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WK GROUP

RENO DRAINAGE STUDY

ANALYSIS OF THE STEAD DRAINAGE DEFICIENCY AREA

MARCH 1985

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City of Reno

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CHAPTER I

INTRODUCTION

A. PROJECT BACKGROUND

The City of Reno, Nevada is located at the base of the eastern slope of the Sierra Nevada Mountain Range in the Truckee Meadows basin. The present population is approximately 101,000. Reno City limits encompasses approximately 28,200 acres and extends from approximately South McCarran Boulevard in the south to the Stead area in the north.

Perhaps the most significant hydrologic feature is the Truckee River that flows northeast out of Lake Tahoe, passing through the Reno-Sparks metropolitan areas before turning north to Pyramid Lake. The Truckee River has caused significant flooding in the past, though the flooding threat has been reduced by flood control dams in the upper reaches.

There have been numerous storm drainage reports (dating back to 1957) dealing not only with the Truckee River flood potential, but local drainage flood potential. Table 1 lists these various studies. In addition, there have been numerous smaller drainage studies completed for various subdivisions in the Reno area.

TABLE 1

STORM DRAINAGE REPORTS

A Master Plan Report on Storm Drainage and Sanitary Sewerage for the City of Reno, October 1957 - Clyde C. Kennedy.

An Addendum Report on Storm Drainage, August 1963 - Kennedy Engineers.

Flood Plain Information, Truckee River, Reno-Sparks-Truckee Meadows, Nevada, October 1970 - Department of the Army, Sacramento District, Corps of Engineers.

City of Reno In-house Storm Drain Deficiency Report, started 1976.

Truckee Meadows Investigation (Reno-Sparks Metropolitan Area) Nevada Plan for Channel Modifications - Truckee River - Twin Lakes Drive to U.S. Highway 395 (River Mile 55.12 to 50.49, March 1982 - Leeds, Hill and Jewett, Inc.

B. PRESENT PROJECT

Although a significant number of the proposed projects in the various drainage reports have been completed, there are still numerous isolated areas within the city where flooding continues to be a problem.

The City of Reno recently authorized a study that would review these various drainage deficiency areas in an attempt to define what the problem or problems are at the various locations. In addition, the City requested that the existing rainfall intensity duration-frequency curve for the Reno area developed in 1960 be updated. During the negotiations, it was decided that rainfall isopleth maps be developed in conjunction with the new rainfall intensity curves which would enhance the rainfall intensity accuracy for those areas not adjacent to the Reno-Cannon International Airport.

At the present time, twenty drainage deficiency areas have been identified Table 2 lists the various deficiency areas by priority.

This particular report analyzes Drainage Deficiency Area Priority 1 at Stead.

TABLE 2

STORM DRAINAGE DEFICIENCY AREAS[1]

PRIORITY	LOCATION
1	Stead - including Stead Blvd. and Old State Complex (full drainage study)
2	Huffaker Hills Area
3	Harding and Gulling
4	Plumas Street near West Moana
5	Rewana Farms, north of Peckham
6	Market Street and Miami Way
7	Roberts Street near Yori Avenue (Libby C. Booth School)
8	Thomas Jefferson Drive and Aguila Avenue
9	Belford Road and Sharon Way
10	Second Street at the railroad crossing
11	Charles Drive - Clough Road area
12	Marsh Avenue and LaRue Avenue
13	Riverside Drive and Ralston Street
14	Lake Ridge Golf Course area
15	Panther Valley area
16	Longley Lane and McCarran Blvd.
17	University Drain at Longley Lane
18	Grant Drive and West Moana Lane
19	Parr Blvd. near Catron Drive
20	Dry Creek Drainage

[1]Refer to "Reno Drainage Study Preliminary Report: Analysis of Drainage Deficiency Areas Within the City Limits", December 1984, Figure 1.

CHAPTER II

DESIGN CONSIDERATIONS

A. INTRODUCTION

The purpose of the individual Storm Drainage Deficiency Reports is to analyze a particular problem area identified by the City staff as given in the Priority List, Table 2. The design considerations necessary for this analysis are set forth in this chapter.

B. STORM DRAINAGE SYSTEM

The city has storm drainage mapping that is relatively up to date. There are several areas where the existing facilities are inadequate, especially when considering future growth.

Part of the scope of this study is to field verify the existing storm drainage structures at the various drainage deficiency areas and incorporate this storm drainage network in the final map.

C. HYDROLOGY - HYDRAULICS CONSIDERATIONS

1. HYDRAULIC DESIGN

The city has a policy requiring design of the majority of storm water facilities to pass 5-year return frequency storm flows. Major drainage facilities, where the drainage basin is 100 acres or greater, are sized to pass 100-year return frequency storm flows. Although the ordinance does not state it specifically, it is recommended that storm drains sized for 5-year storm events be sized to pass these flows with no static head. This will allow additional flows to pass with some head for storm events exceeding the 5-year return frequency.

2. RATIONAL METHOD

The Rational Method is the most used method in this country for computing quantities of storm water runoff. It allows consideration of local conditions and relates runoff directly to rainfall by the following equation:

$$Q = cia$$

where:
- Q = peak runoff rate in cubic feet per second
- c = runoff coefficient which is actually the ratio of the peak runoff rate for particular surface types and permeabilities to the average rainfall rate for a period known as the time of concentration.
- i = average rainfall intensity in inches per hour for a period equal to the time of concentration.
- a = drainage area in acres

3. RUNOFF COEFFICIENT

The proper selection of runoff coefficient "c" is critical for storm water runoff computations. It is dependent on a number of factors including slope condition and imperviousness of the surface, as well as the degree of saturation.

The expected land use can greatly affect the amount of runoff which will significantly increase with increased development. After discussions with City staff, values of the runoff coefficient "c" were developed based on the present and future Reno Land Use Maps for the area as shown on Figures 1 and 2. They are listed in Table 3.

City of Reno
Present Land Use Map

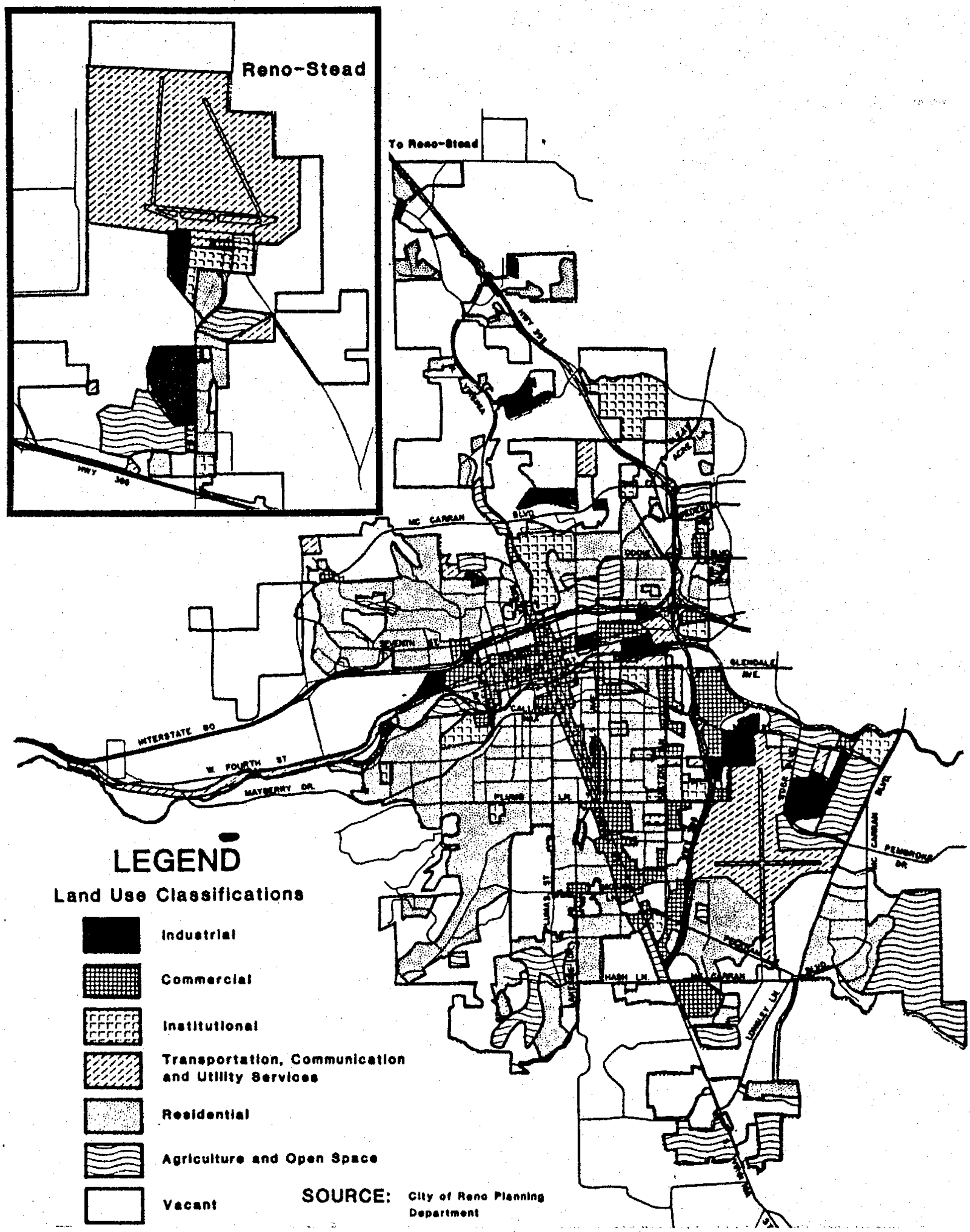


Figure 1

Future Land Use Map

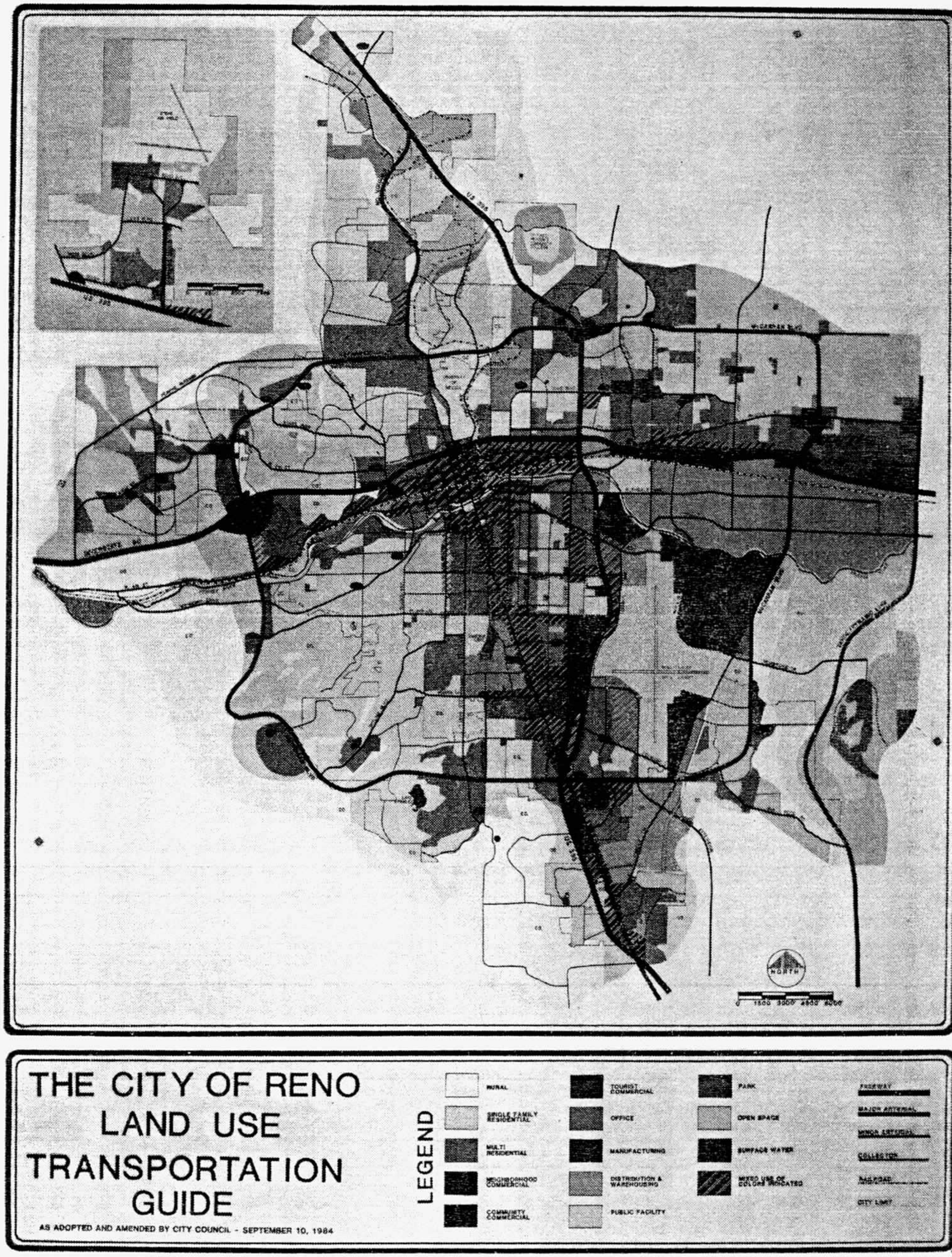


Figure 2

TABLE 3

RUNOFF COEFFICIENTS "C"

Land Use Type	Runoff Coefficient "C"
Rural	0.25-0.35
Single Family Residential	0.45-0.55
Multi-residential	0.60-0.70
Neighborhood Commercial	0.85
Community Commercial	0.85
Tourist Commercial	0.85
Office	0.85
Manufacturing	0.85-0.90
Distribution and Warehousing	0.85-0.90
Public Facility	0.50-0.85
Park	0.25
Open Space	0.20-0.30

These values are somewhat conservative when used for entire areas, as it assumes maximum build-out in all these areas. Substantial portions of rural and low density areas may not develop to full potential. However, it is difficult to determine where growth will or will not develop, and costs of storm water drainage systems are very expensive. Thus, it is generally preferable to size the system for maximum development rather than having to upsize the system later.

The City Ordinance generally does not allow increased runoff from that already existing for new developments. All additional runoff generated from increased development must be kept on site by the use of on-site storage. This is especially true if the increased runoff would exceed the existing downstream storm drainage facilities capacity.

However, exceptions have been allowed in the past. Thus, it is recommended that a more detailed hydraulic study be required for the individual drainage systems at the design or pre-design stage. At this time the actual zoning or land use for the area in question should be re-evaluated to arrive at an acceptable runoff coefficient "c". This report will consider two cases. Case I assumes that additional runoff will be kept on site. This case will use Figure 1, the present land use map, to develop runoff coefficients. Case II assumes that additional runoff will be allowed and maximum development will take place. This case will use Figure 2, the future land use map, to develop runoff coefficients.

4. RAINFALL INTENSITY AND DURATION

An accurate measurement of rainfall intensity and duration "i" is necessary to determine storm water flows for a particular area.

The existing rainfall intensity-duration-frequency (IDF) curves for the Reno area were developed in 1960 and are based on rainfall records through 1939.

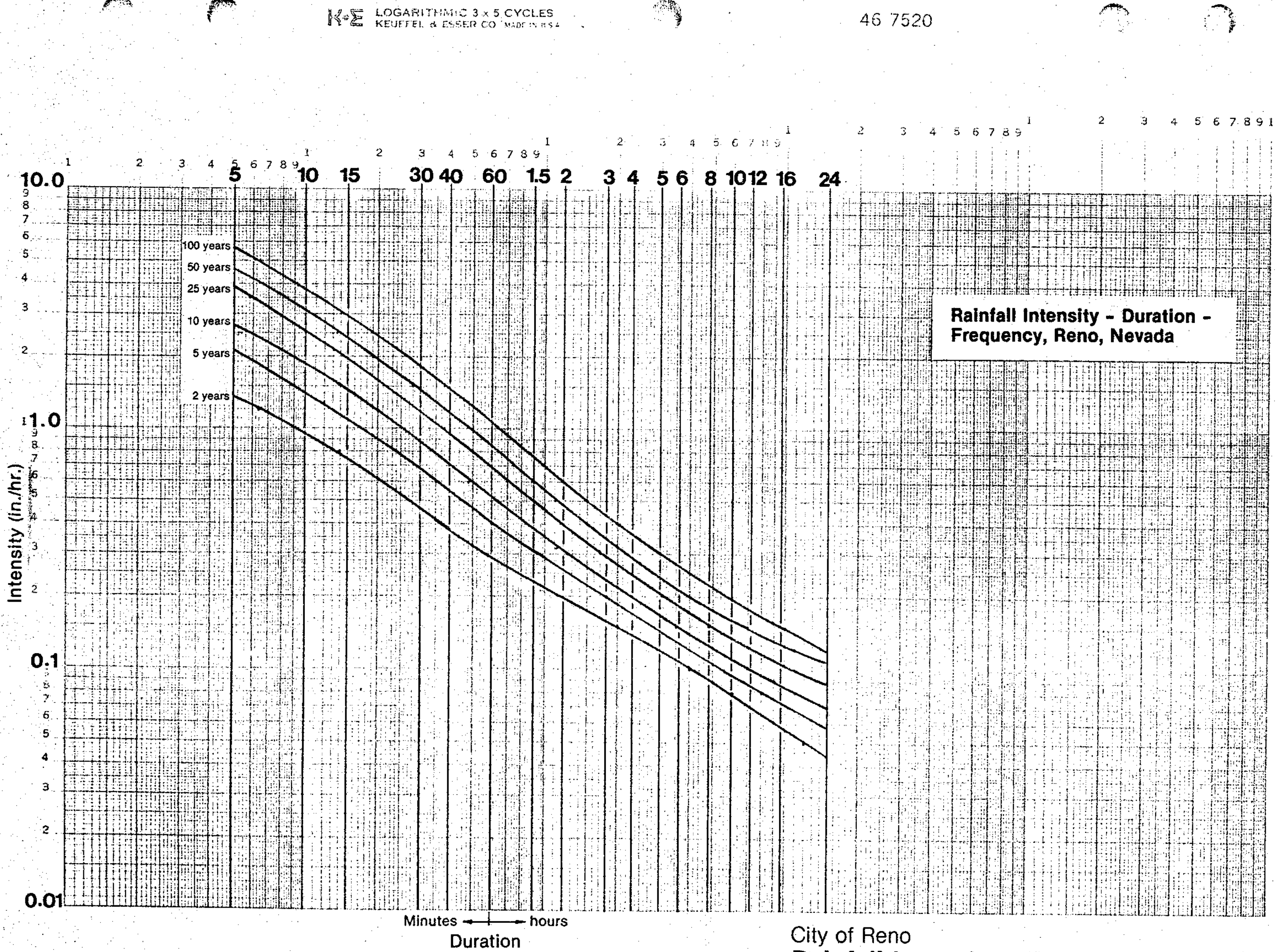
One of the major tasks of this study is to develop new rainfall IDF curves based on more updated data that is available.

In addition, the scope of work includes the analysis of spatial variation of rainfall in the study area. This requires developing rainfall isopleth maps for both the summer and winter seasons, based upon available rain gauging stations in the area.

Three sources of rainfall information were analyzed in developing the rainfall IDF curves. These are:

1) National Weather Service, "Technical Paper No. 40," 1964
2) NOAA "Rainfall Atlas 2 - Volume Vii," 1972
3) Analysis of raw precipitation data from the National Weather Service Climatic Center in Asheville, North Carolina for the Reno-Cannon Airport from 1952 to 1983.

Rainfall IDF curves were developed from each individual source of information. After careful analysis it was decided that the curve based strictly on rainfall records at the Cannon Airport (Figure 3) combined with the use of the rainfall isopleth maps would present the most accurate rainfall intensity records for the various drainages in the study area. It should be noted that the data presented is recommended for use only within the study area. Use of the rainfall IDF curves for areas outside the study area should be done so with caution and careful engineering judgment.



City of Reno
Rainfall Intensity - Duration - Frequency Curves for General Reno Area
Based on Rainfall Data from Cannon Airport Gauging Station

Figure 3

The rainfall isopleth maps are based on nine unofficial gauging stations in the area that have daily rainfall information available for use. These stations are located at Dickerson Road, Royal Drive, Upper Skyline, Ganser, La Veaga Court, Verdi, Sparks Fire Station, Sierra Sage Road, and Christmas Tree.

Each rainfall event at every location was compared and a ratio computed to the corresponding values recorded by the local weather service station at the Reno Cannon Airport. The summer season was assumed to extend from May through October and the winter season was assumed to extend from November through April. The two rainfall isopleth maps are shown as Figures 4 and 5.

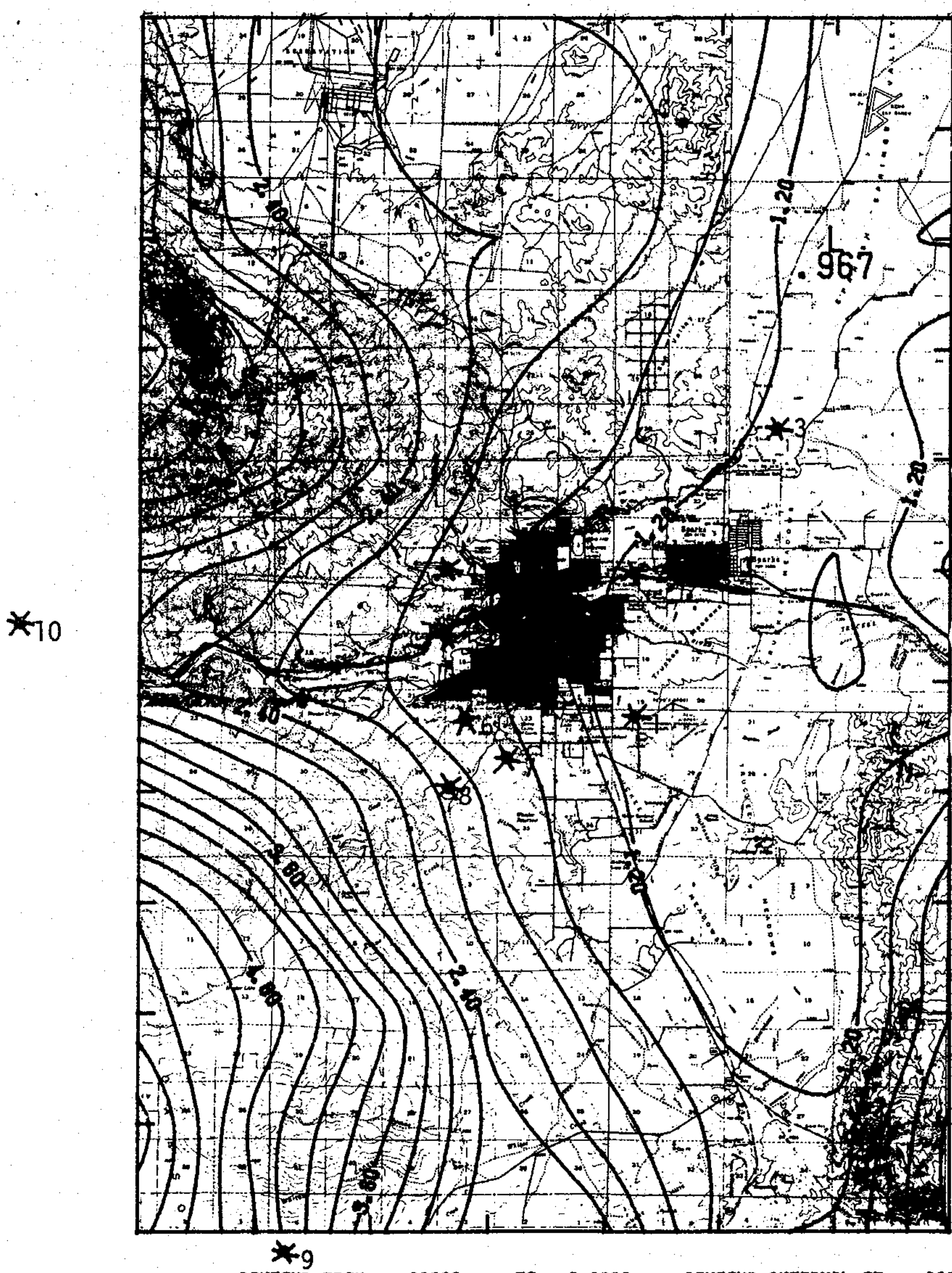
2,000-scale overlays of these isopleth maps have been completed to be used in conjunction with the standard 7.5 minute topographic quadrangle maps of the Reno area.

Figure 6 describes the use of the rainfall isopleth maps for a typical drainage area. Basically the drainage area is divided into subareas, each corresponding to the area under a particular isopleth range. A weighted average is obtained and this average is multiplied by the rainfall intensity taken from the rainfall IDF curve for the Reno-Cannon Airport to derive a modified rainfall intensity for the drainage basin in question.

In using these rainfall isopleth maps, it is recommended that a rainfall intensity correction factor be calculated for both the summer and the winter season. The highest correction factor should be used in calculating the rainfall intensity to be used in the Rational Formula.

City of Reno

Rainfall Isopleth Map for Wet Season November to April



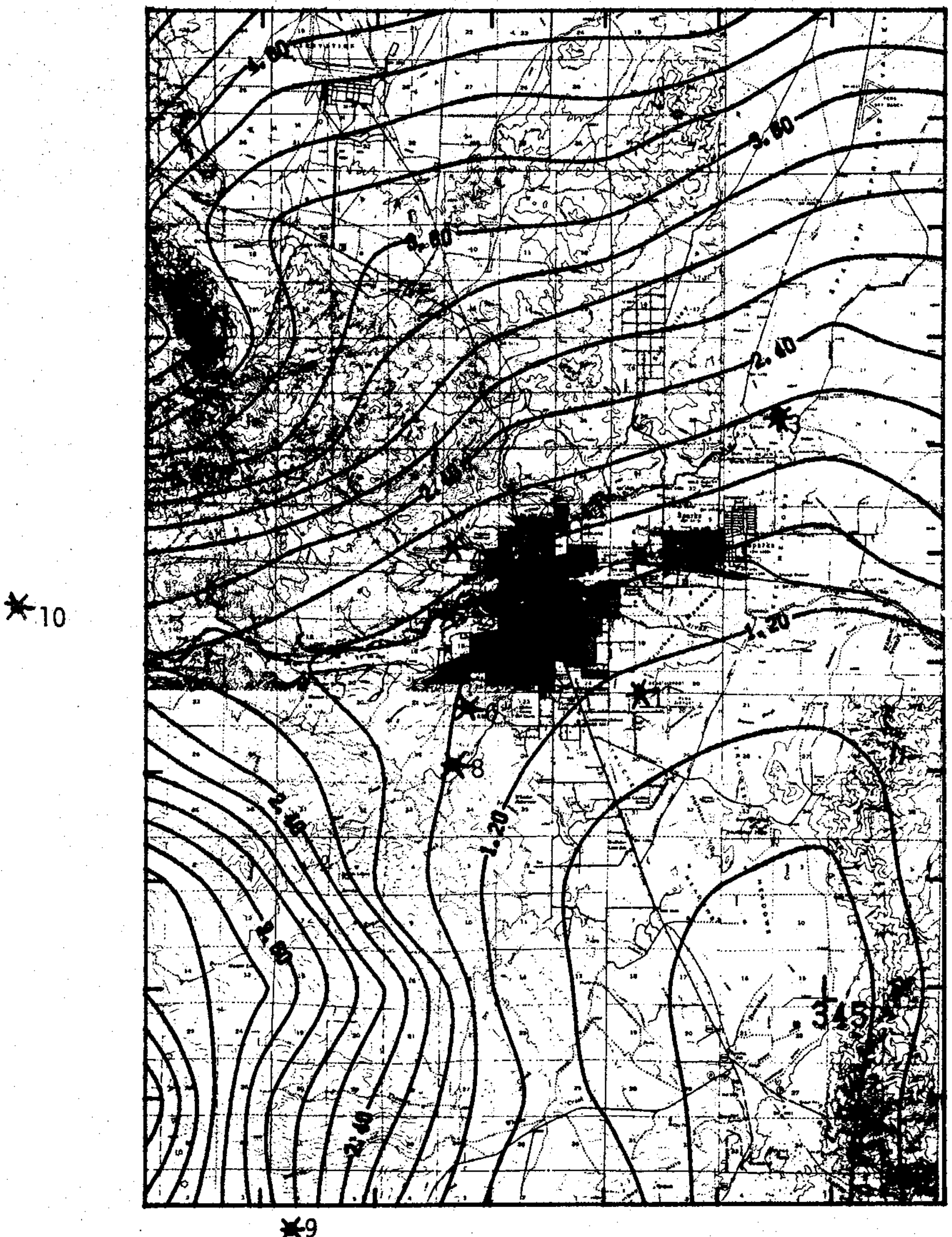
1. Cannon Airport
2. Sparks Fire Station
3. La Veaga Ct.
4. Royal Dr.
5. Dickerson Rd.
6. Ganser
7. Sierra Sage Ln.
8. Upper Skyline
9. Christmas Tree
10. Verdi

CONTOUR FROM .60000 TO 6.0000 CONTOUR INTERVAL OF .60000 PT(3,3)= 4.0878

Figure 4

City of Reno

Rainfall Isopleth Map for Dry Season May to October



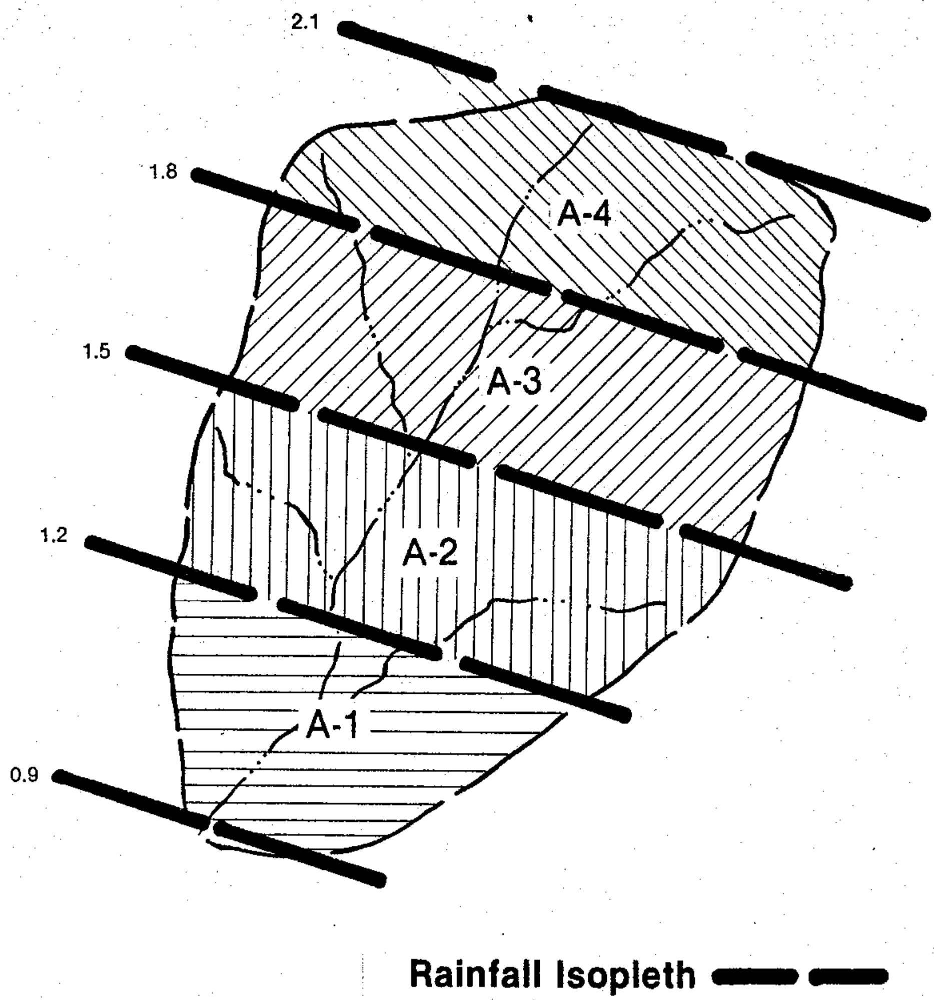
1. Cannon Airport
2. Sparks Fire Station
3. La Veaga Ct.
4. Royal Dr.
5. Dickerson Rd.
6. Ganser
7. Sierra Sage Ln.
8. Upper Skyline
9. Christmas Tree
10. Verdi

CONTOUR FROM .30000 TO 5.4000 CONTOUR INTERVAL OF .30000 PT(3,3)= 2.8281

Figure 5

City of Reno

Rainfall Isopleth Map Usage (Typical Example)



Rainfall Intensity Correction Factor =

$$\frac{A\text{-}1\left(\frac{0.9+1.2}{2}\right) + A\text{-}2\left(\frac{1.2+1.5}{2}\right) + A\text{-}3\left(\frac{1.5+1.8}{2}\right) + A\text{-}4\left(\frac{1.8+2.1}{2}\right)}{A_{TOTAL}}$$

NOTE: This modified rainfall intensity factor is multiplied by the rainfall intensity value from the Cannon Airport Curves

5. TIME OF CONCENTRATION

The time of concentration, "t_c", is defined as the flow time from the most remote point in the drainage area to the point in question. It is composed of two parts, inlet time and conduit travel time. Inlet time consists of the time required for water to flow overland from the most remote point in the watershed to a defined channel such as a street gutter plus the gutter flow time to the first inlet. The time of concentration is affected by several factors such as steepness of terrain, vegetation or land cover, and existing soil moisture conditions.

Inlet time in this study for unimproved areas is determined using average overland velocities shown on Figure 7. (From SCS "Urban Hydrology for Small Watersheds", T.R. 55). Inlet time for improved areas can vary widely and accurate values are difficult to obtain. Values between 5 and 30 minutes are normally used. Design inlet times from 5 to 15 minutes are used for developed areas with steep slopes or closely spaced inlets. 10 to 15 minute periods are common for similar areas with flatter slopes and for areas with widely spaced inlets and/or very gentle slopes, inlet times of 20 to 30 minutes are normally used.

It is recommended that a minimum inlet time of 10 minutes be adopted by the City in this and future runoff analyses. A 5 minute time of concentration is unreasonable except for very small drainages and will give exceedingly high runoff valves that field analysis does not support.

D. ANALYSIS OF DRAINAGE DEFICIENCY AREAS

The third phase of this project addressed in the report in Chapter III is PROBLEM IDENTIFICATION. As is stated in Chapter I, twenty potential drainage deficiency areas have been identified by City staff for review.

City of Reno

Average Velocities for Estimating Travel for Overland Flow

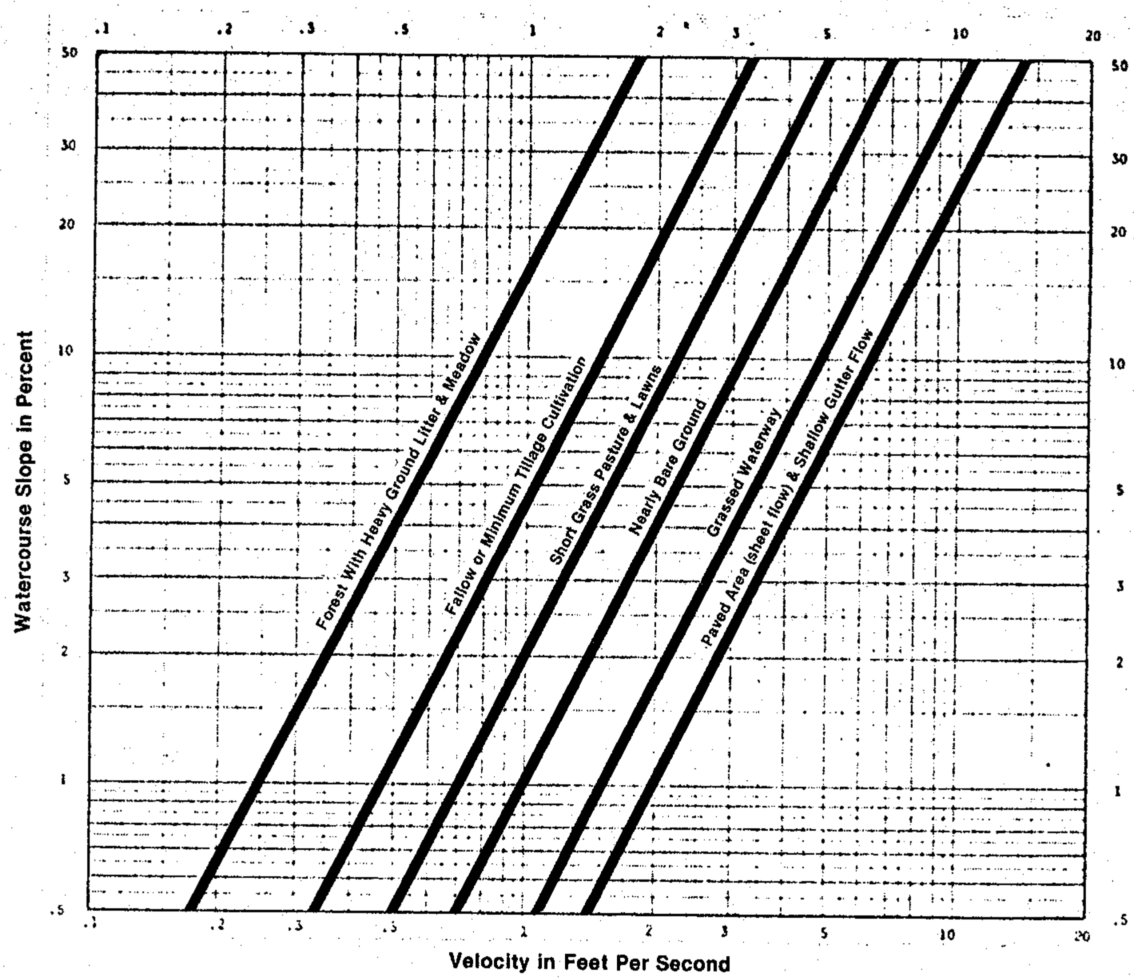


Figure 7

We propose to analyze these deficiency areas in the following manner: The existing storm drainage facilities will be plotted on 500 scale mapping available from Washoe County Department of Comprehensive Planning (formerly Regional Administrative Planning Agency) and will be field verified. Generally the flooding will occur at a particular node such as a culvert crossing. The drainage basin that contributes to a particular node will be identified. This drainage basin will be broken into sub-areas if required, each corresponding to the proposed land use (refer to Figures 1 and 2). Each land use has a runoff coefficient "C" assigned to it. A weighted average "C" will be calculated for the particular drainage basin.

A time of concentration "t_c" will be calculated as described in Section II-C-5 above. From this time of concentration, a rainfall intensity can be obtained from the rainfall IDF curve for the Reno-Cannon Airport. A modified rainfall intensity will be derived using the rainfall isopleth maps as described in Section II-C-4.

With this information, storm runoff flows for a five year return frequency storm (Q_5) and a one-hundred year return frequency storm (Q_{100}) can be calculated. These flows will be compared with the existing storm drainage node capacity to determine if the existing system is undersized. If the system is adequately sized, but flooding still occurs, attempts will be made to pinpoint where the problem may be, such as excessive siltation or poor inlet configuration.

CHAPTER III

FIELD ANALYSIS AND CONCLUSIONS

A. INTRODUCTION

The Stead area is a large drainage system consisting of approximately 4000 acres. (Refer to Figure 8 attached to the back of this report.) It is a relatively narrow drainage running north and south, extending north of Lemmon Drive and south of U.S. 395. Included within the drainage basin are Stead Boulevard running north and south essentially down the middle of the drainage system, the old State Complex and a majority of the Reno-Stead Airport. Approximately 1250 acres of the 4000 acre drainage are located south of U.S. 395.

There is significant street flooding along Stead Boulevard and in certain locations in the old State Complex during periods of intense rainfall. Until recently, little storm drainage planning was considered, although the area is a prime candidate for future growth both as a residential site and an industrial/manufacturing site.

B. FIELD ANALYSIS

The Stead drainage area consists largely of unimproved grassy hillsides with sparse sagebrush and other vegetation. This is particularly true both in the north and the south. The drainage system is bounded by hills on both the north and south with a flat broad plain in the middle. Silver Lake lies to the west and Lemmon Valley to the east of this low lying plain. Most of the existing development is located bordering Stead Boulevard and to the north in the Old State Complex. Development consists of several residential developments as well as warehouse facilities, most notably the large J.C. Penney Catalog warehouse complex.

The storm water runoff flows both north and south towards this central plain. The runoff from the north crosses Lemmon Drive through a 15-inch CMP, continuing south as overland flow through undeveloped land until reaching the Reno-Stead Airport. Runoff is increased off the airport pavement and streets of the Old State Complex.

The drainage system is quite old and there is little mapping defining the existing system. From what mapping does exist and from field analysis, it appears that the flows from the north all exit to the west via three separate systems. There is an RCP system running from the east to the west at the northern boundary of the State Complex just north of Texas Avenue. It begins in the east as a 30-inch RCP increasing to a 36-inch RCP, exiting into a large drainage ditch behind the Lear Fan Ltd. complex. There are numerous drop inlets along this RCP drainage system to pick up flows from the north.

A short section of this pipe proceeds east to a drop inlet meeting flows from an 18-inch RCP flowing west and ties into a pipe network on Alpha Avenue. However, most of the flows south of Texas Avenue proceed as street and overland flow entering a pipe network at various drop inlets. This pipe network begins on Alpha Avenue near the intersection with Mt. Vida Street as a 12-inch RCP. It proceeds west on Alpha Avenue and turns south on Mt. Charleston Street. At Mt. Charleston Street and Bravo Avenue it becomes an 18-inch RCP. It turns west on Cocoa Avenue. Some flows are diverted south in an 18-inch RCP on Mt. Lola Street and continue southwest in several overland swales to the intersection of Echo Avenue and Mt. Babcock Street. Flows are picked up here in a drainage ditch that flows southwest traversing around the large Desert Research Institute Building. Flows cross Mt. Bismark in five 15-inch RCPs that are badly silted in with a great deal of brush and garbage blocking the inlets. The flows proceed south in a roadside ditch on the west side of Mt. Bismark to a 36-inch RCP at Mt. Anderson Street. This ties to a M.H. and a 42-inch storm drain that runs west on Mt. Anderson before turning south and discharging to a ditch north of the J.C. Penney warehouse flowing west towards Silver Lake.

The remaining flows continue west on Cocoa Avenue in a 21-inch RCP to Mt. Bismark Street and turn south on Bt. Bismark in a 24-inch RCP. The existing mapping indicates that this 24-inch RCP changes to dual 15-inch; 12-inch RCPs just north of the outlet of the five 15-inch RCPs that cross Mt. Bismark Street mentioned above. The flow discharges to the ditch on the west side of Mt. Bismark and proceed across Mt. Anderson and west towards Silver Lake. At the intersection of Mt. Bismark Street and Echo Avenue there are drop inlets that collect gutter flow and proceed west on Echo Avenue in a 10-inch RCP that exits into a ditch running south along the west side of Mt. Anderson Street. These flows cross the old railroad grade in a wooden box culvert approximately 15 inches high x 28 inches wide and then cross an old road grade in a 24-inch steel culvert, continuing west towards Silver Lake.

There are approximately 1250 acres south of U.S. 395 that contribute to the Stead drainage. Most of the flow from this area crosses North Virginia Street through dual 36-inch CMPs that show considerable inlet siltation, and continues under U.S. 395 in a 36-inch RCP.

Just to the west of the 36-inch RCP under U.S. 395 there is a 48-inch pipe. The inlet is CMP, the outlet is RCP. It is probable that the change occurs in the freeway median strip where there is a drop inlet. There does not appear to be much flow that can reach this 48-inch pipe from the south. There is no culvert crossing of North Virginia upstream, although it appears that some of the ground has been filled between North Virginia and the freeway. It is possible that at one time a significant portion of the flow through the dual 36-inch CMPs across North Virginia reached this 48-inch pipe.

Downstream of the 48-inch pipe the flow enters a 24-inch RCP running east behind the Silver Lakes Subdivision. These flows along with the flows from the 36-inch RCP across U.S. 395 discharge into a ditch that ties to another ditch along the west side of the Western Pacific Railroad track that parallels Stead Boulevard. The flow continues north in this ditch, crossing Silver Lake Road in a 24-inch RCP and crosses under the railroad tracks in a 36-inch CMP where the tracks turn west just south of the J.C. Penney Complex. The runoff proceeds as overland flow in a relatively undefined channel for a short distance before reaching a drop inlet in part of the J.C. Penney storm drain network. The flow is contained in a 24-inch RCP and continues north and east to tie to a 30-inch RCP storm drain in Stead Boulevard that increases to a 42-inch RCP and eventually drains into the Granite Hills Drainage System, which flows east into Lemmon Valley. A 42-inch RCP carries flows from Hannibal Court and Lear Boulevard from the west, tying to the pipe network on Stead Boulevard.

There is a smaller drainage basin south of U.S. 395 that crosses North Virginia and U.S. 395 and continues north in a series of culverts and ditches along the west side of Stead Boulevard. The majority of the flow crosses Stead Boulevard in a 24-inch RCP just south of O'Brian Jr. High School and continues east exiting into a ditch behind the school. This ditch flows through undeveloped land to the lake in Lemmon Valley. Excess flows along the west side of Stead Boulevard can continue north in a ditch rather than crossing Stead Boulevard, eventually ending up in the storm drain network in Stead Boulevard that starts just south of Ural Street and continues north to the Granite Hills Drainage System.

A third drainage basin is located west of the two aforementioned basins. There is an 18-inch CMP crossing North Virginia near the western edge of the project boundary. Flows proceed north crossing U.S. 395 in a 36-inch RCP just to the west of the Silver Lake Subdivision and crossing Silver Lake Road in a 36-inch RCP. The flows proceed south through the Lake Ridge Golf Course in a series of ponds and ditches. They eventually reach the new railroad grade just south of the J.C. Penney Complex and are diverted west in a ditch towards Silver Lake.

C. ESTIMATED STORM RUNOFF

Estimated storm runoff is calculated at selected nodes. These nodes and the related flows are shown on Figure 8, the project boundary map appended at the back of the report. Table 4 summarizes these nodes, giving location, description of node, capacity of node and estimated storm runoff at the node. The existing capacity assumes inlet control. Generally a range is given. The lower value assumes no head at the inlet while the higher value is at maximum head on the culvert.

As most of the subdrainages exceed 100 acres, the 100 year return flood flows must be analyzed. The drainage pipe systems are sized to pass 5 year storm flows, but ditches and storage basins are sized for the 100 year flows.

D. ESTIMATES OF COST

This section on cost estimates for proposed storm drainage modifications is included in the Stead Report, as the City requested a complete drainage study for the particular deficiency area.

TABLE 4 - STEAD EXISTING DRAINAGE FACILITIES SUMMARY

Node and Location	Existing Storm Drainage System	Existing Capacity (cfs)	Estimated Flows Present Land Use		Estimated Flows Future Land Use	
			Q5 (cfs)	Q100 (cfs)	Q5 (cfs)	Q100 (cfs)
a - North Virginia approx. 0.06 miles west of Stead Blvd.	18" CMP	6-25	45	125	45	125
b - U.S. 395 approx. 0.63 miles west of Stead Blvd.	36" RCP	35-100	55	145	55	145
c - North Virginia approx. 0.4 miles west of Stead Blvd.	Dual 36" CMP's	70-120	250	580	250	580
d - U.S. 395 approx. 0.3 & 0.5 miles west of Stead Blvd.	36" RCP 48" CMP/RCP	35-60 70-140	250	580	250	580
e - North Virginia just west of RR Xing	36" CMP	35-70	95	245	95	245
f - Railroad and Stead Blvd. opposite O'Brian Middle School	48" CMP across RR 24" RCP across Stead Blvd.	70-170 13-20	105	245	105	245
g - Silver Lake Rd. just west of Stead Blvd.	24" RCP	13-25	265	585	275	610
h - Silver Lake Rd. approx. 0.6 miles west of intersection with Stead Blvd.	36" RCP	35	135	265	155	300
i - Railroad Xing just south of Penney complex	36" CMP	35-95	265	585	280	610

TABLE 4 - STEAD EXISTING DRAINAGE FACILITIES SUMMARY (continued)

Node and Location	Existing Storm Drainage System	Existing Capacity (cfs)	Estimated Flows Present Land Use		Estimated Flows Future Land Use	
			Q5 (cfs)	Q100 (cfs)	Q5 (cfs)	Q100 (cfs)
j - DI south edge of Penney complex	24"to 30" network	13-22	295	645	315	690
k - Ditch west of Penney complex to Silver Lake	Overland flow	-	110	300	130	345
l - Stead Blvd. between Lear Blvd. & Norton Rd.	Dual 54" RCP's 79"x49" CMP	195	560	1530	625	1715
m - Lemmon Drive north of airstrip	15" CMP	5-10	130	335	130	335
n - DI's & pipe running east-west just north of Texas Ave.	18" to 36"	7-35	630	1355	630	1355
o - Intersection of Echo & Babcock	drainage ditch	255	155	410	155	410
p - Pipe crossing Mt. Bismark St. north of Anderson	5-15" RCP's	20-60	155	410	155	410
q - Pipe crossing Anderson just west of Mt. Bismark St.	36" RCP	35-80	390	1020	390	1020
r - Pipe & ditch system on Echo to Anderson	12" RCP	3-83	140	375	140	375
s - Culvert crossing Mt. Babcock just north of intersection with Mt. Anderson	12" RCP	3-8	190	500	190	500

Preliminary cost estimates for the various proposed projects within the drainage basin are necessary for economic feasibility evaluations. Cost estimates are based on the premise that all construction will be accomplished by competitively bid contracts. The costs include construction and contingency costs as well as engineering and administrative costs.

1. Storm Drains

Storm drain costs were developed using the 1985 Means Construction Cost Data. Class 3 reinforced concrete pipe is used in the estimating. 10% was added to the subtotal cost including overhead and profit for profit to arrive at a total cost per foot of pipe installed. $1500 per storm drain inlet is used as an average cost. Table 5 summarizes the costs of pipe from 12 inch to 96 inch.

TABLE 5 - COST ESTIMATES FOR RCP INSTALLED

Size	Cost/L.F. Installed
12"	$ 29.50
15"	31.98
18"	35.44
24"	43.14
30"	61.84
36"	78.34
42"	88.24
48"	101.24
60"	156.67
72"	189.67
84"	269.14
96"	318.64

An additional cost of $12 per foot is used for paving and $6 per foot for gravel.

2. Channel Construction

Channel costs can vary substantially depending on accessibility and type of ground. An excavation cost of $6 per cubic yard is used for roadside channels and easily accessible areas located on firm ground. In marshy areas particularly along the major creek beds an excavation cost of $12 per cubic yard is used. Clearing costs range from $0.50 per linear foot to $6 per linear foot, depending on location, and seeding is estimated at $2 per linear foot.

3. Contingencies

Contingencies are funds set aside for unexpected complications that may arise. For these estimates a 10% contingency of construction costs is assumed.

4. Engineering

Estimated engineering fees would include pre-design and design services as well as bid phase and construction inspection services. An estimate of 15% of construction costs is used in this report.

5. Administration

An estimate of 5% of construction costs is assumed for administration costs during the design and construction of the proposed projects.

6. Right-of-Way

Right-of-way costs will vary widely depending on location within the study area. Although it is recommended that easements be deeded as a requirement for building, in many instances off-site easements may be required to allow an area to develop and may need to be purchased. Because these costs are so ambiguous at this stage they are not included in the cost estimates. However, it should be noted that in certain cases right-of-way may add substantially to the cost of the projects.

E. PROPOSED STORM DRAINAGE FACILITIES.

This section is included in the Stead Report as the City requested a complete drainage study for this particular deficiency area.

Table 6 summarizes the proposed modifications and their related costs. A brief description of these proposals is listed below. The letters key to the node letters on Figure 8 appended to the back of this report.

a. Replace the existing 18-inch CMP across North Virginia with a 42-inch RCP.

b. Existing 36-inch RCP across U.S. 395 is adequate.

c. Replace the existing dual 36-inch CMP's across North Virginia with dual 60-inch RCP's.

d. Install by jack and bore method new 60-inch RCP across U.S. 395 paralleling existing 36-inch and 48-inch RCP/CMP's. Excavate new ditch between North Virginia and U.S. 395 to allow more flow to reach existing 48-inch RCP/CMP across U.S. 395.

e. Replace existing 36-inch CMP across North Virginia with a 60-inch RCP.

f. Existing 48-inch CMP across railroad is adequate. Replace existing 24-inch RCP across Stead Blvd. and around O'Brian Middle School with a 60-inch RCP.

g. Replace existing 24-inch RCP across Silver Lake Road with an 84-inch RCP.

h. Replace existing pipe system on Peppermint and Silver Lake Road with an 84-inch RCP.

i. <u>Alternate 1</u>:

Replace existing 36-inch CMP across Railroad with an 84-inch RCP by jack and bore method.

<u>Alternate 2</u>:

Construct 100-year storm storage basin upstream of existing RR pipe crossing.

j. <u>Alternate 1</u>:

Install new 84-inch RCP system from the J.C. Penney complex out to Stead Blvd. and north paralleling existing system to the existing dual 54-inch RCP's crossing Stead Blvd. between Lear and Norton.

<u>Alternate 2</u>:

Construct 100-year storm storage basin just north of J.C. Penney complex.

k. No change is recommended.

l. Install new 72-inch RCP across Stead Blvd. and through existing subdivision paralleling existing dual 54-inch RCP's - 79-inch by 39-inch CMP. (This is required if Alternate 2j is not selected.)

m. Replace existing 15-inch CMP with a 60-inch RCP and excavate new ditch to daylight downstream.

n. Alternate 1:

Parallel existing 18-inch to 36-inch RCP pipe system with dual 84-inch RCP's.

Alternate 2:

Install ditch, culvert system along north side of existing runway.

o. Widen existing ditch to handle 100-year flows.

p. Replace existing five 15-inch RCP's across Mt. Bismark with dual 48-inch RCP's.

q. Parallel existing 36-inch, 42-inch RCP system across Anderson with dual 72-inch, 84-inch RCP's.

r. Install 60-inch RCP on Echo Avenue from Mt. McClellan to Anderson.

s. Install 72-inch RCP culverts across Mt. Babcock and Mt. Bismark with a ditch between them on the north side of Mt. Anderson.

TABLE 6 - STEAD PROPOSED DRAINAGE FACILITIES SUMMARY

Node and Location	Existing Storm Drainage System		Proposed Storm Drainage System	Cost
a - North Virginia approx. 0.65 miles west of Stead Blvd.	18" CMP		42" RCP	$ 12,600
b - U.S. 395 approx. 0.63 miles west of Stead Blvd.	36" RCP		No change	-0-
c - North Virginia approx. 0.4 miles west of Stead Blvd.	dual 36" CMP's		dual 60" RCP's	$ 36,500
d - U.S. 395 approx. 0.3 and 0.5 miles west of Stead Blvd.	36" RCP 48" RCP/CMP		parallel existing pipes with 60" RCP	$ 121,400
e - North Virginia just west of RR crossing	36" CMP		60" RCP	$ 18,900
f - RR and Stead Blvd. opposite O'Brian Middle School	48" CMP across RR 24" RCP across Stead Blvd.		No change 60" RCP across Stead and around school	$ 154,300
g - Silver Lake Road - just west of Stead Blvd.	24" RCP		84" RCP	$ 18,800
h - Silver Lake Road approx. 0.6 miles west of Stead Blvd.	24" to 36" RCP		72" RCP on Peppermint and across Silver Lake Road	$ 323,400
i - RR crossing just south of Penney complex	36" CMP	Alt. 1	84" RCP	$ 27,300
		Alt. 2	100-yr. flow storage basin	$ 605,100

TABLE 6 - STEAD PROPOSED DRAINAGE FACILITIES SUMMARY (continued)

Node and Location	Existing Storm Drainage System		Proposed Storm Drainage System	Cost
j - D.I. at south edge of Penney complex	24" to 30" RCP	Alt. 1	Parallel existing pipe w/84" RCP to Stead Blvd. and north to crossing between Lear and Norton	$1,314,600
		Alt. 2	100-yr. flow storage basin	$1,843,500
k - Ditch, overland flow west of Penney complex to Silver Lake	ditch/overland flow		No change	-0-
l - Stead Blvd. between Lear and Norton	dual 54" RCP's - 79" x 49" CMP		Parallel existing pipe w/72" RCP	$ 497,700
m - Lemmon Drive north of airstrip	15" CMP		60" RCP and ditch to daylight downstream	$ 13,400
n - Pipe and D.I.'s running east-west just north of Texas Avenue	18" to 36" RCP		Alt. 1 - parallel with dual 84" RCP's	$2,324,300
			Alt. 2 - ditch, culvert along north side of runway.	$ 769,100
o - Intersection of Echo and Babcock	drainage ditch		Widen existing ditch	$ 15,100
p - Pipe crossing Mt. Bismark north of Anderson	5 - 15" RCP's		dual 48" RCP's	$ 52,100
q - Pipe crossing Anderson just west of Mt. Bismark	36" RCP		parallel existing pipe with dual 60"; 72" RCP's	$ 200,400

TABLE 6 - STEAD PROPOSED DRAINAGE FACILITIES SUMMARY (continued)

Node and Location	Existing Storm Drainage System	Proposed Storm Drainage System	Cost
r - Pipe and ditch system on Echo to Anderson	12" RCP	60" RCP on Echo from Mt. McClellan to Anderson	$ 96,300
s - Culvert and ditch system along north side of Mt. Anderson between Mt. Babcock ard Mt. Bismark	12" RCP - ditch	72" RCP across Mt. Babcock and Mt. Bismark with widened ditch between them	$ 52,200

F. RECOMMENDED PROJECTS

There are seventeen individual projects described in the Stead drainage area, some with more than one alternate. It is recommended that all of these projects be implemented as development warrants.

Presently, however, there is no need to do any of the proposed projects south of U.S. 395 or north of the old State complex and Texas Avenue.

Although the crossings on North Virginia and U.S. 395 are for the most part inadequate, any flooding that occurs causes no immediate problems as the area is largely undeveloped. In fact, by keeping these pipes undersized it may aid in slowing or reducing the flows reaching the developed area downstream. It is expected, however, that these flows will eventually arrive by overland flow bypassing the existing culverts.

The costs for the various projects are very expensive. As the area is a relatively large drainage basin, in most cases in excess of 100 acres for the individual subdrainages, the 100-year storm flows need to be addressed. The alternates that include storage basins and ditches are sized for these 100-year flows although the remainder of the projects are sized for 5-year storm flows.

The existing storm drainage system in Stead Blvd. is seriously undersized which is unfortunate as this is a relatively new system. The use of storage basins are considered at both node i and node j in an attempt to reduce the modifications to this system.

The storage basin at node i is not recommended. The reason is that the flows generated at node j and node l are based on a much shorter duration storm than for node i. The flows at node i assume that the entire drainage basin upstream south of U.S. 395 is contributing with an estimated time of concentration in excess of three hours. If this same assumption is made for node 1, much smaller flows are developed than if the subarea only downstream of node i is considered. Although the acreage is much less, it is basically all zoned manufacturing and the time of concentration is approximately 30 minutes. Thus even if a storage basin were constructed at node i to contain upstream flows, the estimated flows at node 1 would remain basically the same.

On the other hand, the storage basin at node j is the recommended alternate. This will hold back flows from reaching node 1 thus negating the need for any storm drainage upsizing. The only concern is that this is prime land for future development. Approximately 65 acre-feet of storage would be required in alternate 2j and the cost of acquiring this land could be significant.

Alternate 2n is the preferred alternative. It would use a ditch, culvert combination rather than a pipe network. This would better stop flows from the north from proceeding south and is significantly less expensive. Again, this project is not recommended until future development increases runoff in the area.

The remaining projects should be done as funds become available. The total cost for all projects including those required in the future is $3,754,300. Those recommended to be completed at this time (excluding nodes a, b, c, d, e, m and n) would cost $2,783,400.

STORM DRAINAGE
DEFICIENCY MAP
FIGURE 8

NO DOCUMENTS
BEHIND TAB
@ SCAN