

Alternate 1: Conditions existing at the time of the storm with the Signal Butte Floodway construction plug in place.

Alternate 2: Assuming that the Signal Butte Floodway was completed and the construction plug was not in place.

Alternate 3: Assuming that construction on the Signal Butte Floodway had not begun, i.e. conditions without the Signal Butte Floodway.

Alternate 4: Assuming that construction of the total Buckhorn Mesa Project had been completed.

The first alternate is based on actual storm conditions and was used to calibrate the model. The other three alternatives are hypothetical and were used to analyze the effect of the Signal Butte Floodway "with" and "without" the construction plug, and to determine what the historical flood discharges would have been along the CAP had the Buckhorn Mesa Project been completed.

The combination of flood hydrographs from the individual sub-basins differed for each alternative. This is accounted for in the model. Rainfall amounts also varied by sub-basin and were taken from an Isohyetal Map for the storm furnished by the Maricopa County Flood Control District. (See Isohyetal Map located in back of report). To simplify the model, weighted rainfalls for larger drainage basins were used, where the differences in rainfall amounts for individual sub-basins were not significant.

The distribution of the storm with respect to time was based on a mass rainfall curve developed from two recording rain gauges located in or near the study area. This mass curve was used as input to the model.

In addition to analyzing the historical storm event, four synthetic storm frequencies were also analyzed. These were the 10-, 25-, 50- and 100-year, 24-hour rainfall amounts taken from "NOAA Atlas 2, Precipitation Frequencies Atlas for the Western United States, Volume VIII, Arizona". The SCS, Type II rainfall distribution was used for these storms. The rainfall was then distributed uniformly over the watershed. These latter storms were used to estimate the flood frequency of the historical storm event. (Note, the Type II distribution and 24-hour rainfall amounts were those used for the evaluation of the Buckhorn Mesa Watershed and for the 100-year design storm for the Signal Butte and Bulldog Wash Floodways).

THE STORM

The storm began in the early evening hours of July 17, 1984, with some drizzle beginning as early as 4:00 P.M. on that date. The major rain, however, did not begin until about 10:00 or 10:30 P.M. From 10:30 P.M. it rained continually for about 2.5 hours or until about 1:00 A.M. on the 18th. The highest intensity rainfall occurred between 10:30 P.M. and midnight with more than 90% of the total rainfall occurring within this period.

The total rainfall recorded on the Buckhorn Mesa Watershed varied from less than 0.2 inch in the northwest corner of the Spook Hill drainage to nearly 4-inches near 96th Street and University Drive (See Isohyetal map). Most of the watershed, however, including the area above the Signal Butte Floodway had rainfall amounts totaling between 1.0 and 2.5 inches. The weighted average for the total study area (23.47 square miles) was 2.27 inches. This is approximately equal to a 20-year, 3-hour storm or a 30-year, 2-hour storm. The maximum point rainfall for the historical storm exceeded the 100-year frequency for both of these durations. The stated frequencies (i.e. the 20 and 30-year frequencies) are similar to those obtained when comparing computed peak discharges for the historical storm to those calculated using the SCS Type II distribution and 24-hour rainfall amounts from NOAA Atlas 2, assuming conditions similar to those existing at the time of the flood. Should a comparison be made of computed flows for the various storms for "without project" conditions (i.e. w/o the Signal Butte Floodway), the flood frequency varies anywhere from a 6-year storm to over a 100-year storm frequency, depending on the location within the watershed. This variation is due mostly to the different rainfall depths occurring over the watershed. The average frequency was again in the 20 to 30 year range.

THE FLOOD

Runoff response to the rainfall was almost immediate. Within one half hour from the beginning of the most intense portion of the storm, runoff began filling the Signal Butte Floodway channel. It soon overtopped its south bank and continued downstream. Due to the construction plug in the channel near Station 95+00, the channel acted as a storage reservoir. The storage capacity in the floodway was estimated to be about 65 acre-feet (See TABLE 1). Minor amounts of water were also stored upstream of the north embankment of the Signal Butte Floodway below invert elevations of side inlet structures. This volume was estimated to be only about 4 acre-feet (TABLE 1). Thus, about 69 acre-feet of storm runoff was stored upstream of the construction plug. This compares to the total estimated storm runoff for the drainage area above the plug (5.44 square miles) of 276 acre-feet (TABLE 2). This means that about 207 acre-feet overtopped the floodway and continued its course downstream.

From survey data, it was determined that the floodway was overtopped in three locations. The first was on its east end near Signal Butte Road (from Station 12+50 to 23+00) where a major tributary (2.04 square miles) intersects the channel. The peak of the inflow hydrograph at this location was estimated at 1,200 CFS, and the capacity of the floodway was determined to be about 750 CFS. This means that a maximum peak of 450 CFS ^{1/} and an estimated volume of nearly 22 acre-feet overtopped the channel at this location. Overflow depths were estimated to range between two to four inches.

^{1/} Note, the routed peak for this location as given in Column 1, TABLE 3 is 280 CFS. This latter peak is the discharge at Apache Trail where the overflow intersects the CAP Canal. Most of the other discharges and volumes quoted in this section of the report can also be found in TABLE 3 under appropriate columns for "Existing Conditions w/S. B. Plug".

The second location where the floodway was overtopped was in the vicinity of Crismon Road. The overflow area at this location extended from Station 61+50 to Station 75+00. (Note; the centerline of Crismon Road is at Station 71+65, therefore overflow occurred both upstream and downstream of the road.) Maximum overflow depths at this location were estimated to be about four inches. The routed peak overflow was put at 280 CFS with a total outflow volume of about 22 acre-feet.

The final location where the floodway was overtopped was at the construction plug itself. It was at this location where the major discharge occurred. The overflow area extended from Station 95+00 upstream to approximately Station 78+00. The maximum discharge was estimated at 1,500 CFS with a total outflow volume of about 164 acre-feet.

All flows entering the concrete lined portion of the floodway were diverted into the Spook Hill FRS, and therefore, did little or no damage. This volume was estimated at 64 acre-feet with a maximum discharge of 440 CFS.

Water from the three overflow areas generally flowed in a south-southwest direction from their points of discharge to intersect the CAP Canal near Apache Trail, at University Drive, and at Ellsworth Road, respectively. The overflow which intersected the CAP near Ellsworth Road (i.e. the flow which overtopped the floodway near the construction plug) first flooded a house located south and east of the floodway and north of Brown Road. It also eroded a parcel of land located south of Brown Road on which a small subdivision was being developed. Upon reaching Ellsworth Road, the floodwaters were divided between those which remained east of Ellsworth Road

and those which crossed Ellsworth and flowed south-southwest to enter the CAP near Station 345+50. This latter flow was estimated at 380 CFS with a total volume of about 31 acre-feet. This volume combined with the local runoff occurring below the floodway and west of Ellsworth Road to give a total discharge into the CAP at Station 345+50 of nearly 44 acre-feet, with a routed inflow peak of 260 CFS. Prior to entering the CAP, about 12 acre-feet was stored temporarily along the north CAP embankment causing some flooding in this area (See Flood Location Map). The maximum flood elevation was determined to be 1573.7 feet above the National Geodetic Vertical Datum (NGVD) based on surveyed high water marks.

Overflows from the Signal Butte Floodway which intersected the CAP on the east side of Ellsworth Road continued along its north embankment to University Drive where it was joined by the discharge from the floodway occurring near Crismon Road. Added to these flows was the local runoff occurring below the floodway between Ellsworth Road and 95th place. Part of the total flow (about 22 acre-feet) was ponded upstream of the CAP's north embankment causing flooding in this reach (See Flood Location Map). The maximum flood elevation was estimated to be about 1574.0 feet (NGVD) based on high water marks. A small portion of the total flow within this reach (about 11 acre-feet) was discharged into the CAP at Station 366+35. The maximum inflow peak at this location was estimated at 100 CFS.

The total hydrograph near the intersection of University Drive and 95th Place was estimated at 176 acre-feet with a maximum peak of 800 CFS and a surveyed high water elevation of 1572.0 feet (NGVD). This hydrograph was divided into three distinct flows. The major part of the hydrograph (about 110 acre-feet

with a maximum peak of 500 CFS) was discharged into the CAP. This flow occurred on both sides of University Drive. Upon entering the CAP the flow was confined between two CAP construction plugs; the first being located just upstream or west of University Bridge near Station 383+00, and the second downstream of 96th Street at Station 398+00. The exact elevations of the top of these plugs are not known, but have been estimated based on high water marks and a video tape furnished by the Bureau of Reclamation. The plug at Station 383+00 appeared on the video tape to be somewhat lower than the one at Station 398+00. The video showed water still seeping over the upstream plug at the end of the storm, and somewhat below the top of the plug at Station 398+00. The difference in elevation was estimated to be about 1.0 to 1.5 feet. Using the high water mark for the water which was stored between the two plugs, the elevation of the upstream plug was estimated at 1563.4 feet (NGVD). The elevation determined for the plug at Station 398+00 was 1565.1 feet (NGVD). This latter elevation was based on flood hydrograph routings required to equal the maximum surveyed high water mark (1567.8 feet, NGVD) in the CAP for the total inflow to the canal between the University Bridge and Apache Trail Boulevard (See later discussion).

The analysis indicated that once the storage area between the two construction plugs was filled (about 24 acre-feet, TABLE 1), water would overflow the upstream plug and be stored in the CAP upstream of University Bridge, i.e. between the bridge and the Salt-Gila pumping plant. This is confirmed by an estimate of the water stored in the CAP in this reach, which was estimated at 175 acre-feet (TABLE 1). This compares with the total estimated inflow to the CAP upstream of the bridge of 55 acre-feet. Thus, about 120 acre-feet had to overtop the plug at Station 383+00 to account for the total storage in the

reach between the bridge and the pumping plant. There may have been some flow into the CAP north of the Spook Hill FRS, but this would have been relatively minor, since the total rainfall in this area was minimal.

It is possible, but not likely, that some of the water which entered the CAP between the two construction plugs as discussed above could have been discharged to the east. This is based on the fact that a large volume of water entered the CAP Canal in the reach between Crismon Road and Apache Trail (See later discussion), and this would tend to force all flows into the CAP upstream of Crismon Road across the plug at Station 383+00.

The second major discharge occurring at University and 95th Place was the flow which crossed University Bridge and flooded areas between University Drive and Sleepy Hollow, east of 93rd Street (See Flood Location Map). This flow was estimated at 240 CFS with a total volume of about 53 acre-feet. The flow entered this area near the University Bridge. It then flowed south spreading out into shallow sheet flow with depths of less than 1-foot and more likely in the range of 4 to 6 inches. It filled several small detention reservoirs located in the area. Flooding was limited to yards and landscaping with no water getting inside the raised mobile homes themselves. There was some sediment deposited on roads, in yards, and in carports.

The final division of flow at University and 95th Place was the flow that crossed University Drive and continued east along the north side of the CAP Canal O&M road. This flow was estimated at 60 CFS with a total volume of about 13 acre-feet. The flow continued downstream to approximately Station 392+00 where it entered the CAP Canal.

Another location where water entered the CAP was at the overchute located near Station 397+00. At this location, flows actually crossed the CAP by means of the overchute and ponded on the downstream side and then entered the CAP from its south side by eroding the embankment adjacent to the overchute.

The total discharge into the CAP between University Drive and Crismon Road was estimated at 49 acre-feet with a maximum peak of 490 CFS. This included the flow crossing University Drive plus the runoff from local drainage below the floodway between 95th Place and Crismon Road. There was also some flow across Crismon Road from the southeast, but this volume was not estimated and is included in the total discharge which enters the CAP between Crismon Road and Apache Trail. Since the flow at Stations 392+00 and 397+00 enters the CAP between the two construction plugs discussed previously, most of this flow also overtopped the plug at Station 383+00 and was stored in the CAP upstream of University Drive.

One of the major inflows to the CAP occurred between Crismon Road and Apache Trail. The discharge at this location originated on the uncontrolled drainage areas lying to the east of the Signal Butte Floodway. It also included the overflow from the Signal Butte Floodway which occurred near Signal Butte Road, plus the local inflow between the two roads. The drainage area above the proposed Signal Butte Dam and a portion of the Bulldog Wash Floodway drainage area contributed directly to the discharge between the two roads. Runoff from the remaining drainage area, including a large percentage of the local runoff, generally overtopped or passed through the Apache Trail Highway with about 500 CFS being diverted by the highway into the overflow section between Apache Trail and Crismon road. The total hydrograph between the two roads was

estimated to contain about 396 acre-feet with a peak discharge of 2,900 CFS. This hydrograph caused some ponding above the CAP to an elevation of about 1576.8 feet (NGVD), and was split between the flows which entered the CAP at this location and those which flowed south overtopping Apache Trail adjacent to the CAP. The total flow entering the CAP was estimated at 293 acre-feet with a maximum peak discharge of 2,100 CFS. Therefore, the flow crossing Apache Trail to the south was estimated to be 800 CFS with a total volume of 103 acre-feet. This latter flow combined with the remaining flow from Bulldog Wash and Apache Junction Dam drainage areas, plus local drainage to the south of Apache Trail to give a total inflow hydrograph near Station 456+60 of about 140 acre-feet with a maximum peak of 800 CFS. Some ponding also occurred at this location to an elevation of about 1565.0 feet (NGVD). (Note, some of this flow may have entered the CAP through overchute openings located east of Station 456+60). The storage in the area is small (less than 10 acre-feet) relative to the total runoff of 140 acre-feet, and thus had very little effect on the inflow peak.

It was only at this later location (i.e. Station 456+60) where any significant outflow actually occurred from the CAP, although some overtopping of the CAP may have occurred just upstream of Apache Trail. Using the inflow hydrographs to the CAP, plus estimated storage and discharges across the construction plugs located at University Drive and Apache Trail, it was determined that the total outflow from the CAP was approximately 387 acre-feet with a maximum peak outflow of 2,200 CFS, (TABLE 3, Col. 19). This flow continued downstream in a south-southwest direction flooding areas within its path. However, as stated earlier, the flooding below the CAP at this point was not evaluated as part of this study.

TABLE 1: Estimated Runoff for Storm of July 17 & 18, 1984,
 Buckhorn Mesa Watershed, Maricopa & Pinal Counties,
 Arizona, Based on Field Data

LOCATION	RUNOFF (Ac-Ft)
Runoff retained upstream of side inlets Signal Butte Floodway	4
Runoff retained in Signal Butte Floodway Channel	65
Runoff retained in CAP Canal upstream of University Drive	175
Runoff retained in CAP Canal between University Drive & 96th St.	24
Runoff retained in CAP Canal between 96th St. & Apache Trail	65
Runoff temporarily detained in CAP Canal between Apache Trail & Signal Butte Rd.	112
Flow across University Bridge	53 <u>1/</u>
Runoff retained in Spook Hill FRS	64 <u>1/</u>
Outflow from CAP near Broadway	<u>352</u>
TOTAL NET RUNOFF	<u>802</u> <u>2/</u>

1/ Volume estimated based on computer model.

2/ Does not include volume detained in CAP Canal between Apache Trail and Signal Butte Road, since most of this latter volume was drained from the Canal and would be included in the CAP outflow estimate.

TABLE 2: Estimated Runoff for Storm of July 17 & 18, 1984,
 Buckhorn Mesa Watershed, Maricopa & Pinal Counties
 Arizona, Based on Rainfall and Curve Number Procedure

Subarea No.	D. A. (Sq.Mi.)	Precip. (In)	24-hr. (Cn)	Runoff (In)	Runoff (Ac-Ft)	COMMENTS
9	.04	2.50	75	0.65	1	
10	2.04	2.50	84	1.11	121	
11	0.85	2.50	82	1.00	45	
12	0.91	2.50	82	1.00	48	
13	0.34	2.50	75	0.65	12	
14	0.47	2.50	77	0.74	19	
15	0.71	2.50	76	0.69	26	
16	0.08	2.50	76	0.68	3	
SUBTOTAL	5.44	2.50	81	0.95	276	Total drainage area and runoff above S.B. piug
17	1.00	1.46	76	0.17	9	
17A	1.21	2.30	76	0.58	37	
18	0.03	2.70	75	0.77	1	
19	0.06	2.70	75	0.77	3	
20	0.17	2.70	75	0.77	7	
21	0.17	2.70	75	0.77	7	
SUBTOTAL	2.64	2.05	76	0.45	64	Drainage area and runoff entering Spook Hill FRS
22	.03	2.70	75	0.77	1	
23	0.06	2.70	75	0.77	3	
24	0.15	2.70	75	0.77	6	
25	0.15	2.70	75	0.77	6	
26	0.32	2.70	73	0.68	12	
26A	0.14	2.70	73	0.68	5	
27A	0.29	3.24	74	1.06	16	
SUBTOTAL	1.14	2.84	74	0.81	49	Local drainage area and runoff between Spook Hill Dam and University Drive
27B	0.29	3.24	74	1.06	16	
28	0.38	3.10	74	0.97	20	
29	0.51	2.64	74	0.69	19	
30	0.33	2.64	75	0.73	13	
SUBTOTAL	1.51	2.87	74	0.84	68	Local drainage area and runoff between University Dr. & Crismon Rd.
5	2.00	2.43	83	1.00	107	
6	1.14	2.43	79	0.79	48	
7	1.07	2.43	75	0.61	35	
8	0.57	2.43	75	0.61	18	
31	0.68	2.43	74	0.57	21	
SUBTOTAL	5.46	2.43	79	0.79	229	Drainage area & runoff contributing to hydrograph between Crismon Rd. and Apache Trail
1	1.51	1.18	80	0.15	12	
2	2.54	1.75	80	0.42	56	
3	2.44	2.26	74	0.48	62	
4	0.65	2.26	75	0.51	18	
32	0.15	2.26	71	0.38	3	
SUBTOTAL	7.28	1.86	78	0.39	151	Drainage area & runoff contributing to CAP inflow hydrograph at SEA 456+60
TOTAL	23.47	2.27	78.0	0.67	837	Drainage area & runoff for total watershed

ALTERNATIVE FLOOD ANALYSES

Four watershed alternatives were analyzed as a part of this study. These are listed under the "Methods of Analysis" section of this report. The results of these investigations are shown in TABLE 3.

It will be noted by comparing Alternates 1 and 2 (TABLE 3) that even without the construction plug in the Signal Butte Floodway, the overflow discharges at Crismon Road and near Signal Butte Road were approximately the same as those with the plug. However, at Station 95+00 no overflow would have occurred if the floodway had functioned as designed. The net effect on downstream flooded areas of preventing overflow from the floodway at Station 95+00 can be determined by comparing computed flood parameters for Alternate 1 with those computed for the other three alternates (TABLE 3).

In the area immediately downstream of the spill at Station 95+00, i.e. in the vicinity of Brown Road (See Column 5, TABLE 3), the magnitude of the flood was increased by the spill. Had the floodway functioned as designed, the maximum peak flow would have been about 180 CFS with a total volume of 12 acre-feet. This compares to a peak of 1,400 CFS and a volume of 164 acre-feet with the overflow. The peak discharge expected in this reach under natural conditions, i.e. without the Signal Butte Floodway, is about 400 CFS, with a volume of 61 acre-feet.

In the area adjacent to the CAP west of Ellsworth Road (Column 6, TABLE 3) the flood volume and peak would have been reduced, respectively, by about 31 acre-feet and 200 CFS had the construction plug not been in place in the Signal

Butte Floodway. However, under Alternate 3, calculated volumes and peaks were similar to those calculated for Alternate 1. This would seem to indicate that in this area, if the floodway had been functioning as designed, flooding would have been reduced; but with the construction plug in place, flood depths similar to those expected under pre-floodway conditions were experienced.

In the area flooded between Ellsworth Road and 95th Place, a similar comparison can be made. In this reach the construction plug increased the flood potential over pre-floodway conditions. With water overtopping the floodway at Station 95+00, the flood volume and peak discharges in this area were increased by about 85 acre-feet and 640 CFS, respectively, over pre-floodway conditions; and about 132 acre-feet and 800 CFS over that which would have occurred under Alternate 2.

In all of the above reaches, the flood parameters computed under Alternate 4, i.e. assuming the Buckhorn Mesa Project was completely installed, were the same as those calculated for Alternate 2. This is reasonable since under Alternate 2 no runoff from the drainage area above the floodway contributed to the discharge in the subject areas, which is the same condition that will exist when the total project is in place.

In the vicinity of University Drive and 95th place (Columns 8, 9, and 10, TABLE 3) the effect of the Signal Butte construction plug is not as significant as in the last reach discussed above. With the plug in place, the total volumes and discharges were, respectively, 176 acre-feet and 800 CFS. Had the plug not been in place, the computed volumes and discharges would drop to about 51 acre-feet and 260 CFS. However, had the floodway not been

installed, the designated parameters would have been about 125 acre-feet and 680 CFS, or only about 48 acre-feet and 120 CFS less than that which occurred under actual storm conditions. Another comparison at this location is the amount of water estimated to be crossing University Bridge (Column 9, TABLE 3). Had the Signal Butte Floodway plug not been in place, (Alternate 2), the volume of water crossing the bridge would have been only about 30% of that which occurred under actual storm conditions (Alternate 1), i.e. the flow "with" the plug was estimated at 53 acre-feet and "without" the plug it was estimated to be 16 acre-feet. The computed volume crossing the University Bridge with the Buckhorn Mesa Project completed was 11 acre-feet.

In the reach along the CAP between 95th Place and Crismon Road (Column 11, TABLE 3), the Signal Butte Floodway construction plug had little or no effect on the computed discharges. Some of the water which overtopped the Signal Butte Floodway near Signal Butte Road could have been diverted into this area as there was some overflow across Crismon Road from the east. However, about the same magnitude of overflow occurs under both Alternates 1 and 2; therefore there would have been little or no change in the computed discharges for the subject reach. Even in comparing Alternates 3 and 4 (i.e. "with" and "without" Buckhorn Mesa Project), there is little difference in the computed discharges for this reach. This is a result of the assumption used in the model where no flow is shown crossing Crismon Road. The assumption appears to be reasonable since no flooding was reported in the reach, and most of the flow was contained in the collection channel located along the north side of the CAP O&M road. Also, it made no difference in conditions downstream of the CAP below Station 456+60 whether the water was shown entering the CAP at Station 397+00 or between Crismon Road and Apache Trail.

In the CAP reach between Crismon Road and Apache Trail, the effects of the Signal Butte Floodway construction plug were again very minor. This can be seen by comparing the relative discharges and volumes computed for this reach as shown in Columns 12 and 13 of TABLE 3. When a comparison is made between Alternates 1 and 3 it is indicated that the floodway, even with the plug, reduced the total volume in this area from 593 acre-feet to 396 acre-feet. Of course, had the Buckhorn Mesa Project been completed (Alternate 4) the magnitude and volume of the flood discharge at this location would have been reduced even further, or to about 133 acre-feet.

The final location where flooding occurred in the study area as a result of the July 1984 storm is near Station 456+60 on the CAP (See Column 14, TABLE 3). The effect of the Signal Butte Floodway is similar to that described above, i.e. under either Alternates 1 or 2, the magnitude of the flood was reduced over Alternate 3 or pre-floodway conditions. The net effect of completing the Buckhorn Mesa Project is also similar to that described above, and the total volume will be reduced from 140 acre-feet under Alternate 1 to about 52 acre-feet under Alternate 4.

The net effect of the Signal Butte Floodway and/or the Buckhorn Mesa Project as a whole on the expected outflow from the CAP at Station 456+60 can be determined by analyzing the data in Column 19, TABLE 3. With the project completely installed (Alternate 4), the peak discharge is less than 20% of the pre-floodway conditions (Alternate 3). With just the floodway by itself, (under either Alternates 1 or 2) the total peak discharge from the CAP was reduced by nearly 36 % over pre-floodway conditions. Thus, the net effect of the floodway was to reduce the total discharge downstream of the CAP at Station 456+60.

TABLE 3: ALTERNATIVE FLOOD ANALYSES FOR FLOOD OF JULY 17 & 18, 1984,
BUCKHORN MESA WATERSHED, MARICOPA & PINAL COUNTIES, ARIZONA

Alt. No.	Description	1		2		3		4		5		6		7		
		Routed S.B. F/way overflow nr. S.B. Rd. (VS-152)		Routed S.B. F/way overflow Cris. Rd. (VS-56)		S.B. F/way overflow @ plug (STR-1)		Flow Into Spook Hill FRS (VS-65)		Flow near Brown Rd. below S.B. F/way plug (VS-67)		Flow Into CAP @ STA 345+50 (STR-2)		Flow into CAP @ STA 366+35 (VS-171)		
		(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)	
1	Existing cond. w/S.B. plug	280	22	280	22	1500	164	440	64	1400	164	260	44	100	11	
2	Existing cond. w/o S.B. plug	270	18	260	18	1660	^{1/} 240	2030	304	180	^(VS-26) 12	60	13	—	—	
3	W/o Signal Butte F/way	—	—	—	—	—	—	—	—	400	61	270	32	30	3	
4	W/Buckhorn Mesa Project Completed	—	—	—	—	—	—	—	597	^{2/} 12	180	12	60	13	—	—

^{1/} Note: No overtopping occurred at this location under this alternate. The above discharge was contained within the channel.

^{2/} Note: Under this alternate some runoff would be stored in Apache Junction, Signal Butte and Spook Hill FRS. The division of this flow, however, was not determined in this analysis. The above volume is the total runoff above project measures.

TABLE 3: ALTERNATIVE FLOOD ANALYSES FOR FLOOD OF JULY 17 & 18, 1984,
BUCKHORN MESA WATERSHED, MARICOPA & PINAL COUNTIES, ARIZONA

Alt. No.	Description	8		9		10		11		12		13		14	
		Flow into CAP @ Univ. Drive (VS-174)		Flow Across Univ. Bridge (VS-176)		Flow Across Univ. Drive to S. E. (VS-76)		Flow into CAP @ STA's 392+00 & 397+00 (VS-80)		Flow into CAP bet Cris. Rd & Apache Trail (VS-188)		Flow across Apache Trail @ CAP (VS-187)		Flow into CAP @ STA 456+60 (VS-91)	
		(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)	(CFS)	(AC-FT)
1	Existing cond. w/S.B. Plug	500	110	240	53	60	13	490	49	2100	293	800	103	800	140
2	Existing cond. w/o S. B. Plug	240	31	100	16	25	4	490	40	2100	290	760	102	800	139
3	W/o Signal Butte F/way	430	77	200	37	50	9	490	57	3300	435	1200	158	1250	194
4	W/Buckhorn Mesa Project Completed	170	19	80	11	20	3	490	39	650	102	220	31	420	52

TABLE 3: ALTERNATIVE FLOOD ANALYSES FOR FLOOD OF JULY 17 & 18, 1984,
BUCKHORN MESA WATERSHED, MARICOPA & PINAL COUNTIES, ARIZONA

Alt. No.	Description	15		16		17		18		19		20
		Total Volume into CAP U.S. of Univ. Dr. (STR 2+VS-171)	(AG-FT) (Col 5 + Col 6)	Total Routed Flow in CAP bet Univ. Dr. & Apache Trail (STR-6, CAP)	(CFS) (AG-FT)	Flow Across Plug @ Univ. Dr. (VS-174, CAP)	(CFS) (AG-FT)	Flow Across Plug @ Apache Trail (VS-91, CAP)	(CFS) (AG-FT)	Total Flow Exiting CAP @ STA 456+60 (VS-91, CAP)	(CFS) (AG-FT)	Total Volume in CAP U.S. @ Univ. Dr. (AG-FT) (Col 14 & Col 16)
1	Existing cond. w/S.B. Plug	55		2850	365	920	118	1420	247	2200	387	173
2	Existing cond. w/o S.B. Plug	13		2330	275	900	89	1400	186	2170	325	102
3	W/o Signal Butte F/way	35		3850	483	1600	177	2230	306	3400	500	212
4	W/Buckhorn Mesa Project Completed	13		530	75	130	14	400	61	630	112	27

FINDINGS

A flood occurred on the Buckhorn Mesa Watershed following heavy rainfall on July 17 & 18, 1984. Because of the high intensity of the storm, and the presence of a construction plug near Station 95+00, runoff soon filled and overtopped the Signal Butte Floodway, which was under construction at the time of the storm. The present study was made to determine the net effect of the floodway's discharge on downstream areas where flooding occurred.

Based on surveyed data, the floodway overtopped in three locations: (1) near Signal Butte Road, (2) near Crismon Road and (3) at the construction plug. The effects of the overflows at the first two locations were relatively minor, since their magnitudes were small. Had the floodway not been in place, peak discharges at these locations would have been larger than those resulting from overtopping of the floodway. The net effect of the overflow discharge at the construction plug, however, was to increase the total volume and peak flows immediately downstream of the plug.

In the area which was flooded along the CAP west of Ellsworth Road, the Signal Butte Floodway construction plug caused an increase of 31 acre-feet and 200 CFS above those estimated for "without plug " conditions. However, had the floodway not been in place, flood volumes and discharges similar to those experienced under actual storm conditions would have occurred.

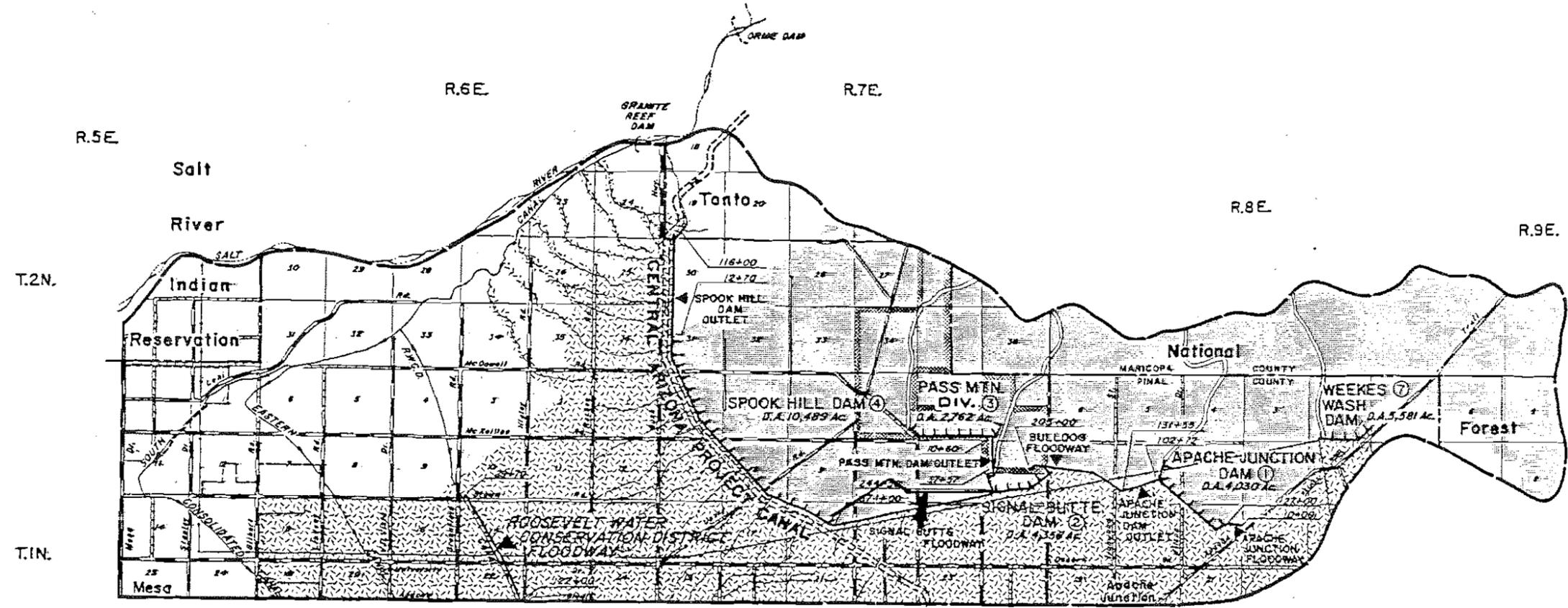
In the area between Ellsworth Road and University Drive, the overtopping of the Signal Butte Floodway caused an increase in peak discharge and flood volume of 640 CFS and 85 acre-feet, respectively, above "pre-floodway"

conditions, and about 800 CFS and 132 acre-feet above those calculated for Alternate 2, i.e. "without plug" conditions.

At the University Bridge location, flow across the bridge was also increased as a result of the overflow from the floodway.

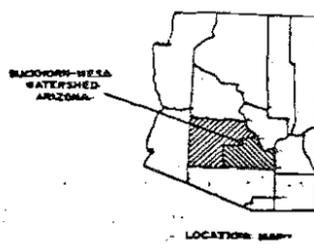
For the other areas located east of University Drive or 95th Place and downstream of the outflow from the CAP at Station 456+60, the effect of the Signal Butte Floodway was generally beneficial. It was shown that the floodway, even with the overflow, actually reduced the total volume of flow in the reach between Crismon Road and Apache Trail. The volume of the inflow hydrograph at Station 456+60 on the CAP was also reduced. The same can be said for the total outflow discharge from the CAP on its south side at this same location.

In summary, the Signal Butte Floodway had beneficial effects of reducing flood volumes and peak discharges for all areas located east of 95th Place and/or University Drive bridge and downslope of the CAP outlet at Station 456+60. The construction plug in the Signal Butte Floodway at Station 95+00 had the effect of increasing flood volumes and discharges immediately downstream of the floodway, and for the areas along the CAP from University Drive upstream to Station 345+50, and for the area immediately downstream of the University Drive bridge.

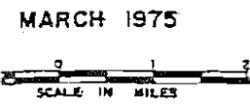


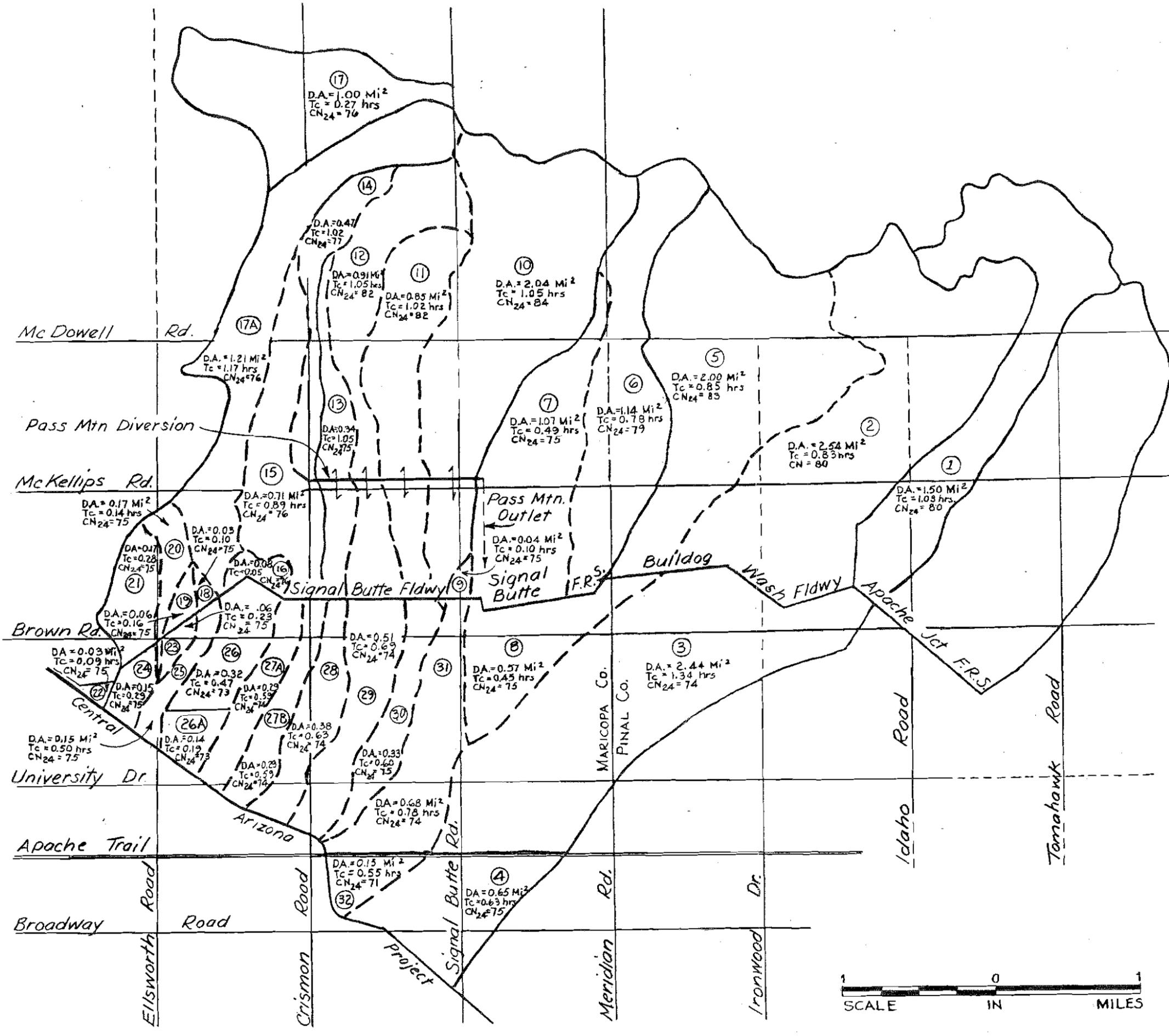
LEGEND

U.S. TOWNSHIP LINE	---
SECTION LINE	---
SECTION NUMBER	76
PAVED ROAD	==
GRADED ROAD	---
UNIMPROVED ROAD	---
POWER LINE	---
CANAL	---
INTERMITTENT STREAM	---
COUNTY LINE	---
INDIAN RESERVATION BOUNDARY	---
NATIONAL FOREST BOUNDARY	---
WATERSHED BOUNDARY	---
CENTRAL ARIZONA PROJECT AREA	---
MESA CITY LIMITS	---
DRAINAGE AREA CONTROLLED BY STRUCTURE	---
AREA BENEFITED	---
FLOODWATER RETARDING STRUCTURE	---
STRUCTURE NUMBER	①
DRAINAGE AREA ACREAGE	D.A. 1,581 AC.
CHANNEL IMPROVEMENT FOR FLOOD PREVENTION	---
UTILITY LOCATIONS (E.G. - RAILROAD, ROAD)	---



PROJECT MAP
 BUCKHORN - MESA WATERSHED
 MARICOPA AND PINAL COUNTIES, ARIZONA



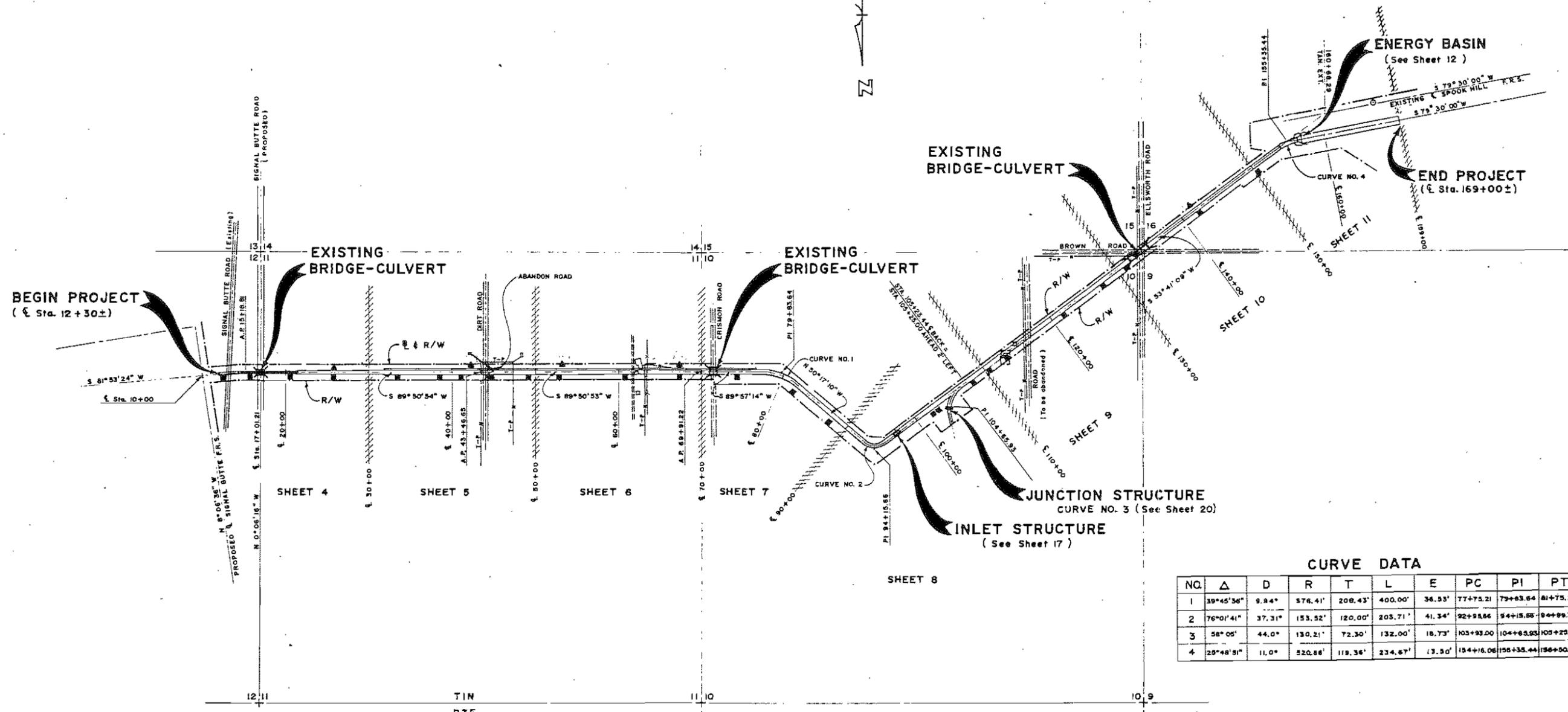


- LEGEND**
- Structure Drainage Areas and Study Boundary
 - - - Sub-basin Drainage Area Boundary
 - ① Sub-basin Number
 - D.A. Drainage Area in Square Miles
 - Tc Time of Concentration in Hours
 - CN₂₄ 24-Hour Runoff Curve Number



DRAINAGE AREA MAP
BUCKHORN-MESA WATERSHED
MARICOPA & PINAL COUNTIES
ARIZONA

STORM OF JULY 17 & 18, 1984



CURVE DATA

NO.	Δ	D	R	T	L	E	PC	PI	PT
1	39°45'36"	9.84'	576.41'	208.43'	400.00'	36.93'	77+75.21	79+83.64	81+75.21
2	76°01'41"	37.31'	153.52'	120.00'	203.71'	41.34'	92+93.66	94+15.58	94+99.37
3	56°05'	44.0'	130.21'	72.30'	132.00'	18.73'	103+93.00	104+63.93	105+25.00
4	25°48'51"	11.0'	520.86'	119.36'	234.67'	13.50'	134+16.06	136+35.44	138+00.73

LEGEND

- RIGHT OF WAY (R/W)
- CENTERLINE (C)
- +— BASELINE
- SIDE INLET STRUCTURE
- ▲ VEGETATIVE OUTLET STRUCTURE
- x-x- EXISTING FENCE
- ▭ BUILDING OR SHED
- N-T-P- UTILITY LINE (Telephone & Power)
- ▭ BRIDGE-CULVERT
- ==== ROAD

PROJECT LAYOUT



PROJECT LAYOUT
 SIGNAL BUTTE FLOODWAY
 SUCKHORN-MESA WATERSHED
 MARICOPA & PINAL COUNTIES, ARIZONA

U.S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE

DESIGNED	L.L.B.	4-78	TITLE	
DRAWN	M.S.	1-80	TITLE	
TRACED	V.B.L.	2-80	TITLE	
CHECKED	P.J.M.	2-83	SHEET	3 OF 50

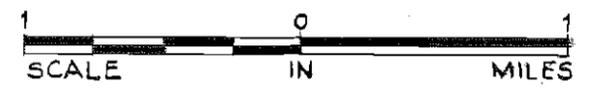
81002-AZ-CH

Source:
 Rainfall Isohyetal Lines
 furnished by MARICOPA COUNTY
 FLOOD CONTROL DISTRICT.
 BASE MAP-PREPARED BY
 the SOIL CONSERVATION SERVICE

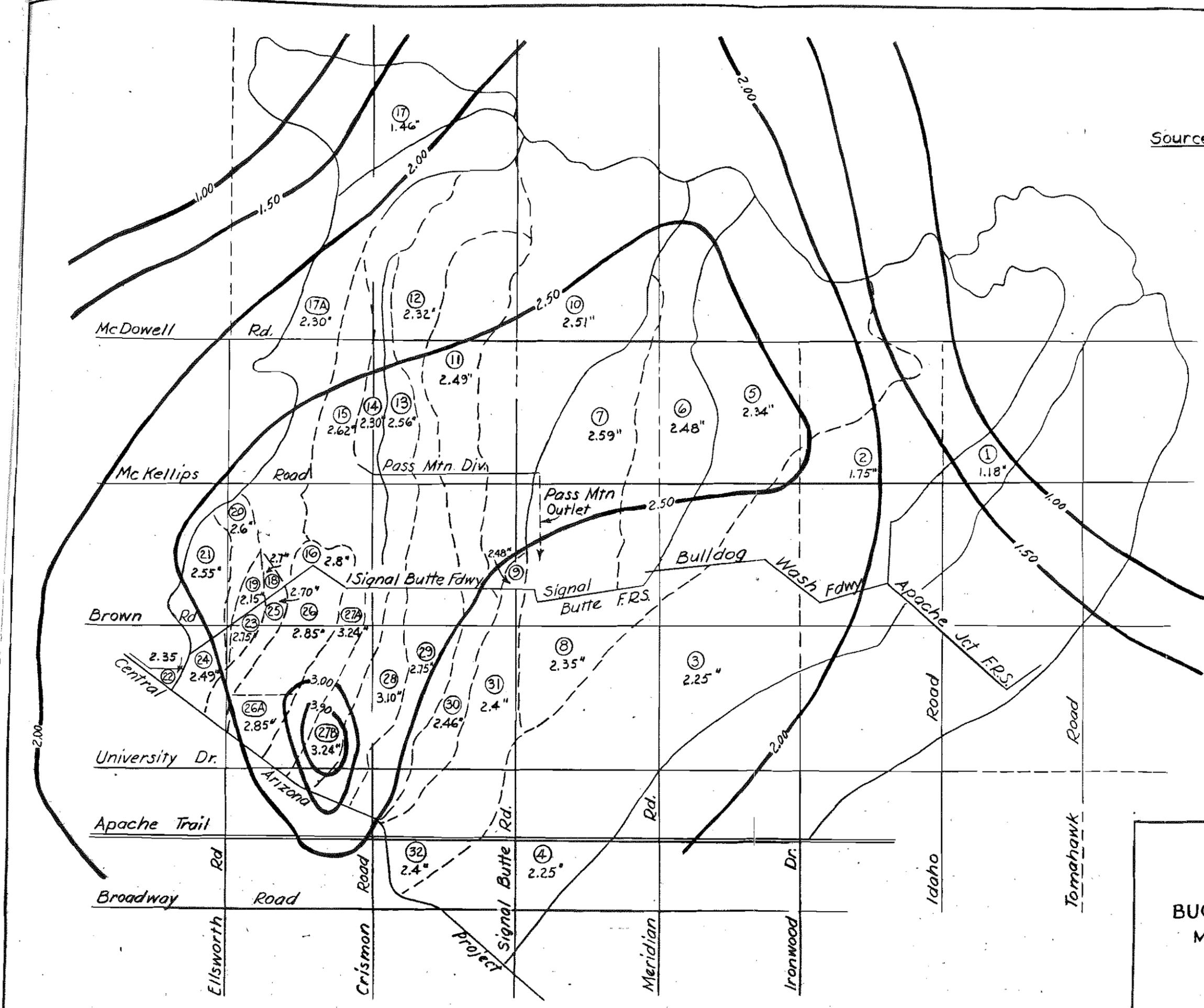


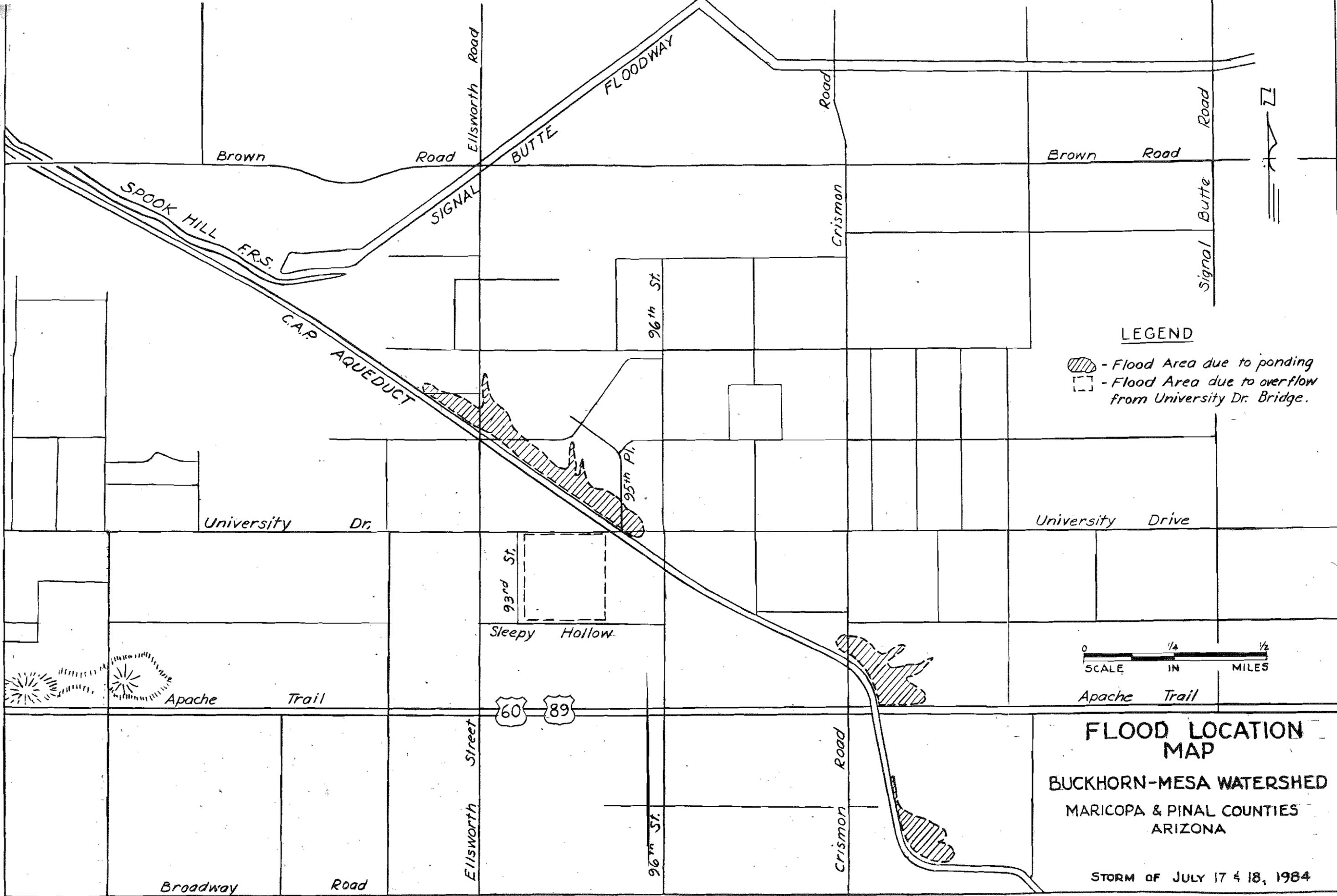
LEGEND

- 2.00— Isohyetal Line
- 1.18 Weighted Rainfall for Sub-basin
- ① Sub-basin Number



ISOHYETAL MAP
BUCKHORN-MESA WATERSHED
MARICOPA & PINAL COUNTIES
ARIZONA
 STORM of JULY 17 & 18, 1984





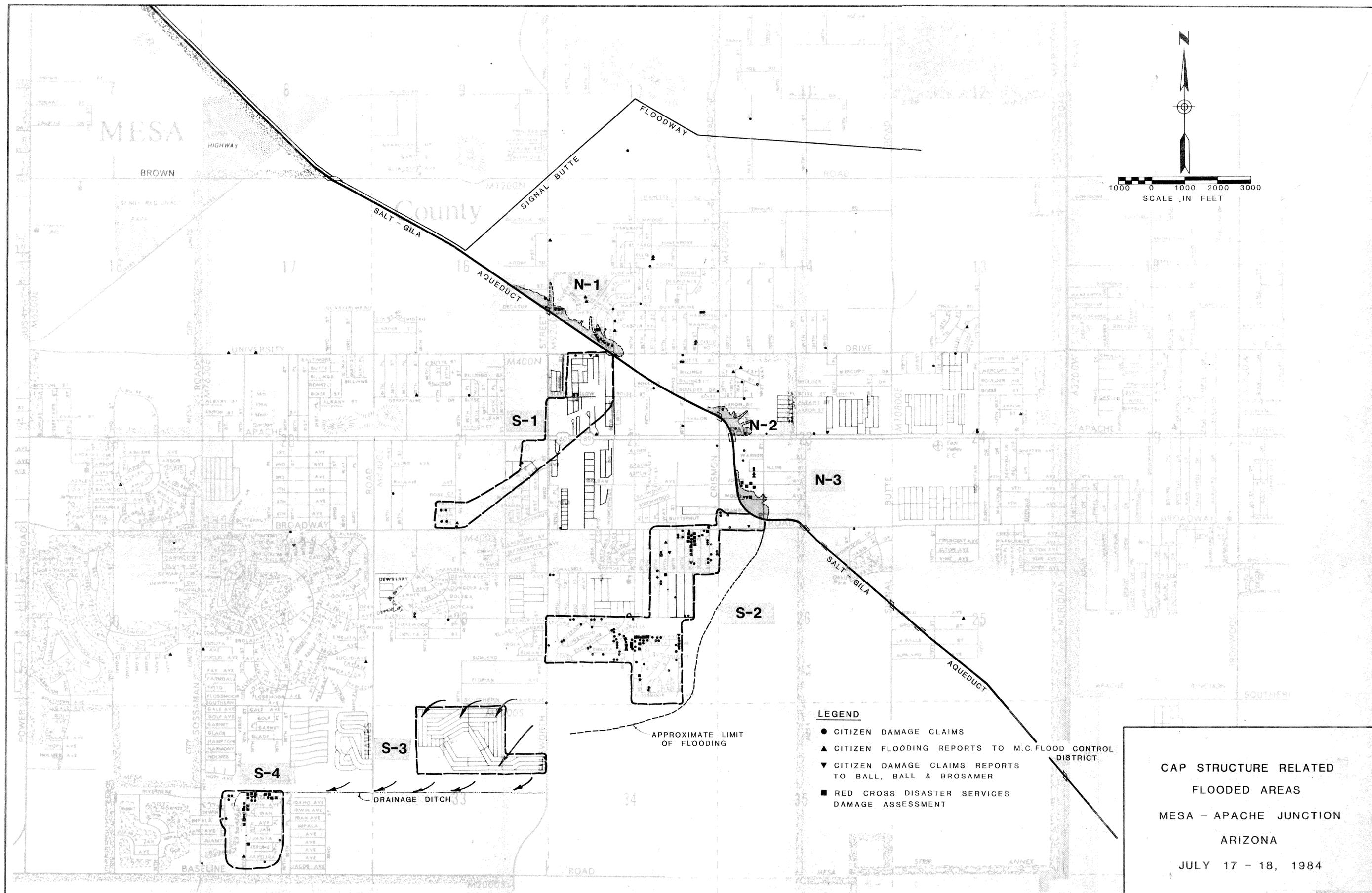
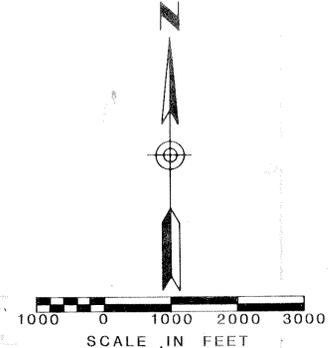
LEGEND

-  - Flood Area due to ponding
-  - Flood Area due to overflow from University Dr. Bridge.



FLOOD LOCATION MAP
BUCKHORN-MESA WATERSHED
 MARICOPA & PINAL COUNTIES
 ARIZONA

STORM OF JULY 17 & 18, 1984



- LEGEND**
- CITIZEN DAMAGE CLAIMS
 - ▲ CITIZEN FLOODING REPORTS TO M.C.FLOOD CONTROL DISTRICT
 - ▼ CITIZEN DAMAGE CLAIMS REPORTS TO BALL, BALL & BROSAMER
 - RED CROSS DISASTER SERVICES DAMAGE ASSESSMENT

**CAP STRUCTURE RELATED
 FLOODED AREAS
 MESA - APACHE JUNCTION
 ARIZONA
 JULY 17 - 18, 1984**