REPORT ON THE

REMOVAL OF STORM WATER FROM CERTAIN AREAS

IN THE

CITY OF TEMPE

ARIZONA

1964

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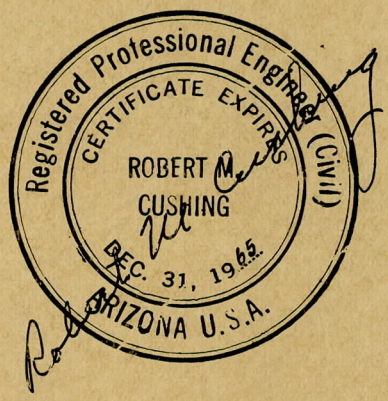

JOHN CAROLLO ENGINEERS

Phoenix, Arizona

TELEPHONE 265-6796

JOHN CAROLLO ENGINEERS
3368 NORTH THIRD STREET PHOENIX, ARIZONA 85012

JOHN A. CAROLLO
ROBERT H. BRERETON
LEON W. JACKSON
CHARLES A. ROLLINS
ROBERT M. CUSHING
H. HARVEY HUNT
DONALD R. PREISLER
HOWARD M. WAY

December 31, 1964

Honorable Mayor and Council
City of Tempe
City Hall
Tempe, Arizona

Gentlemen:

Submitted herewith is our Report on the Removal of Storm Water from certain areas in the City of Tempe. This Report covers seven specific storm water problem areas which the City requested to be studied and contains results of our investigation, recommended improvements, and estimates of cost. Our services are available to you at your convenience for discussions relative to explanation and interpretation of this Report.

We wish to thank Mr. J. Louis Scherer, Jr., Mr. Robert Snyder, Mr. A. G. Nolte, and other members of the staff of the Public Works Department for data and information made available during the preparation of this Report.

Respectively submitted,

JOHN CAROLLO ENGINEERS

Robert M. Cushing, Partner

Registered Professional Engineer (Civil) CERTIFICATE EXPIRES ROBERT M. CUSHING DEC. 31, 1965 ARIZONA U.S.A.

RMC:mm

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INTRODUCTION

This Report presents a discussion of the storm drainage problems in the City of Tempe, together with a description of the present storm drainage system and a recommendation of methods of alleviation of the problem of surface water removal.

The inadequacy of the present drainage system was brought to the attention of the City during the summer of 1964 when in July, August, and September, three rainfalls occurred causing property damage and considerable inconvenience from ponding of storm waters.

This is not a City-wide Report but covers seven specific areas, in which damage occurred this past summer, that the City of Tempe authorized our firm to study. These seven areas are as follows:

1. The downtown business district along Mill Avenue from Third Street to Seventh Street
2. The area east and west of the railroad on Thirteenth Street
3. The area east of the railroad on Broadway Road
4. Parkside Manor
5. Hudson Manor
6. The area north of Fillmore Street and west of Scottsdale Road
7. Cavalier Hills Subdivision

During the course of this investigation, it became evident that additional nearby sections having a flood problem should be incorporated into the plans of improvement by extensions of proposed pipelines. One

of these is a section lying south of Southern Avenue east of the railroad where the disposal of the flood water from that area could be accomplished by extending a proposed improvement. Another area lying around the Una-Butte Avenue intersection was also given consideration since it fell within the scope of the proposed pipeline for the drainage of Hudson Manor.

In addition to all the above areas, a number of other sections of Tempe have a surface water removal problem and should be considered in a supplemental report.

It is the purpose of this Report to discuss each of the above flood areas and to present the best and most economical approach to the solution for the removal of their excess surface storm water.

DRAINAGE

The City of Tempe south of the Salt River generally drains to the west with very little of the surface flow from the area west of Rural Road entering the Salt River within the City Limits. This means that rain falling in the eastern portion of the City must traverse the entire City, east to west, before reaching an outlet to the river. The average ground slope east and west is about 11 feet per mile as indicated by the elevation of Apache Boulevard near Price Road of 1,190 feet and at a point five miles to the west at 48th Street and Transmission Road of 1,136 feet.

On the north side of the Salt River along the area adjoining Scottsdale Road, ground slopes are considerably steeper and the drainage is generally to the east to the Indian Bend Wash and to the southeast toward the Salt River Bottoms.

During the course of development of Tempe, man-made barriers have been constructed that have hindered the flow of water in its natural drainage courses. These barriers include railroads and streets, and in many instances, subdividers have erected homes and shopping centers that block the natural flow of storm runoff. The amount of runoff has been greatly increased from certain areas through the paving of streets and parking areas and the increase of large areas under roofs, this construction all tending to decrease the area subject to infiltration into the pervious soil. As Tempe continues to grow, more paving and roof areas can be expected with a resulting increase in surface drainage in existing problem areas as well as in new flood areas where future development will occur.

AMOUNT OF STORM RUNOFF

Before an approach may be made to a possible solution of the flooding problem in any one area, the quantity of storm water to be controlled in each particular area has to be determined. To determine this quantity, the drainage area, or area contributing runoff, must be known as well as the condition of the ground in that particular area to accept infiltration. A study of the intensity-duration-frequency of past storms that have occurred in the Tempe section of Arizona provides a means of forecasting future rainfall intensity subject to the Tempe areas under study.

The basic approach to the determination of rainfall runoff in the various areas under consideration has been made by the use of the rational formula $Q = CiA$. The rational method translates rainfall into runoff by the above formula in which A is the drainage area, in acres, tributary to the point under design; i is the average rainfall intensity, in inches per hour, for the period of maximum rainfall of a given frequency of occurrence having a duration equal to the time required for the runoff originating during said period of maximum rainfall to flow from the remotest part of the drainage area to the point under design; C is a runoff coefficient which is the ratio between the maximum rate of runoff from the area and the average rate of rainfall on the area during the time of concentration; and Q is the maximum rate of runoff expressed as cubic feet per second when A and i are expressed in acres and inches per hour, respectively.

The drainage area of each area being considered was obtained from observation of runoff movement, elevation surveys, paving plans, and contour maps. The factor "C" was obtained by inspecting the entire drainage area to determine the infiltration factor for each portion of the area. The following "C" values were applied to individual tracts:

Description of Area	"C" Value
Paved streets and parking lots	0.95
Built-up business areas	0.85 - 0.95
Residential (with irrigation borders)	0.05
Residential (no irrigation)	0.25 - 0.35
Apartments (with irrigation borders)	0.30
Apartments (no irrigation)	0.55
Parks and grassed areas	0.20
Railroad yard areas	0.25
Undeveloped desert areas	0.35

After determining the "C" value for individual tracts, a weighted or average "C" value was determined for the entire individual drainage area under consideration.

Rainfall intensity-duration-frequency curves were developed for the Tempe vicinity from data provided in the U. S. Weather Bureau Technical Paper No. 40. The data is based on records beginning in 1906 for the Phoenix Weather Bureau Station. These curves are indicated on Plate 1. In order to determine the time element to be used with the curves, flood water was routed from the upper reaches of the drainage area to the point under study. Velocities of flow ranged from 0.5 to 1.0 foot per second for flow across grassed or desert areas, 1 to 2 feet per second in gutters and to greater velocities in pipelines.

Monthly rainfall amounts for the period 1955 through September 1964 as recorded by the O. L. Barnes Cooperative Weather Bureau Station, located at 1104 Ash Avenue, Tempe, Arizona, are indicated on Plates 2 and 3. In Table 1, the greatest 24-hour rainfalls for the period 1955 through September 1964 are listed.

TABLE 1

O. L. BARNES TEMPE WEATHER BUREAU STATION
Greatest 24-hour rainfall in each year, 1955 - 1964
(24-hour period ending at 8 AM on date indicated)

Date	24-Hour Rainfall in Inches
July 25, 1955	1.54
January 29, 1956	.38
May 12, 1957))	.96
October 31, 1957)	
September 13, 1958	1.08
October 30, 1959	1.47
July 23, 1960	.89
September 14, 1961	.80
January 22, 1962	.91
October 19, 1963	1.19
August 14, 1964	1.69

1964 MAJOR RAINFALLS

Three major rainfalls swept across Tempe during the summer of 1964 causing damage from ponding of the surface water at locations where it could not escape into drainage channels or pipelines. In a number of locations, the existing drainage pipelines are also used for the delivery of irrigation water or for the disposal of waste irrigation water. During these summer storms, several of the combination irrigation and waste water pipelines were partially or wholly being used for irrigation purposes, and therefore, proved to be incapable of efficiently removing the storm runoff.

July 14, 1964 Storm. This storm occurred during the period 10:30 P. M. to midnight of July 14. The O. L. Barnes Cooperative Weather Bureau Station in Tempe recorded 1.01 inches during that period. Other nearby rainfalls recorded were 0.30 inch at the Phoenix Weather Bureau Station, and 0.86 inch at the University of Arizona Citrus Station in southwest Tempe. This rainfall ended a long drought in Tempe. Ponding of runoff waters occurred along Mill Avenue between East Fourth and East Sixth Streets; at McKellips Road and Scottsdale Road where an apartment complex was flooded; and along West Broadway, a large flood area was reported. As indicated on Plate 1, this storm had a calculated frequency of occurrence of once in three years.

August 13, 1964 Storm. This storm occurred during the evening hours when 1.69 inches of rain were recorded at the Barnes Tempe station. The Phoenix station reported 0.21 inch while the Tempe citrus station recorded 1.18 inches. This storm caused damage to many sections of

Tempe not flooded during the July storm. Reports indicated that the greatest damage was experienced in the main business area along the east side of Mill Avenue between Fourth and Sixth Streets. Stores and business places were flooded to such an extent that stock and furnishings were said to be severely damaged. Water to a depth of 20 inches was reported in the intersections along Mill Avenue in this area. Northside Tempe areas were particularly hard hit by the storm. Cavalier Hills Subdivision reported several homes damaged from runoff coming from Papago Park to the west. Streets and business places along Scottsdale Road were also reported to have been flooded. This storm had a calculated return frequency of about once in 12 years and was the greatest recorded in Tempe since the storm of October 30-31, 1959.

September 14, 1964 Storm. Almost a month after the August storm, another major rainfall struck Tempe when 1.51 inches were reported at the Barnes Tempe station. Again, the rainfall appeared to be centered over Tempe as the Phoenix station measured 1.47 inches and the University of Arizona citrus station recorded only 0.37 inch during the storm period. In Mesa at the University of Arizona farm, the precipitation totaled 1.19 inches. Again, all the areas flooded by the August storm were subject to storm water damage from flooding, with the business district on the east side of Mill Avenue suffering heavy flood damage. This storm, as indicated on Plate 1, had a calculated return frequency of about once in 10 years. No record was made of the intensity-duration of this storm at the Tempe station so the intensity-duration records for the Phoenix station were plotted since the total amount recorded and the duration of the storm was similar to that experienced at Tempe.

EXISTING STORM DRAINAGE SYSTEM

The existing storm water removal system in the City of Tempe consists mostly of street drainage with curbs and gutters carrying runoff to a point where it is either picked up by a pipeline or allowed to find its way to some outlet point. In some cases, the pipeline serves the dual purpose of serving irrigation water users either as a delivery line or as a waste water line. A number of the outlet lines end at a point where the flow will be carried away without downstream damage, while other lines deposit flows that aggravate downstream problems.

The main storm drainage system serves an area in central Tempe and consists of a pipeline beginning at Rural Road and extends westerly along Apache Boulevard and Thirteenth Street to a point where it empties into a good outlet at the east end of the Tempe Drainage District No. 2 ditch at 52nd Street. As will be discussed later, parts of this system are adequate to furnish the desired degree of protection while other sections, especially the lateral lines, have proved to be undersized.

Other principal drainage systems include the Arizona Highway Department installed storm drain on Mill Avenue, a pipeline beginning at Terrace Road and Apache Boulevard and extending northwesterly along Terrace Road and northerly along Rural Road, and a pipeline beginning at Eighth Street and extending northerly parallel to the railroad, approximately 170 feet west of Ash Avenue. All of these lines empty into the Salt River and present no outlet problem; however, pipeline sizes restrict the amount of water that they can handle and are consequently capable of carrying the total runoff from only the smaller of the storms.

At other locations throughout the City, street drainage is picked up by pipelines that are either joint-use lines serving irrigation purposes or pipelines that empty into a joint-use line. In most locations, the pipelines are sized to carry runoff from only the lesser storms with the added possibility of much of the pipeline capacity being used for irrigation purposes.

The existing storm drainage system, in the individual areas being studied under this Report, will be further discussed under PLANS OF IMPROVEMENT.

PLANS OF IMPROVEMENT

The seven areas of storm water damage were studied to present the best and most economical relief from storm water. Plans of improvement were developed to provide protection against runoff from storms having a return frequency of 1, 2, 5, and 10-year occurrence and estimates of costs were made for each degree of protection. It was found that the relatively small additional cost of an increased size of pipe resulted in a greatly improved degree of protection afforded. As a result of these studies of cost estimates, it is recommended that large built-up business areas be afforded protection from storms having a return frequency of once in 10 years, while residential areas be protected against storms of once in a 5-year frequency. The use of combination irrigation-waste water-storm water pipelines was deemed to be inadvisable because of the unreliability of being able to use enough of the pipeline capacity for removal of storm runoff. The large irrigation ditches are for delivery purposes and are usually located along high ground and are not suitable for drainage from low-lying areas. Therefore, recommended improvements consist mostly of constructing new pipelines. Unit construction costs used in connection with cost estimates are based on past bids for similar work in the vicinity of Tempe.

The following is a description of the drainage area, present drainage facilities, and the proposed plan or plans of improvement for the seven storm water areas under consideration.

Mill Avenue between Third and Seventh Streets (Plate 4). This area comprises the principal business district of Tempe and has been subject to flooding from storms having a frequency of once in one year. The drainage area covers 59 acres including an area of high runoff from Tempe Butte and large paved areas in the business district with the tempering aspect of including a residential section that contributes little runoff due to the existence of irrigation borders around each lot.

Formerly, water coming from Tempe Butte was caught in the old Hayden Canal at the base of the Butte and north of the railroad tracks. However, this canal has been placed in a pipeline and runoff now passes over the railroad tracks and into the business district. Also, before the U. S. Highway 60-70-80-89 on Mill Avenue was improved with a high center crown, flood waters could pass across and under Mill Avenue to the west. The present highway acts as a dam causing water from the heavy rainstorms to pond on the east side of the highway. The existing storm drain pipeline on the east side of the highway, constructed by the Arizona Highway Department as part of the highway improvement, has been inadequate to remove storm waters resulting from the larger storms. The creamery spur track of the Southern Pacific Company also presents an obstacle for water flowing north on Mill Avenue by gravity along the street gutters. It is calculated that the present storm drain constructed at the time of the improvement of Mill Avenue by the Arizona Highway Department along the east side of Mill Avenue will carry only 9 cubic feet per second whereas a 5-year storm would bring about 77 cubic feet per second into the area and a 10-year storm would contribute 92 cubic feet per second.

In determining a "C" value for the drainage area consideration was given to the future increase in paved areas through extension of the business district to the east and the conversion of some residential tracts to apartment sites. The weighted "C" value thus arrived at amounted to 0.62. The time of concentration of the runoff to Mill Avenue was determined to be about 30 minutes from the remotest end of the drainage area.

Several plans of improvement were studied to bring out the best solution to the problem. Included was a study of the feasibility of diverting runoff from Tempe Butte by constructing a dike north of the railroad track with catch basins to divert flow into the Hayden Canal pipeline. The cost of rock excavation and the ever present possibility of the existing pipeline being full of irrigation water made this part of the plan of improvement inadvisable. However, a small diversion dike could be constructed along the railroad tracks near the east end of East Third Street to divert water away from business places in that vicinity. Other plans of improvement included replacing, or paralleling, the present pipeline on Mill Avenue with a larger pipeline to carry the runoff from along the Highway to the river.

The plan of improvement that we recommend is indicated on Plate 4 and proposes to provide protection against a 10-year storm except in the area between Mill Avenue and the railroad where 5-year protection will be provided by means of the following:

1. Leave the existing storm drain on Mill Avenue in place and utilize its capacity of about 9 cubic feet per second

2. Construct a new 48-inch storm drain beginning at Mill Avenue and extending west along Fifth Street to Farmers Avenue. This line would be connected to the existing line on the east side of Mill Avenue to remove flow that the Mill Avenue line cannot handle

3. On Farmer Avenue connect to the proposed Farmer Avenue interceptor which is discussed on Page 16

4. Construct a short stub line east on Fifth Street from Mill Avenue with necessary catch basins

5. Construct additional catch basins on Mill Avenue at Fifth Street

6. Connect the new 48-inch line on Fifth Street to the existing storm sewer that is located east of the railroad tracks and intercept the flow of the existing line at that point

This plan has the advantage of utilizing the present line on Mill Avenue, and the small amount of construction on the Highway will not be a great disruption of traffic or an inconvenience to business places along Mill Avenue. In addition, the diversion of the flow from the existing storm drain east of the railroad will provide greater protection for the business and light industrial developments in the area east of the railroad tracks. The present storm drain east of the railroad will barely afford protection against 2-year storms and with further development in this vicinity more protection will be required. The proposed improvement will provide protection against a 5-year storm under future conditions of development for this vicinity east of the railroad.

In addition to the pipeline from Fifth Street and Mill Avenue, it will be necessary to construct additional catch basins on Mill Avenue and along East Fifth Street to provide sufficient inlet capacity to the new pipeline.

It is recommended that immediate emergency measures be taken to relieve the frequent flood conditions occurring along the east side of Mill Avenue in the vicinity of Fourth and Fifth Streets. This could be accomplished by constructing the proposed 48-inch pipeline under Mill Avenue at Fifth Street as soon as possible. The downstream temporary outlet which would be located about 200 feet west of Mill Avenue should be constricted to permit a flow of only 10 cubic feet per second from the pipeline at this time. It is estimated that the additional flow of 10 cubic feet per second would not materially change flood conditions west of Mill Avenue to the railroad. The cost of the emergency work at this location would amount to about $12,000. When the complete plan of improvement for this area as recommended previously in this Report is constructed, this emergency work can be incorporated in the final project.

The cost of the proposed improvements on Fifth Street from Mill Avenue to Farmer Avenue is estimated at $45,000, not including the cost of the emergency work. The following is a breakdown of the estimate of cost for this part of the improvement:

48-inch RCP	650 LF	@ $ 26.00	$16,900*
60-inch RCP	250 LF	36.00	9,000
60-inch RCP under RR	100 LF	90.00	9,000
Pavement replacement	85 SY	14.00	1,200
New catch basins	10 Ea	400.00	4,000
Miscellaneous and contingencies	LS		4,900
Total Cost			$45,000

*All estimates rounded to hundredths of dollars.

If the Farmer Avenue storm drain interceptor which is discussed on Page 16 is not constructed, it would be necessary to continue the 60-inch pipeline to the river at an additional cost of about $75,000 making a total cost for this plan of improvement of $120,000.

Farmer Avenue Interceptor Storm Drain (Plate 4). It is recommended that an interceptor be constructed along Farmer Avenue from Broadway Road to the Salt River as indicated on Plate 4. This storm drain will serve flood areas that have developed along Broadway Road east of the railroad, at Thirteenth Street in areas east and west of the railroad and at Eighth Street where the existing joint-use with an irrigation pipeline is not dependable, and will serve to remove runoff from the downtown business area and the area between the railroad and Mill Avenue north of Eighth Street and south of Third Street.

The amount of slope north toward the river from Broadway Road to Fifth Street is very small; therefore, pipe sizes necessary to carry a 5-year runoff from contributing areas and a 10-year runoff from the downtown business area would be fairly large. A study was made of a proposal to carry storm water from the vicinity of the railroad to the west in separate pipelines along Broadway Road, Thirteenth Street, and Eighth Street, far enough for a suitable outlet to the river. These individual lines would exceed the cost of the Farmer Avenue interceptor and would further compound the outfall problems on the west side of Tempe. If the Thirteenth Street drainage line was extended from the railroad to the east end of the large storm drain at Beck Avenue and Howe Street, the existing storm drain at Beck Avenue would have capacity for this added amount of storm flow but would be at its peak with no more capacity for additional flow that will surely arise with new subdivisions, paved streets, parking areas, and other future developments in that area on the west side of Tempe.

With the future development of West Eighth Street with wider paving, curbs, and gutters, elimination of storm water from a westward flow by the Farmer Avenue interceptor will greatly reduce storm drain costs for that project. The cutoff of the storm flow at Broadway Road and the railroad tracks by the interceptor will permit smaller pipe sizes to be used when paving improvements are installed on that street west of Hardy Drive. In addition, the existing outlet ditch west of Priest Road and north of Broadway Road has limited capacity which would be further taxed if all the flow east of the railroad were permitted to continue west along Broadway Road.

It is further recommended to size the pipeline for the Farmer Avenue interceptor so that the line could be extended south to Southern Avenue in the future. This extension could pick up storm water flows from a large rapidly developing residential area lying along Southern Avenue and extending south to the proposed freeway a half-mile south of Southern Avenue.

The estimated cost of the Farmer Avenue interceptor storm drain from Broadway Road to the Salt River amounts to $520,000. A breakdown of the cost for this interceptor is as follows:

78-inch RCP	4,540 LF @	$48.50	$220,000
84-inch RCP	3,960 LF	55.00	218,000
Pavement replacement	4,000 SY	14.00	56,000
Miscellaneous and contingencies	LS		26,000
Total Cost			$520,000

It is estimated that the extension of the line to Southern Avenue from Broadway Road would cost $200,000. In addition, a collecting storm drain along Southern Avenue would have to be built. This extension is recommended for construction at a later phase of this program.

Thirteenth Street Flood Area (Plate 4). With the construction of a Farmer Avenue interceptor drainage pipeline along Farmer Avenue, the flood problems along Thirteenth Street east and west of the railroad would be largely relieved. The storm drainage system west of the railroad on Thirteenth Street consists of two 18-inch pipelines from the railroad to Judd Street at which point the pipeline becomes 24-inches in size. At Judd Street and the alley south of Twelfth Street the pipeline turns west and is 27-inches in size. The 27-inch pipeline continues to Hardy Drive and Twelfth Street where it turns west in a 30-inch pipeline. At Beck Avenue and Howe Street the pipeline increases to 36-inch size and continues west to empty into the Tempe Drainage District No. 2 ditch. After the construction of the Farmer Avenue interceptor, the existing storm drain west of the railroad would be capable of handling a 2-year storm and because of the street grades no large pond areas would be formed for floods up to a 5-year magnitude.

The area to the east of the railroad on Thirteenth Street is drained largely by an 18-inch to 24-inch storm drain on the south side of Apache Boulevard. This drain was constructed by the Arizona Highway Department as a part of the improvement of Apache Boulevard. In addition, there are two lateral drains on Mill Avenue. A 24-inch pipeline extends from north of Tenth Street to Thirteenth Street and the other is a 14-inch pipeline extending from Fifteenth Street to Thirteenth Street. All three of these lines empty into a 30-inch storm drain at Thirteenth Street and Mill Avenue and this 30-inch pipeline extends westward to the railroad tracks. Also, on Thirteenth Street between Mill Avenue and the railroad,

there are two other lines, an 18-inch pipeline and a 16-inch pipeline serving catch basins. These latter two lines empty into a structure at the end of the 30-inch line. A 24-inch pipeline carries the flow under the railroad to meet the two previously described 18-inch lines to the west as indicated on Plate 4.

The three lines on Mill Avenue and Apache Boulevard are just barely able to carry the runoff from a 1-year storm. Flooding has occurred frequently at the intersections of Fourteenth Street, Parkway Boulevard, and Fifteenth Street with Mill Avenue. This condition will probably be rectified when Mill Avenue is improved from Thirteenth Street to Broadway. The 24-inch pipeline on Mill Avenue from north of Tenth Street was able to carry storm water from its area from a 2-year storm until the large parking lot was constructed for the Grady Gammage Auditorium. Here the parking lot acts as a sump and the water is pumped out of the lot by two 400-gallon per minute pumps. Pumping at the peak of the storm runoff presently overtaxes the storm drains downstream. At the present time there are no serious flood problems along Apache Boulevard; however, this may change with future building plans.

Under present conditions with a constricted outlet at the railroad tracks, the 30-inch pipeline on Thirteenth Street between Mill Avenue and the railroad will provide for flow from only the smaller storms. However, if the Farmer Avenue interceptor is installed and the 30-inch pipeline is connected to the interceptor, the 30-inch storm drain on Thirteenth Street will accommodate the runoff from a 3-year storm. No improvements are recommended for this area at the present with the exception of the connection to the Farmer Avenue interceptor.

It is recommended that immediate emergency measures be taken to relieve the flood conditions at Ash Avenue and Thirteenth Street. This could be accomplished by constructing the proposed 30-inch pipeline under the railroad tracks. The new pipeline would commence at the structure at the west end of the existing 30-inch pipeline and extend westerly under the railroad tracks to Farmer Avenue where the pipeline would terminate at a catch basin which would permit flow of the pipeline to rise and empty into the street gutter. The 5 cubic feet per second that would be permitted to flow out of this catch basin would relieve the ponding at Ash Avenue and would not affect downstream flood conditions. It is estimated that this emergency work would cost $8,400 and the pipeline could be incorporated into the proposed plan for the Farmer Avenue interceptor storm drain.

Broadway Road Flood Area (Plate 4). The area along Broadway Road east of the railroad tracks has been subject to flooding during the three major storms occurring this past summer. The flooding has resulted largely from the high intensity of the storms and also because the storm drainage system along Broadway Road is a joint-use pipeline serving irrigation purposes as well as storm runoff. At the peak of these storms enough irrigation water was being run in the pipeline to interfere with its storm drainage use. In addition, since Broadway Road was improved, an 18-inch storm drain was constructed on Mill Avenue extending northerly from a point south of Alameda Drive to Broadway Road. This storm drain picks up considerable tributary runoff and has materially increased flood conditions on Mill Avenue at Broadway Road.

The plan of improvement for Broadway Road is to provide for 5-year protection by constructing a new 27-inch pipeline and necessary catch basins commencing at College Avenue and extending to a point west of the railroad tracks as indicated on Plate 4. At Mill Avenue the pipeline will pick up the flow from the 18-inch line south on Mill Avenue. West of the railroad tracks the 27-inch pipeline will empty into the Farmer Avenue interceptor. The interceptor at this point will also pick up excess storm water from the existing joint-use pipeline, therefore enabling this pipeline to have more downstream capacity to carry storm water from future developments in the industrial park area south of Broadway between the railroad and Hardy Drive. This improvement will provide the area along Broadway Road east of the railroad tracks with at least a 5-year protection and more if the existing joint-use pipeline has storm water capacity. West of the railroad tracks to Hardy Drive the existing curb and gutter flowage capacity combined with possible use of existing joint-use pipeline should protect this area from at least a 3-year storm and more if the joint-use line has capacity. However, when Broadway Road is improved west of Hardy Drive, a separate storm drain should be installed to a suitable outlet to the west.

It is recommended that immediate emergency construction be undertaken to relieve the flood conditions that develop east of the railroad on Broadway Road. This emergency work would consist of constructing the proposed 27-inch pipeline under the railroad beginning at a new catch basin at the low point in the roadway east of the railroad and terminating at an outlet catch basin west of Farmer Avenue. The emergency pipeline

would carry only 5 cubic feet per second due to a constricted outlet. The additional 5 cubic feet per second carried by the street gutter west of the railroad would not affect flood conditions westerly on Broadway Road under present conditions of development. It is estimated that the emergency work would cost $13,000 and the pipeline could be incorporated in the proposed plan of improvement for Broadway Road.

The estimated cost of the new line on Broadway Road east of the railroad, not including the emergency work, amounts to $57,000. A breakdown of the cost is as follows:

18-inch RCP	300 LF @	$ 8.00	$ 2,400
27-inch RCP	2,230 LF	12.50	27,900
Pavement replacement	1,300 SY	14.00	18,200
Catch basins	8 Ea	400.00	3,200
Miscellaneous and contingencies	LS		5,300
Total Cost			$57,000

Eighth Street and Farmer Avenue (Plate 4). Although this location is not a storm problem area, it is proposed to connect the existing 30-inch joint-use pipeline to the Farmer Avenue interceptor at this point to carry off storm runoff. This irrigation line serves as a storm drain with a large drainage area extending east along Eighth Street and including a large segment of the Arizona State University campus. Continued development of dormitories and other buildings, as well as paved parking lots, will surely make this line west of the railroad undersized in the future. By diverting storm runoff at Farmer Avenue, pipeline capacities will be reduced downstream, and drainage costs for future improvement of west Eighth Street will be reduced. The cost estimate of making the diversion at this location is included in the cost of the Farmer Avenue interceptor.

Parkside Subdivision Flood Area (Plate 5). This area has flooded during each of the three major summer storms and property damage has resulted. Flooding in this area has been the result of increasing the drainage area by the process of adding street on street as subdivisions have developed westerly in this section of Tempe. Surface runoff follows the street gutters from one subdivision to another until it is concentrated in one low point in the west side of Parkside Manor. Here the drainage is carried in an 18" x 11" corrugated metal arch pipe from the northeast corner of the Holdeman School and along the alley north of the school to an outlet in a ditch on the west side of Priest Road. The existing pipeline has a capacity of only 2 cubic feet per second. It is estimated that a 5-year storm would contribute 20 cubic feet per second to the low point at the northeast corner of the school after about 3 cubic feet per second has been diverted to Broadway Road down an alley west of the subdivision.

It is recommended that the existing pipeline on the north side of the Holdeman School be removed and replaced with a 27-inch pipe to Priest Road to provide protection from runoff resulting from a 5-year storm as indicated on Plate 5. At Priest Road the line would be continued northward in a 33-inch pipe to Howe Street where it would connect to the existing storm drain emptying into the Tempe Drainage ditch. The construction of the Farmer Avenue interceptor will provide additional capacity in the existing 36-inch storm drain on Howe Street by cutting off runoff coming down Thirteenth Street. This additional capacity would then be available for the proposed pipeline on Priest Road. In addition, 18-inch pipelines should be constructed eastward from the drainage area

low point to pick up the flow to prevent a concentration of water at the northeast corner of the school property. The pipeline on Priest Road will be sized to carry runoff from a 5-year storm from future developments on the east side of Priest Road between the school and Howe Street.

It is recommended that the 33-inch pipeline on Priest Road be constructed immediately. Priest Road, in this vicinity, will be paved as a part of a sewer interceptor installation and the storm drain pipeline should be constructed prior to the paving work. It is estimated that the cost of this emergency pipeline work would amount to $36,000. If cast-in-place concrete pipe could be used at this location, the total cost of this emergency work would be reduced to $23,000.

The estimated cost of the improvement amounts to $20,000 not including the cost of the emergency work. The following is a breakdown of the costs:

18-inch RCP	600 LF @	$ 8.00	$ 4,800
27-inch RCP	700 LF	12.50	8,800
Pavement replacement	250 SY	8.00	2,000
Catch basins	7 Ea	400.00	2,800
Miscellaneous and contingencies	LS		1,600
Total Cost			$20,000

Hudson Manor (Plate 6). The lower end of this subdivision near Cedar Street and Hudson Drive was subject to flooding during the August and September storms of 1964. Homes in this area of the subdivision were reported to be flooded to a depth of several inches over the ground floor and much property damage and inconvenience resulted. This subdivision is surface drained along paved streets to a low point at Cedar Street and the alley south of Apache Boulevard. At this point runoff

water enters two catch basins from which it is carried by an 18-inch pipe to the south side of Apache Boulevard where it enters a 27-inch State Highway Department storm drain. This drain along the Highway empties into a 30-inch pipeline on Terrace Road from which point it is carried to the Salt River along Rural Road.

The storm drains along the Highway and along Terrace Road apparently were designed to carry runoff from a 1-year storm. The existing drain at the lower end of Hudson Manor was originally designed to take care of a 2-year storm. These storm drains have functioned within their capabilities, but when this area was visited by two storms in one year each of a 10-year or more return frequency, severe flooding resulted.

The cost of replacing the existing storm drains from Cedar Street to the river with a drain capable of handling a 5-year or 10-year storm is estimated to cost about $165,000. An estimate of cost of a smaller parallel line along the same route would amount to more than $120,000.

It is recommended that a new route be taken to dispose of the storm water from Hudson Manor. The recommended route is from the existing catch basins on Cedar Street west to the west line of the subdivision, thence northerly across the Highway and northerly along an easement that would have to be acquired to the south end of Dorsey Lane. The line would continue north along Dorsey Lane to Transmission Road and thence north to the Salt River as indicated on Plate 6. Additional catch basins would be installed in the vicinity of Cedar Street and Hudson Drive and along Dorsey Lane.

This plan would have the advantage of also providing for the removal of the flood waters from the Una-Butte intersection. This area in Borden Homes Subdivision has been subject to rainwater ponding on many occasions, and the flooding above ground-floor elevations has occurred at a number of residences. The proposed plan provides for 5-year protection by constructing catch basins and a 24-inch pipeline from the Una-Butte intersection running westward along the first alley north of Apache Boulevard, thence across an easement that will have to be acquired, to a junction with the north-south pipeline from Hudson Manor. The pipelines would have sufficient capacity to provide drainage for present and future business developments on the north side of Apache Boulevard east of Terrace Road to Una-Butte Avenue.

In addition, it is proposed to size the pipeline from the Salt River to the first alley south of Apache Boulevard to enable the pipeline to be extended southerly to Broadway Road in the future. It is expected that a storm water removal problem will develop along Broadway Road between Rural Road and the east Tempe City Limits when the area between the railroad and the canal south of Broadway becomes a built-up residential district. The proposed future extension to Broadway Road is indicated on Plate 6.

The proposed plan for drainage improvement will provide protection against 5-year floods in these areas; however, due to pipe size increments the Hudson Manor flood area will be protected from storms

of greater intensity. The estimated cost of this improvement amounts to $220,000. A breakdown of the cost is as follows:

18-inch RCP	200 LF @	$ 8.00	$ 1,600
24-inch RCP	1,600 LF	11.50	18,400
27-inch RCP	150 LF	12.50	1,900
54-inch RCP	2,250 LF	32.50	73,100
60-inch RCP	2,600 LF	36.00	93,600
Catch basins	8 Ea	400.00	3,200
Pavement replacement	700 SY	8.00	5,600
Pavement replacement	150 SY	14.00	2,100
Miscellaneous and contingencies	LS		20,500
Total Cost			$220,000

Flood Area North of McKellips Road (Plate 7). The major storms this past summer were reported to have caused flooding and property damage to homes, churches, and apartments in the area in North Tempe, north of McKellips Road between College Avenue and Scottsdale Road. About 144 acres are in this drainage area, of which about 60 acres lie within the Scottsdale City Limits. Flood waters originating as far north as Belleview Street in Scottsdale and as far west as the Crosscut Canal move down streets, some of which have inverted crowns, and across residential lots to reach the low point in the area at Scottsdale Road and McKellips Road. In the course of runoff, the water jumps curbs and cuts across residential areas causing damage to private property. The area is almost entirely residential, and since the land is generally steep, no lots are irrigated. Therefore, most of the entire 144 acres contribute to the runoff. A weighted "C" value of 0.36 was used to compute the runoff which amounts to 47 cubic feet per second for a 5-year storm after deducting some flow that goes east on Continental Drive at McAllister Avenue.

There are no existing storm drain pipelines in this area with the exception of an irrigation waste water pipe on the east side of Scottsdale Road. According to the Salt River Project, this line carries no irrigation waste water and serves as a storm drain for an area at Scottsdale Road and McDowell Road. In addition, a small catch basin at Scottsdale Road and Continental Drive is connected to this line. The Project estimates that there is capacity in the pipeline for about an additional 25 cubic feet per second. The majority of the drainage area is served by drainage along streets having curbs and gutters. Also, a large amount of water is carried by two streets having inverted crowns. These streets are Pierce Street east of College Avenue and College Avenue north of Pierce Street.

The plan of improvement provides for a pipeline and catch basins on McAllister Avenue commencing at Continental Drive and extending southerly to Fillmore Street as indicated on Plate 7. Pipeline sizes increase from 24 inches to 33 inches on McAllister Avenue. Along Fillmore Street the pipeline changes from 36-inch to 39-inch size. A 42-inch line would then extend southerly along the west side of Scottsdale Road to McKellips Road where it would meet a proposed pipeline running west to east on McKellips Road, which will be discussed in the next paragraph. In addition, the existing drainage line on the east side of Scottsdale Road should be utilized by installing catch basins on the west side of Scottsdale Road between Continental Drive and McKellips Road and piping these structures across Scottsdale Road to the existing drain line.

Pipeline on McKellips Road (Plate 7 and Plate 8). It was reported that property in the north and west sections of Cavalier Hills Subdivision located on the west side of Scottsdale Road between Curry Drive and McKellips Road was damaged during the August and September rainfall runoffs. A large drainage area of rough, steep, and undeveloped land lying to the west of the subdivision contributed the runoff to the subdivision. This drainage area, part of which is included in Papago Park, as indicated on Plate 8, extends to the Crosscut Canal to the west and includes about 215 acres. A larger part of this drainage area (180 acres) is drained by a series of washes which collect in one large wash that enters the subdivision about midway along its western boundary. There it passes down a short stub street and enters McAllister Avenue. McAllister Avenue between this point and the lower end at Curry Drive has an inverted crown. However, the quantity of runoff from these two storms was so great that the floodwaters jumped curbs and caused residential damage.

Smaller drainage areas furnish floodwaters through washes that intersect the west boundary of the subdivision south of the main wash mentioned above. These small washes spill floodwater into the backyards of about eight residences along the west side of the subdivision and cause damage to landscaping and other improvements.

The plan of improvement that we recommend is to reduce the size of the drainage area that contributes storm water flow to the large wash that enters the west side of the subdivision. It is proposed that the existing culvert across McKellips Road south of College Avenue, which is part

of the above-mentioned large wash, be removed and a pipeline installed from this point on the north side of McKellips Road and carry water from this area east to Scottsdale Road. At this point the previously-mentioned proposed 42-inch pipeline on Scottsdale Road would be joined and the run-off from both pipelines carried easterly to Indian Bend Wash in a 60-inch and 66-inch pipeline as indicated on Plate 7.

In addition, it would be feasible to construct a grader ditch along that portion of McKellips Road near the Crosscut Canal where the road runs in a southwest-northeast direction. The grader ditch would divert waters to the north side of McKellips Road west of College Avenue as indicated on Plate 8. The pipeline diversion of the flow down the wash and the grader ditch would reduce the size of the drainage area of the large wash from 180 acres to 103 acres. This reduction in the size of the drainage area would be great enough to permit the safe operation of the present system of using the inverted crown of McAllister Avenue as a drainageway through Cavalier Hills Subdivision.

A study was made of the possibility of not using McAllister Avenue as a drainageway, and the runoff from the large wash was placed in a pipeline along the west side of the subdivision and carried south to Curry Road. However, excessive deep cuts and probable rock excavation would be encountered in laying this pipeline; therefore, it is believed that a pipeline in this location for this purpose would not be economical.

The new Tempe Water Treatment Plant in Papago Park is not expected to materially change runoff conditions into the flood problem areas, although the dam for the waste water pond will reduce the area draining to Curry Road by about 5. 5 acres.

The total estimated cost of the proposed improvements north of McKellips Road amounts to $315,000. A breakdown of the cost estimate is as follows:

18-inch RCP	360 LF @	$ 8.00	$ 2,900
24-inch RCP	1,000 LF	11.00	11,000
27-inch RCP	250 LF	12.50	3,100
30-inch RCP	550 LF	14.25	7,800
36-inch RCP	3,170 LF	18.50	58,600
39-inch RCP	700 LF	20.00	14,000
42-inch RCP	1,300 LF	21.50	28,000
60-inch RCP	1,350 LF	36.00	48,600
66-inch RCP	2,400 LF	40.00	96,000
Catch basins	36 Ea	400.00	14,400
Pavement replacement	400 SY	8.00	3,200
Pavement replacement	200 SY	14.00	2,800
Grader ditch	1,000 LF	1.50	1,500
Miscellaneous and contingencies	LS		23,100
Total Cost			$315,000

Other Cavalier Hills Recommendations (Plate 7). As previously mentioned, there are about eight residences at the south end of the west line of the subdivision that are subject to damage from water coming down smaller washes to the west. It is recommended that these individual washes be piped along easements across these lots to McAllister Avenue and Gene Avenue to the east, as indicated on Plate 7. The estimated cost of protecting these homes amounts to $13,000. The breakdown of the estimate is as follows:

24-inch RCP	750 LF @	$ 11.00	$ 8,200
Catch basins	5 Ea	300.00	1,500
Inlet structures	5 Ea	200.00	1,000
Restore landscaping	LS		1,000
Miscellaneous and contingencies	LS		1,300
Total Cost			$13,000

It is further recommended that, if the land between Cavalier Subdivision and Papago Park is subdivided, a careful study should be made of the drainage of that area with a view to draining streets to the north to McKellips Road and to the south to Curry Drive by means of catch basins and pipelines.

Drainage Plan for Curry Road (Plate 7). It was reported that the large shopping center at the southwest corner of Curry Road and Scottsdale Road suffered damage during all three of the major storms during the past summer. Floodwaters were within inches of entering the many shops that are located in the shopping center and any increase in the intensity of these storms would have caused heavy losses. The removal of silt and debris from the large parking lot always presents a large cost even after minor storms. With the continued growth of business places in this area along Scottsdale Road, it appears that an improvement in the surface drainage at this location is warranted.

The storm runoff passing through and originating in Cavalier Hills Subdivision collects on the north side of Curry Road at McAllister Avenue and at Scottsdale Road. The storm runoff then crosses Curry Drive and enters the large shopping center parking lot on the south side of Curry Road, and part of the runoff continues down Scottsdale Road, causing flood conditions south of Princess Drive along Scottsdale Road.

Existing storm drains consist of a 42-inch to 48-inch pipeline on Princess Drive from Scottsdale Road to McAllister Avenue. This is a joint-use pipeline with irrigation water taking up nearly all the pipeline capacity when being used for that purpose. The existing pipeline could

serve to remove local water falling in that immediate area but could not dispose of additional waters coming from north of Curry Road. In addition, drainage features are included in the improvement district work on McAllister Avenue south of Curry Road but are not large enough to carry a 5-year storm runoff coming from north of Curry Road.

Two plans of improvement were investigated. One plan provided for a pipeline originating at McAllister Avenue and Curry Road and extending eastward to Indian Bend Ditch about 2,600 feet east of Scottsdale Road. However, the prevailing slope in this direction is not great enough for an economical pipeline. The second plan and the route chosen provides for a pipeline originating at Scottsdale Road and Curry Road and extending westerly to a point on the north side of Curry Road west of Gene Avenue, as indicated on Plate 7. From this point the pipeline passes under Curry Road and continues southerly along the west side of McAllister Avenue (west side of the shopping center) to a point south of Princess Drive where the proposed pipeline enters the Indian Bend Ditch. Salt River Project engineers have stated that the Indian Bend Ditch to the west is already at its full storm runoff capacity. Therefore, it is proposed to install a diversion structure in the ditch at a point about 1,300 feet south of Princess Drive to remove storm water entering above at Princess Drive. Flow from the diversion structure would be in a pipeline on Gilbert Drive to the east to a wash that is tributary to the Salt River. The proposed pipelines will carry rnnoff from a 5-year storm and are sized to include surface runoff from the northeast corner of the proposed County Hospital site.

The estimated cost of this improvement amounts to $116,000. A breakdown of the estimate is as follows:

18-inch RCP	400 LF @	$ 8.00	$ 3,200
30-inch RCP	750 LF	14.25	10,700
42-inch RCP	400 LF	21.50	8,600
48-inch RCP	2,050 LF	26.00	53,300
54-inch RCP	600 LF	32.50	19,500
Catch basins	10 Ea	400.00	4,000
Diversion structure	LS		1,500
Channel improvement	LS		2,000
Pavement replacement	220 SY	14.00	3,100
Miscellaneous and contingencies	LS		10,100
Total Cost			$116,000

SUMMARY OF EMERGENCY PROGRAM CONSTRUCTION COSTS

The following is a summary of construction costs for an emergency program to lessen flood damages in certain areas prior to the installation of the improvements recommended in this Report. In addition, the immediate construction of the storm drain on Priest Road should be undertaken before that roadway is paved as part of present construction work in connection with the installation of the sanitary sewer interceptor pipeline. The total cost of the emergency work is estimated at $69,400 and is broken down by areas as follows:

Mill Avenue at Fifth Street	$12,000
Thirteenth Street at the railroad	8,400
Broadway Road at the railroad	13,000
Priest Road	36,000
Total Cost Emergency Work	$69,400

The estimated cost of the emergency work on Priest Road could be reduced to $23,000 if cast-in-place concrete pipe were used on this pipeline. This would then decrease the total cost of all the emergency work to $56,400.

SUMMARY OF CONSTRUCTION COSTS

The following is a summary of the estimates of cost of construction for the individual drainage improvements based on 1964 price levels for construction:

Fifth Street: Mill Avenue to Farmer Avenue	$ 45,000
Broadway Road: College Avenue to Farmer Avenue	57,000
Farmer Avenue interceptor: Broadway Road to Salt River	520,000
Parkside Manor Subdivision	20,000
Hudson Manor Subdivision (including Una-Butte flood area)	220,000
Storm drains north of McKellips Road	315,000
Southwest corner of Cavalier Hills Subdivision	13,000
Scottsdale Road and Curry Road to Indian Bend Ditch	116,000
Total Estimated Construction Cost	$1,306,000

TOTAL COST OF IMPROVEMENTS

The total cost of the improvements proposed in this Report amounts to $1,440,000 not including the recommended emergency program. The breakdown of the total cost is as follows:

Estimated construction cost	$1,306,000
Engineering	110,000
Legal expenses	9,000
Rights-of-way	3,000
Bonds and bond attorney	12,000
Total Cost	$1,440,000

The amount of general obligation bonds that may be issued for all or part of the above improvements would be within the legal limits of bonded indebtedness for the City of Tempe.

CONCLUSION AND RECOMMENDATIONS

Certain areas within the City of Tempe have a serious storm flood problem and remedial works should be constructed as soon as possible. The proposed improvements are designed to provide protection against runoff from storms having a return frequency of once in five years for residential areas and for a return frequency of once in ten years for highly developed business areas.

It is recommended that the City of Tempe undertake the proposed drainage improvements as soon as possible. At a number of locations, the routes chosen were under unpaved streets, and this underground work should be done prior to paving. It is believed that each of the proposed improvements have a favorable cost-benefit ratio in that the cost of the work will be less than benefits returned through a decrease in flood damages.

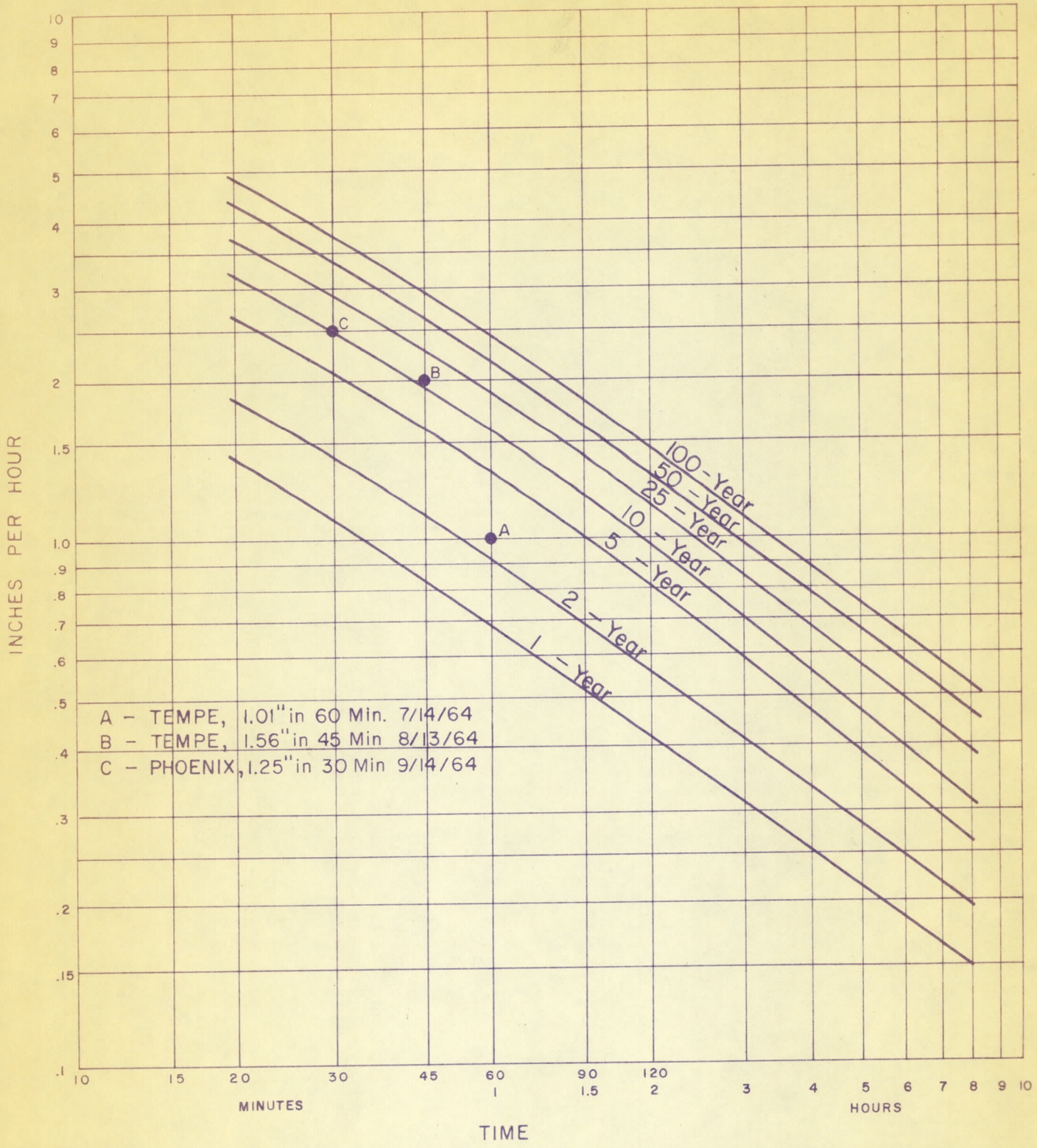
The following additional recommendations are made:

1. The City of Tempe should institute a schedule of periodic inspections of all drainage facilities.
2. Wherever possible the use of joint irrigation storm water pipelines should be avoided due to the unreliability of having sufficient capacity for storm water removal when needed.
3. The City of Tempe should take immediate measures to construct the emergency facilities for the removal of storm water at Mill Avenue and Fifth Street, Thirteenth

Street and the railroad, and at Broadway Road and the railroad. In addition, the pipeline on Priest Road to serve the Parkside Manor subdivision should be constructed immediately prior to the paving improvements on Priest Road. The cost of the emergency work is estimated at $69,400, or if cast-in-place pipe is used on Priest Road, the total estimated cost would amount to $56,400.

4. This Report should be supplemented to cover additional areas within the City that have present or potential flood problems. This is particularly true as the City grows to the south where ground slopes are flatter and the direction of the growth brings each area farther away from an outlet to receive storm water.

PLATES



RAINFALL INTENSITY - DURATION - FREQUENCY

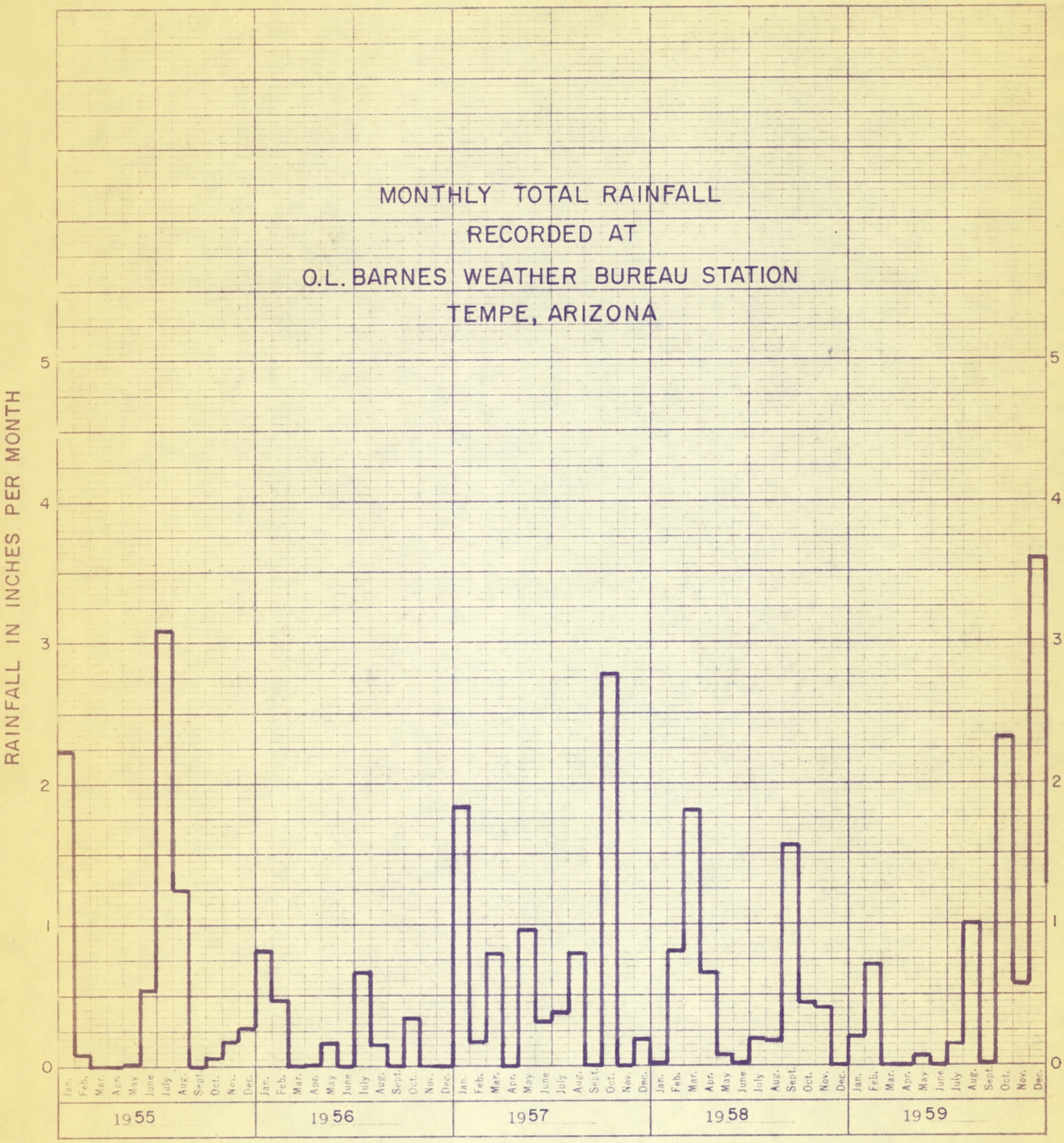
DATA From U.S. WEATHER BUREAU TECHNIAL PAPER NO. 40

DRAINAGE REPORT
CITY OF TEMPE, ARIZONA

RAINFALL INTENSITY CURVES

JOHN CAROLLO ENGINEERS
PHOENIX, ARIZONA DEC. 1964

PLATE 1

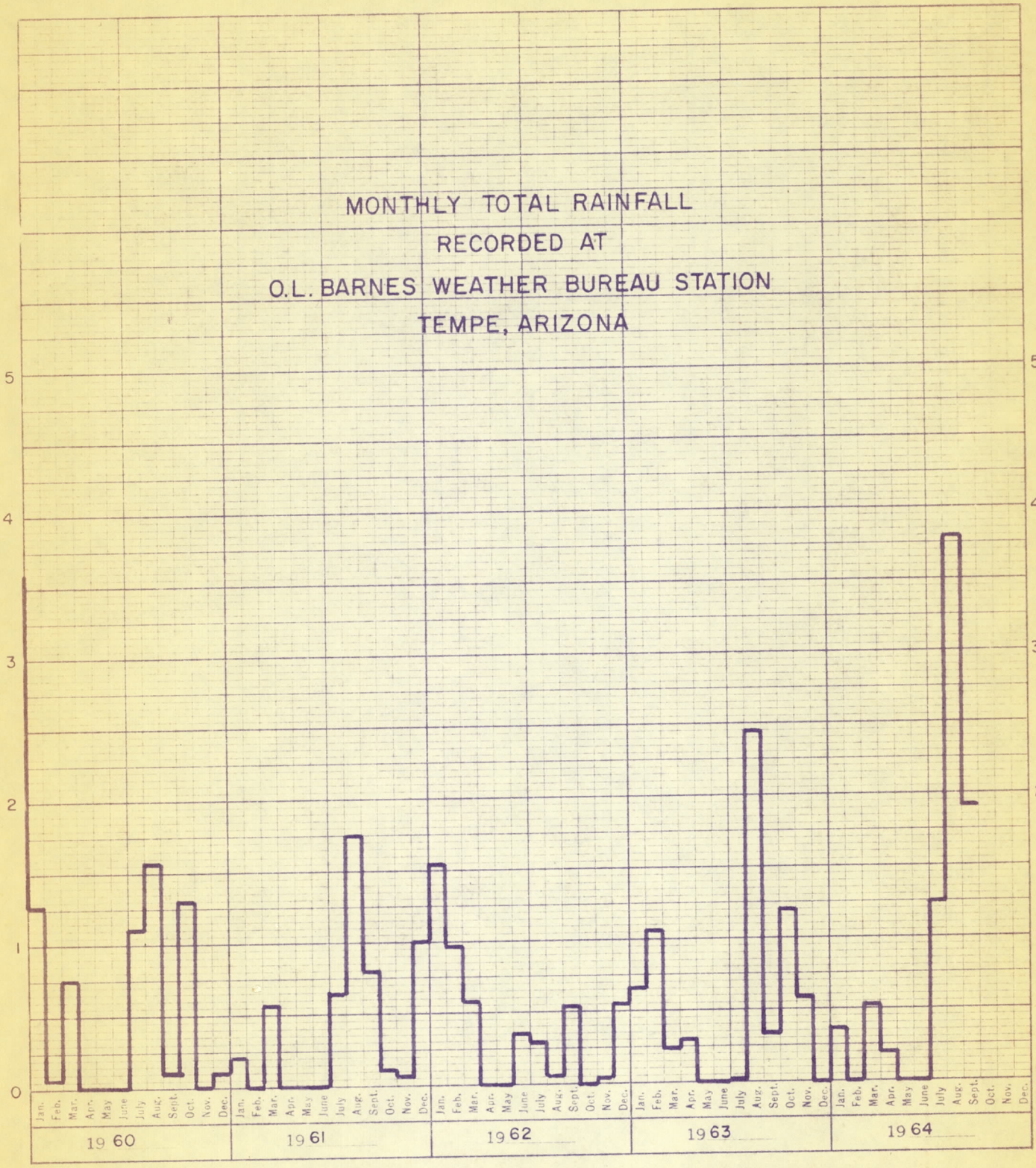


DRAINAGE REPORT
CITY OF TEMPE, ARIZONA

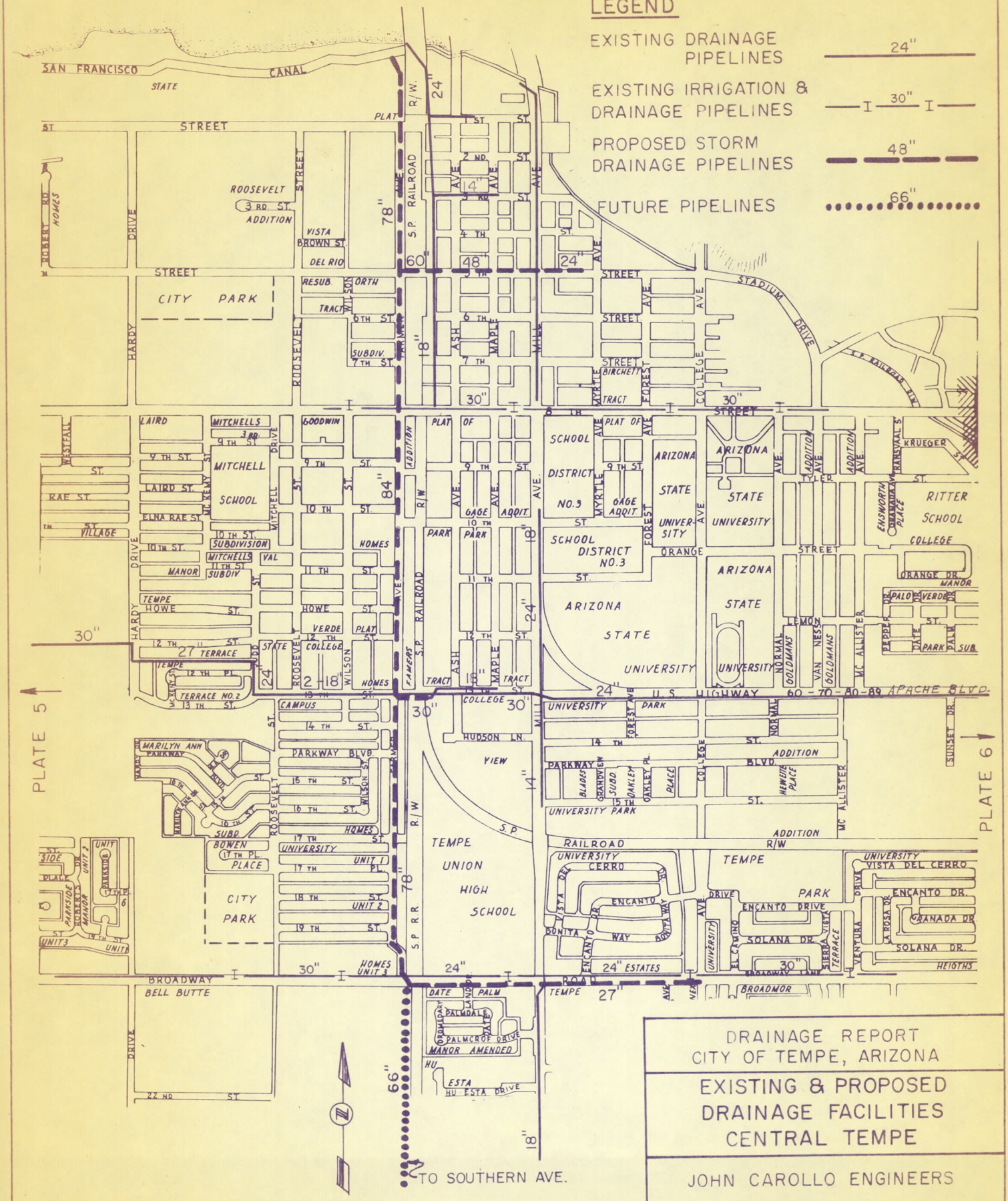
1955-1959 RAINFALL

PLATE 2

JOHN CAROLLO ENGINEERS
PHOENIX, ARIZONA DEC. 1964



JOHN CAROLLO ENGINEERS PHOENIX, ARIZONA DEC. 1964	DRAINAGE REPORT CITY OF TEMPE, ARIZONA
	1960-1964 RAINFALL
	PLATE 3

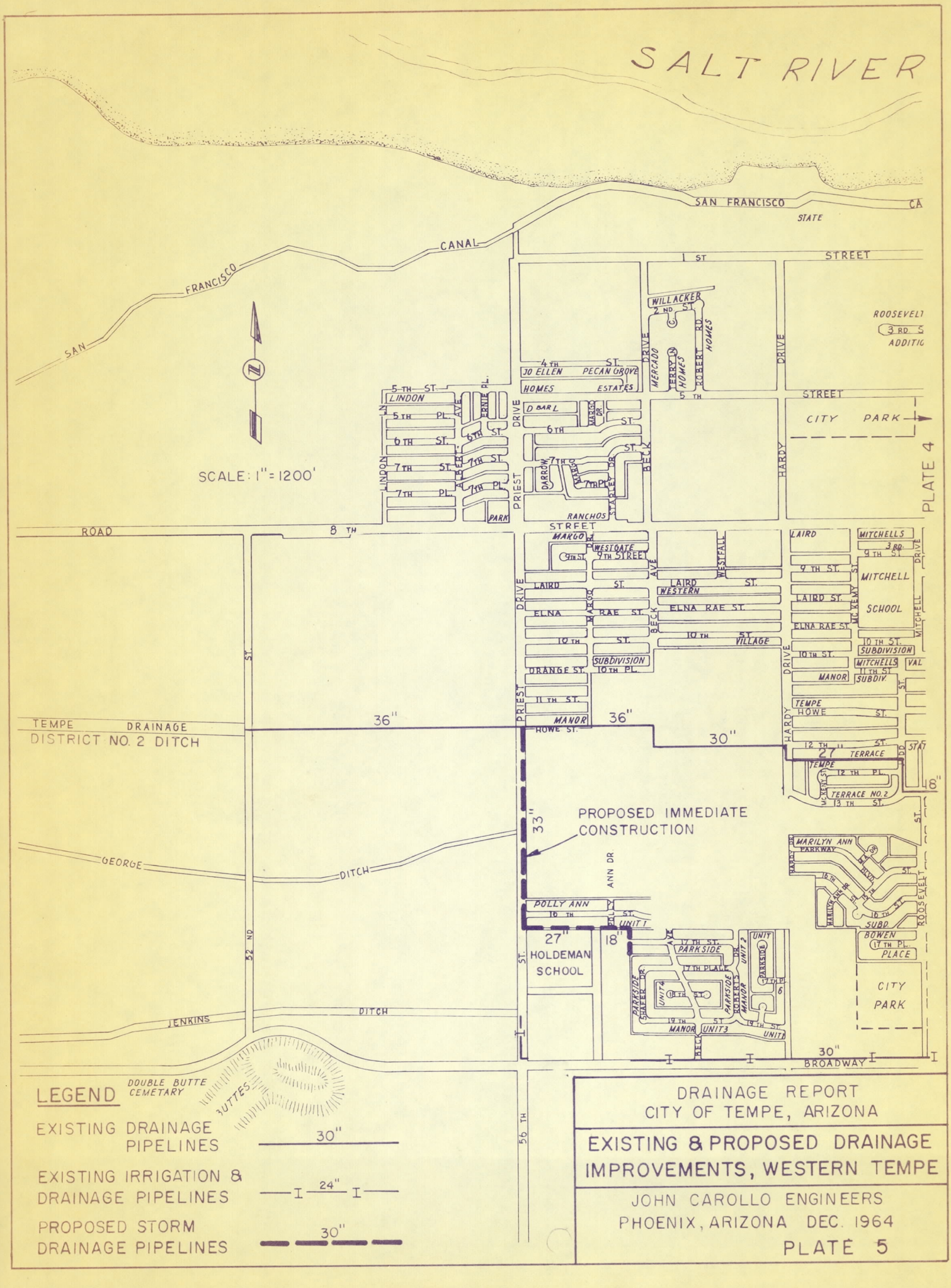


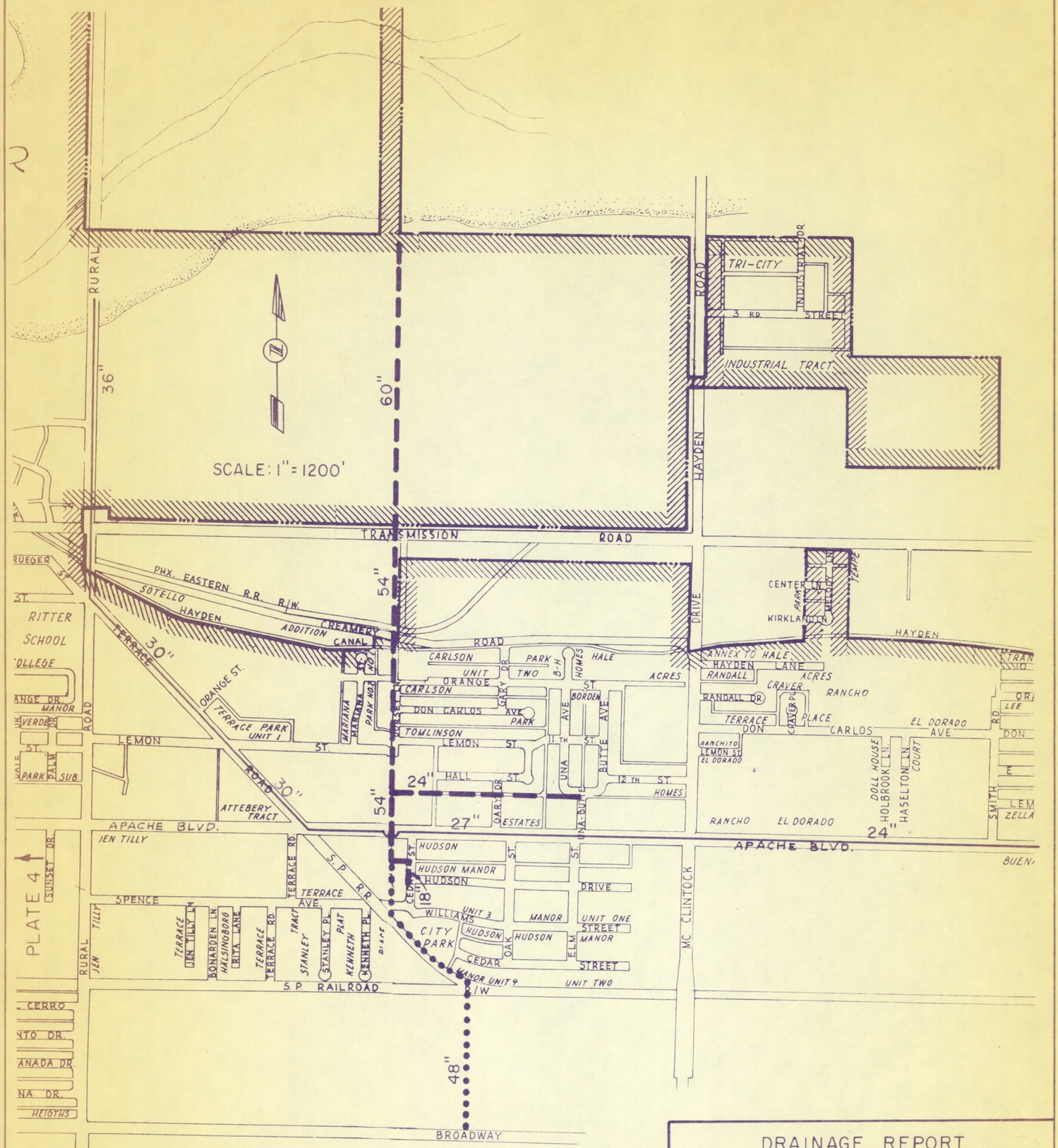
DRAINAGE REPORT
CITY OF TEMPE, ARIZONA

EXISTING & PROPOSED DRAINAGE FACILITIES CENTRAL TEMPE

JOHN CAROLLO ENGINEERS
PHOENIX, ARIZONA DEC. 1964

PLATE 4


SALT RIVER
SAN FRANCISCO CANAL
SAN FRANCISCO CA STATE
SCALE: 1" = 1200'
PLATE 4
1 ST STREET
WILLACKER
2 ND ST
MERCADO DRIVE
TERRY LO HOMES
ROBERT RD HOMES
ROOSEVELT 3 RD ADDITION
4 TH ST
JO ELLEN PECAN GROVE HOMES ESTATES
5 TH STREET
CITY PARK
HARDY DRIVE
LINDON LN
5 TH ST
5 TH PL
6 TH ST
7 TH ST
7 TH PL
ERNIE PL
AVE
DOARL DR
MARGO DR
DARROW DR
STANLEY DR
BECK DR
PRIEST DRIVE
PARK
RANCHOS
8 TH STREET
ROAD
MARGO DR
WESTGATE 9 TH STREET
WESTFALL AVE
LAIRD ST
WESTERN
ELNA RAE ST
10 TH ST
VILLAGE
SUBDIVISION
ORANGE ST
10 TH PL
11 TH ST
MANOR
LAIRD
WITCHELLS 3 RD
9 TH ST
MITCHELL SCHOOL
WILKINS DR
WITCHELL DR
10 TH ST SUBDIVISION
MITCHELLS 11 TH ST SUBDIV
VAL MANOR
TEMPE HOWE ST
12 TH ST
27 TERRACE
TEMPE 12 TH PL
TERRACE NO. 2
13 TH ST
HOWE ST
TEMPE DRAINAGE DISTRICT NO. 2 DITCH
36"
36"
30"
33"
PROPOSED IMMEDIATE CONSTRUCTION
ANN DR
GEORGE DITCH
JENKINS DITCH
52 ND ST
POLLY ANN 16 TH ST
UNIT 1
27" HOLDEMAN SCHOOL
18"
MARILYN ANN PARKWAY
ROOSEVELT
SUBD
BOWEN 17 TH PL PLACE
CITY PARK
17 TH ST PARKSIDE
17 TH PLACE
PARKSIDE DR UNIT 2
PARKSIDE SHAFER DR UNIT 4
PARKSIDE ROBERTS MANOR
18 TH ST
19 TH MANOR
19 TH ST UNIT 3
UNIT 5
30" BROADWAY
DOUBLE BUTTE CEMETARY
BUTTES
56 TH ST
LEGEND
EXISTING DRAINAGE PIPELINES 30"
EXISTING IRRIGATION & DRAINAGE PIPELINES 24"
PROPOSED STORM DRAINAGE PIPELINES 30"
DRAINAGE REPORT
CITY OF TEMPE, ARIZONA
EXISTING & PROPOSED DRAINAGE IMPROVEMENTS, WESTERN TEMPE
JOHN CAROLLO ENGINEERS
PHOENIX, ARIZONA DEC. 1964
PLATE 5



LEGEND

TEMPE CITY LIMITS

EXISTING DRAINAGE PIPELINES — 24"

PROPOSED STORM DRAINAGE PIPELINES — 27"

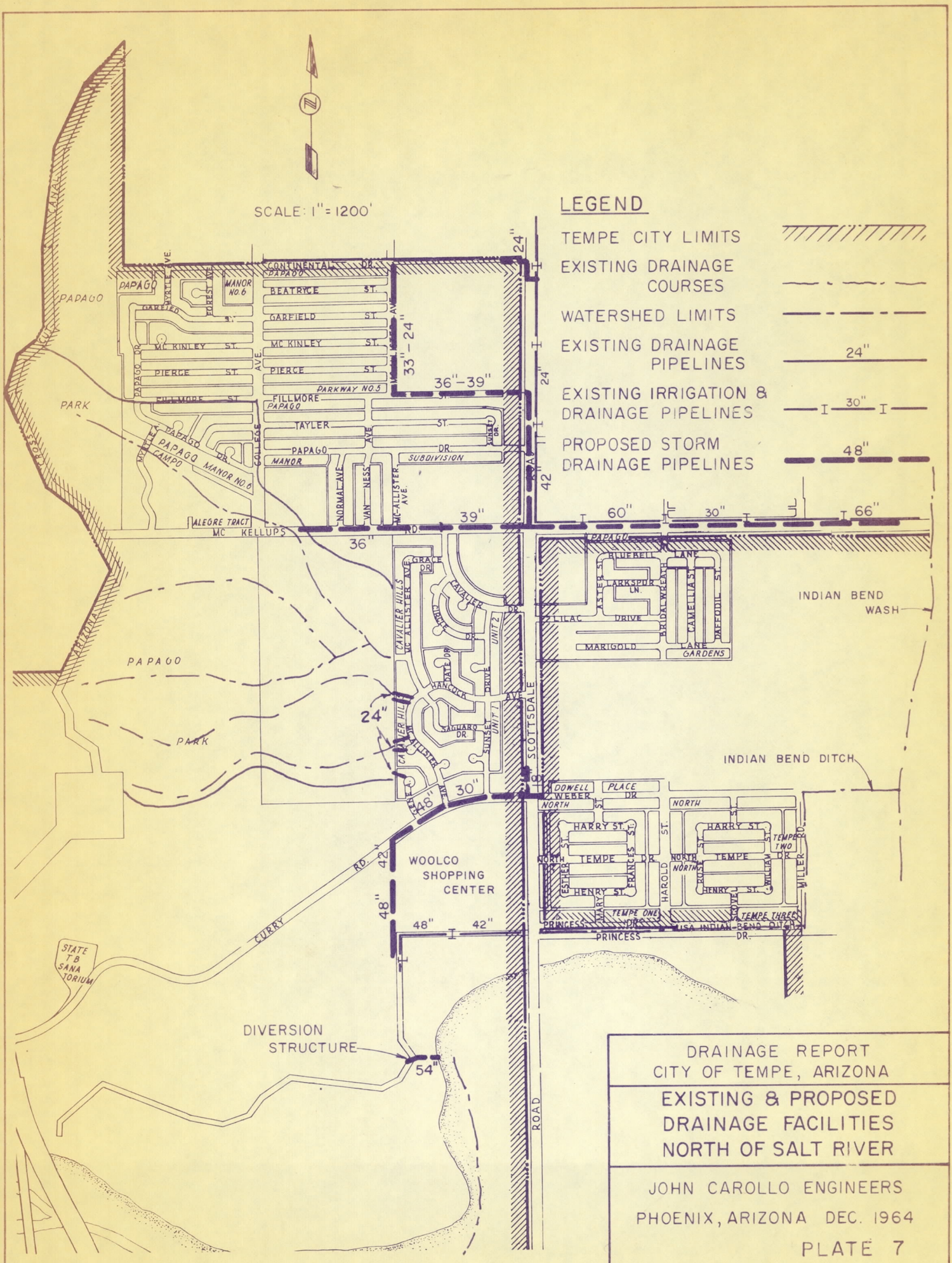
FUTURE PIPELINES — 48"

DRAINAGE REPORT
CITY OF TEMPE, ARIZONA

EXISTING & PROPOSED DRAINAGE IMPROVEMENTS, HUDSON MANOR & UNA BUTTE AREAS

JOHN CAROLLO ENGINEERS
PHOENIX, ARIZONA DEC. 1964

PLATE 6

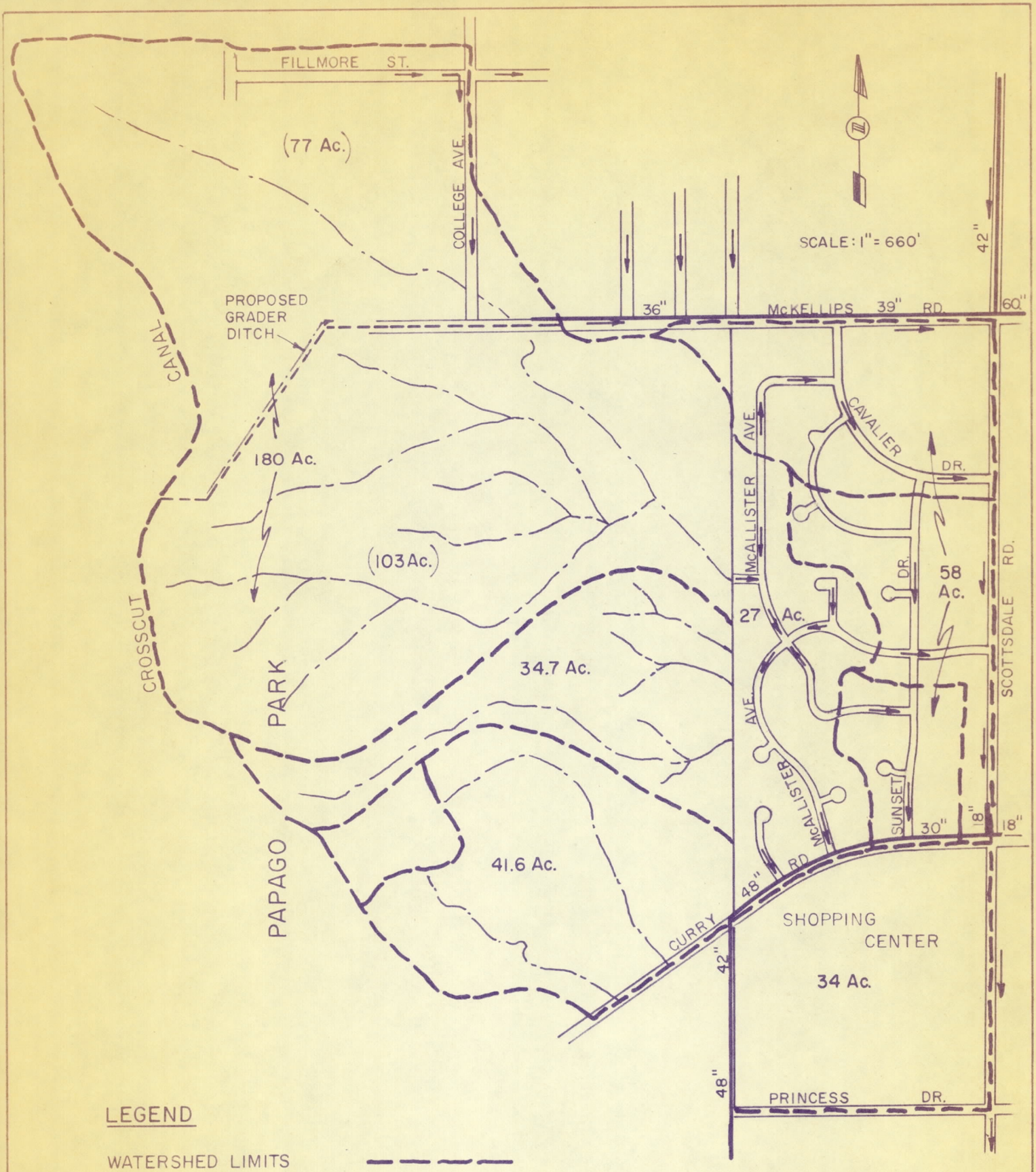


DRAINAGE REPORT
CITY OF TEMPE, ARIZONA

EXISTING & PROPOSED DRAINAGE FACILITIES NORTH OF SALT RIVER

JOHN CAROLLO ENGINEERS
PHOENIX, ARIZONA DEC. 1964

PLATE 7



LEGEND

WATERSHED LIMITS

PROPOSED WATERSHED LIMITS CHANGES

DRAINAGE COURSES

STREET DRAINAGE

PROPOSED STORM DRAINAGE PIPELINES

DRAINAGE REPORT
CITY OF TEMPE, ARIZONA

DRAINAGE AREAS
CAVALIER HILLS SUBDIVISION

JOHN CAROLLO ENGINEERS
PHOENIX, ARIZONA DEC. 1964

PLATE 8