PLANNING REPORT ON

IMPROVEMENTS TO STORM DRAINAGE

IN THE

LOWER SPRING RUN BASIN

FOR THE

CITY OF COLORADO SPRINGS

COLORADO

H. J. KRAETTLI & SONS

CONSULTING ENGINEERS — COLORADO SPRINGS, COLORADO

DECEMBER 1968

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December 24, 1968

Director of Public Works
City of Colorado Springs
Colorado Springs, Colorado

Dear Sir:

In accordance with the terms of our agreement No. 2054, dated October 12, 1967, we are submitting our engineering study on the storm sewer requirements for that portion of Spring Run Drainage Basin lying Easterly of Colorado State Highway No. 115.

The report includes a study of the rainfall-runoff characteristics of the basin, various hydrographs of intermediate area, and recommendations for proposed improvements to accommodate any expected storm problems that may occur within the area.

A summary of estimated construction costs for the drainage basin follows this letter. The costs are based upon current prices for the Colorado Springs area.

We wish to thank the various departments of the Colorado Springs Governments for their assistance and cooperation in the preparation of this report. It has been a pleasure and privilege to prepare this preliminary report. We are available for additional services as you may request.

Very truly yours,

H. J. KRAETTLI & SONS

Harold Jack Kraettli

Harold Jack Kraettli

HJK:sas

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INTRODUCTION

This report encompasses existing and proposed storm drainage facilities in the Stratton Meadows area of Colorado Springs, Colorado, an area which also includes the proposed Park Meadow Subdivision. The study area consists of the Lower Spring Run Drainage Basin bounded on the West by Colorado State Highway 115, on the East by Interstate Highway 25, and on the South by Cheyenne Mountain Boulevard, U. S. Highway 85, 87 and Colorado State Highway 29. The northern boundary, poorly defined because of relatively flat topography and the existing street system, lies in a general east-west direction between Corona and Stevens Avenues.

A detailed map of the area with existing and proposed storm drainage facilities is included as Plate A of this report. As shown on Plate A the total drop in elevation in Spring Run from Colorado State Highway 115 to Interstate Highway 25 is about 100 feet in a distance of approximately 8,000 feet with an overall slope of about 1.25 percent. Because of this relatively flat slope and the small area involved, the Colorado Springs quadrangle map of the U. S. Geological Survey could not be used for layout and design of the proposed drainage facilities. Topographic features and contours shown on the attached map were obtained by means of aerial photography. The work required to obtain these data was also a part of this project.

Excluded from this study was the drainage area tributary to Spring Run west of Colorado State Highway 115, hereafter designated as Highway 115. The peak discharge in Spring Run at Highway 115 as used in this study was furnished by representatives of the City of Colorado Springs.

The headwaters of Spring Run are located on the northeast face of Cheyenne Mountain. From the Broadmoor area to Highway 115, Spring Run has a relatively steep gradient and is confined in a pronounced drainage course. Little Stratton Reservoir and Big Stratton Reservoir are both located on Spring Run west of Highway 115 and have a significant effect upon the flood hydrograph for Spring Run.

The area under study for this report is the outwash plain or alluvial fan, of Spring Run, between the pronounced drainage course to the west and Fountain Creek to the east. In contrast to the well defined drainage course west of Highway 115, the drainage course for Spring Run through the study area is poorly defined. From field observations it appears that any significant amount of runoff in Spring Run would overtop the existing channel and flood the surrounding area. Also, since no provisions were made for storm drainage facilities in areas of Stratton Meadows tributary to Spring Run, frequent flooding has occurred as storm waters were carried to Spring Run by means of the surface drainage system.

Flat gradients and the presence of fine, poorly drained soils have resulted in deterioration of roadway pavements in many parts of the area.

The determination of soil properties throughout the area involved is not a part of this study and will not be considered further in this report.

DESIGN CRITERIA

This report does not include a detailed hydrologic study of rainfall intensities and frequencies in the study area or the area tributary to Spring Run west of Highway 115. The design storm to be used in the study area and the peak runoff for Spring Run at Highway 115 were specified by representatives of the City of Colorado Springs and were as follows:

Design Storm	-	2 inches of rainfall per hour based upon a frequency of once in fifty years.
Peak Discharge at Highway 115	-	The peak discharge in Spring Run west of Highway 115 was specified to be 700 cubic feet of water per second of time (cfs).
Detention Basins	-	Detention basins were not to be considered, and storage of flood waters was to be confined to channel storage only.
Gutter Storage	-	Drainage inlets were to be provided to convey drainage waters into the

underground storm drainage system whenever flow in the gutters reached a depth equal to 2/3 of the overall gutter depth.

The design storm of 2 inches of rainfall per hour was converted to other intensities for times of concentration other than one hour using established engineering procedures. The frequency of once in fifty years is a greater frequency than that normally specified for design of inlet and lateral capacities and is conservative in this respect.

The value of discharge of 700 cfs in Spring Run west of Highway 115 is the peak flow during the design storm. Using Reference 3 the relationship of flow versus time was assumed for use in this study. As will be discussed later, this relationship did not have a significant effect on discharges throughout the study area.

Considerable savings could be effected in the cost of the proposed storm drainage facilities if detention reservoirs or ponds had been used because of the major reduction in peak discharge when flood waters are stored for controlled release at later times. Sites for detention reservoirs are believed to exist immediately west of Highway 115 at the Broadmoor turnoff, between Highway 115 and Highways 85, 87, and in the area along the westerly side of Interstate Highway 25 at the outfall point for the study area. Since it had been specified that detention reservoirs were not to be used, no further consideration was given to this matter.

Because of the low crowns in many streets, the rounded curb and gutter configuration used throughout a portion of the area, and the lack of curbs and gutters along some streets, gutter detention was based upon the standard 8" vertical curb and gutter used by the City. To determine the gutter discharge when 2/3 full, as specified, it was assumed that streets would be reconstructed at a later date to provide sufficient crown so that cross slope at the gutter would be 8.33 percent. This procedure was considered conservative for location of drainage inlets in the present system since storage in existing streets with low crowns would be considerably greater. If streets are reconstructed using 8" curbs and standard crown, the drainage inlets shown will meet the specified criteria.

For this study, it was assumed that all paved streets shown on the attached map would be provided with curbs and gutters on both sides, even where curbs and gutters do not now exist. The cost of street improvements, including installation or replacement of curbs and gutters, were not included in estimates of costs for storm drainage facilities proposed in this report.

REFERENCES

1. John W. Clark and Warren Viessman, Jr., "Water Supply and Pollution Control," International Textbook Company, Scranton, Pennsylvania, 1965.

2. Ray K. Linsley and Joseph B. Franzini, "Water Resources Engineering," McGraw-Hill Book Company, Inc., 1964.

3. U. S. Department of Interior, Bureau of Reclamation, "Design of Small Dams," U. S. Government Printing Office, Washington, D. C., First Edition, 1960.

4. Joint Committee of the American Society of Civil Engineers and the Water Pollution Control Federation, "Design and Construction of Sanitary and Storm Sewers," 1960.

5. U. S. Department of Commerce, Bureau of Public Roads, "Hydraulic Design of Highway Culverts," USCOMM-D 48648, 1958.

6. Elwyn E. Seelye, "Data Book for Civil Engineers - Volume 1 - Design," John Wiley and Sons, Inc., New York, 1945.

7. American Iron and Steel Institute, "Handbook of Steel Drainage and Highway Construction Products."

EXISTING DRAINAGE SYSTEM

The existing drainage system is composed of Spring Run Creek and a surface drainage system tributary to Spring Run throughout the study area.

The drainage area west of Highway 115 for Spring Run is approximately 2,000 acres in size. Having a relatively steep gradient, a well defined channel about three miles in length, and two major on-channel storage reservoirs, this portion of Spring Run is the major source of surface runoff waters for the study area. For this reason it is important that the Spring Run channel and outfall line be maintained through the study area and that it be of sufficient size to convey the discharge entering the area at the upstream end combined with discharge tributary to Spring Run in the study area.

Surface drainage areas in the study area exclusive of the Spring Run channel are as follows:

1. An area bounded by Highway 115, Cheyenne Mountain Boulevard, Highway 85, 87 and Spring Run drainage channel and consisting of 38.5 acres. This area presently drains through two culverts under Highway 85, 87 with one portion flowing to the north along the west side of Southgate Road to Spring Run and the remainder through a complex system along Highway 85, 87 to the southeast. This report proposes that these runoff waters be

conveyed away from the study area by means of a new culvert under Cheyenne Mountain Boulevard south of Highway 85, 87 and modification (deepening) of the roadside drainage ditch along the southerly side of Highway 85, 87.

2. Spring Run channel between Highways 115 and 85, 87 consisting of 17.0 acres. This area is presently drained by means of an 11'-6" diameter multi-plate corrugated metal pipe culvert under Highway 85, 87 connecting to a 60-inch diameter corrugated metal pipe culvert beneath the undeveloped area south of Southgate Shopping Center and discharging into Spring Run west of Southgate Road.

3. The Southgate drainage area between Highway 85, 87, Southgate Road and the drainage divide through the paved area of the shopping center. This area consists of 30.5 acres. The unpaved area drains across the south access road leading to the center and into the west side drainage ditch of Southgate Road which in turn discharges into Spring Run. The paved parking area drains into inlet gratings at entrances from the access road along the east side of the parking area and then into Spring Run

at Southgate Road. Changes in these drainage systems are not proposed in this report.

4. The proposed Park Meadows Subdivision, which is to be located in the large open area in the center of the study area, plus land to the west adjacent to Southgate Road with an aggregate area of 65.4 acres. The area includes the major portion of Spring Run channel in the study area. This report proposes that the channel be located in accordance with the plat for Park Meadows Subdivision with one bridge crossing to be provided for access purposes. Storm drainage design in the Subdivision, if any, must be designed to fit the street system to be built and to discharge into the Spring Run channel. Runoff from this area was considered in the sizing of the outfall line from the area but no consideration was given nor costs furnished for an underground drainage system in this area, since layout of such a system is dependent upon details to be determined by the developer.

5. All other areas, largely developed at the time of this study and comprising a total area of 232.3 acres. Not

included are areas to the south of Highway 85, 87 since this report proposes that the small amount of drainage into the area from the south be diverted along the highway into existing drainage channels.

The aggregate size of all areas considered is then 383.7 acres. Existing drainage in built-up areas is accomplished by means of the existing street system. Generally speaking, streets parallel to Spring Run have sufficient gradient for adequate drainage while those in the perpendicular direction lie along surface contours and are poorly drained.

Abandoned irrigation ditches, some of which presently serve as drainage ditches, exist in portions of the area. Remnants of the Clover Ditch are parallel to Interstate Highway 25 and create no major problems since they drain into Spring Run or to the south out of the study area.

Surface drainage waters intercepted by a second ditch are conveyed through a 24-inch diameter corrugated metal pipe culvert beneath Highway 29 south of Cheyenne Road and discharge on the ground surface in the open area between Highway 29 and Harrison Street. This report recommends that this culvert be plugged at the southern end since the irrigation ditch is no longer in use and since a major drainage channel exists a short distance south of that point.

A third ditch comprises a portion of the drainage system which conveys storm waters from Area 1 described above. This is a complex system crossing to the north beneath Highway 85, 87 at two locations and east beneath Southgate Road, extending along the northerly edge of Highway 85, 87 in open ditch, corrugated metal pipe culvert, open ditch with grouted riprap, corrugated metal pipe arch, and concrete lined ditch until crossing to the south beneath the north-bound lanes of Highway 85, 87 in a corrugated metal pipe culvert. From this point it follows the south-westerly side of the north-bound lanes of Highway 85, 87 in open canal above the roadside ditch and crosses beneath the west abutment of the separation structure, for the roadway connecting Highway 85, 87 south-bound to Highway 29 east-bound, in a corrugated metal pipe. An open canal, pipe culvert and open canal, in that order, then convey the flow into the major drainage area immediately south of the separation structure.

Since this latter drainage system is not adequate to convey surface run-off waters tributary to it, another recommendation of this report is that this system be abandoned and surface waters be conveyed through a corrugated metal pipe culvert to be installed under Cheyenne Mountain Boulevard south of Highway 85, 87 and then via roadside drainage ditch to the same point of discharge as for the existing system being replaced.

Spring Run is the main channel for drainage of surface waters in the study area and conveys small quantities of flow during all months of the year. Besides conveying runoff waters from the surrounding areas it must also have sufficient capacity to convey waters delivered to the area from the portion of Spring Run west of Highway 115.

The existing channel consists of a 60-inch diameter corrugated metal pipe culvert beneath Highway 115 south-bound becoming an 11-foot diameter corrugated metal pipe culvert under Highway 115 north-bound; a well defined open channel to the west side of Highway 85, 87; an 11'-6" diameter corrugated metal pipe culvert under Highway 85, 87 becoming a 60-inch diameter corrugated metal pipe beneath the undeveloped area south of Southgate Shopping Center and discharging into the original channel at the west side of Southgate Road. The original channel through the Park Meadows Subdivision discharges into a 24-inch diameter metal pipe at the north side of the intersection of Hancock Street and Montrose Avenue which in turn discharges into the original channel east of the intersection of Cheyenne Road and Corona Avenue. The outfall pipe for the study area is a 24-inch diameter corrugated metal pipe beneath both lanes of Interstate Highway 25 approximately 3,100 feet from the Harrison Interchange.

This report contains recommendations for improvements to almost the entire length of Spring Run in the study area in order to provide sufficient capacity to handle peak flows entering the area from the west of Highway 115.

DESIGN OF DRAINAGE SYSTEM

Two basic methods of determining storm water runoff were used in the design of the storm drainage system. These were the Rational Method, used to determine peak values of flow for small drainage areas tributary to Spring Run, and the Unitgraph Method, used to determine the discharge-time relationship of runoff for the portion of Spring Run west of Highway 115.

The Rational Method is widely used to determine peak flows from small areas where the size of area and time of concentration are sufficiently small so that the intensity of rainfall can be assumed to be uniform over the area during the entire time in question. The three characteristics required in order to apply this formula are the area involved, expressed in acres; the coefficient of storm water runoff from the ground surface; and the maximum intensity of rainfall, expressed in the equivalent rate of inches per hour for the time of concentration involved and the design storm specified.

The coefficient of runoff represents the ratio of the amount of water reaching the point in question divided by the total amount of rainfall. For paved or highly impervious areas the coefficient of runoff approaches unity while for pervious areas the coefficient is small. For this study the values used were 0.85 in commercial areas containing large expanses of pavement and roof areas, 0.40 in residential areas, and 0.35 in undeveloped outlying areas where future residential or commercial development was considered unlikely.

Time of concentration is defined as the time required for water to flow from the most distant point of the drainage area under consideration to the point in question. It is the sum of the overland flow time, gutter flow time and time to flow through the storm drainage system to that point. The method listed in Reference 3 was used to determine times of concentration except that an additional lag time of ten minutes was added to the computed values to allow for obstructions to flow through residential areas.

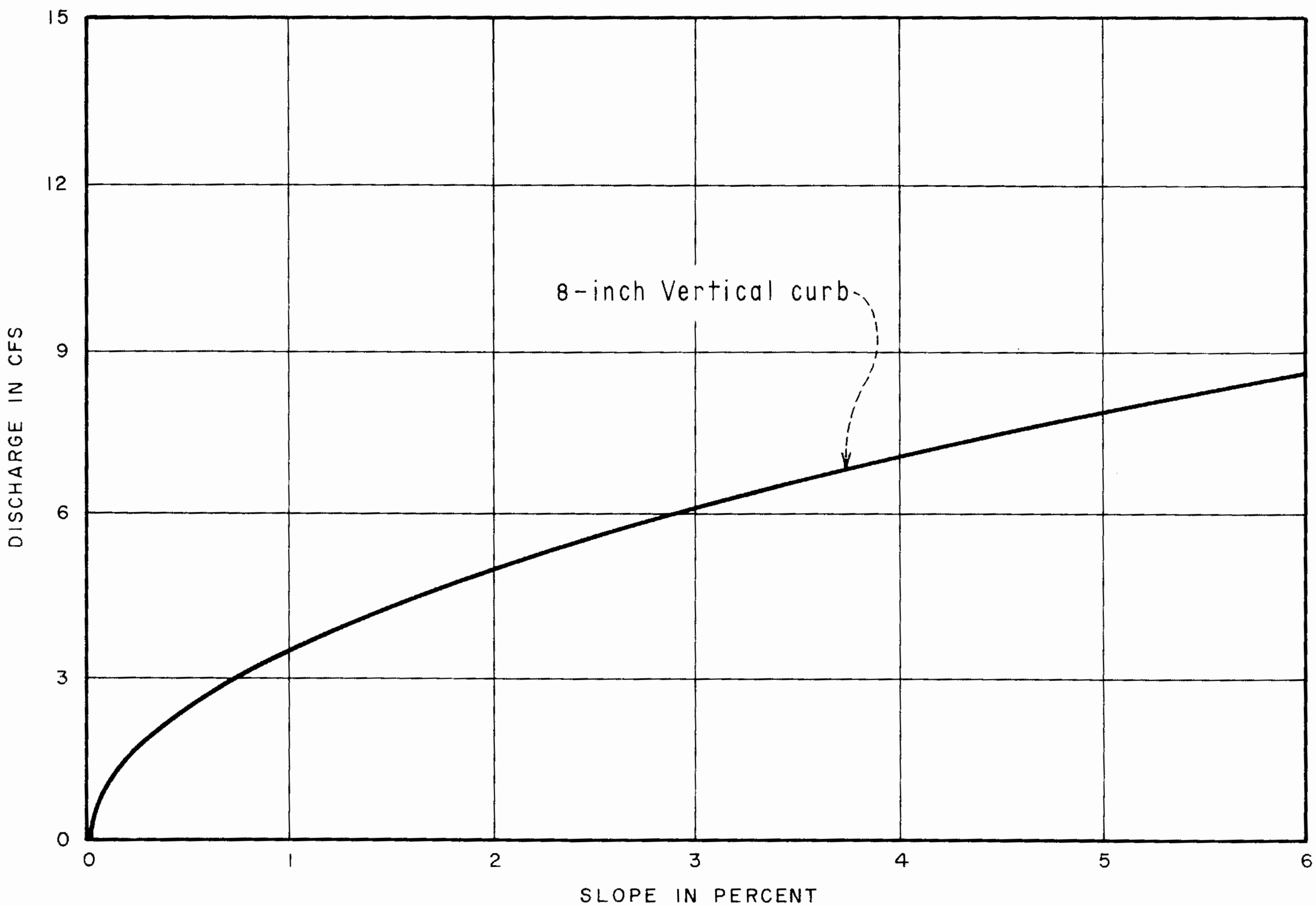
Using the rainfall intensity-duration curve from Reference 6 for the design storm specified and the time of concentration computed for each area, the maximum intensity of rainfall was then determined for each area.

With the values of tributary area, runoff coefficient and intensity of rainfall thus determined, theoretical peak discharge for the point in question was obtained as the product of these three figures. A further modification was made, based upon the Chicago Method listed in Reference 4, to allow for storage of water in gutters and storm drainage system, thus reducing slightly the values of peak flow. Gutter capacity versus slope is shown graphically in Figure 1 and will be discussed in more detail under inlet design.

The design of the Spring Run channel was governed by peak discharge from Spring Run west of Highway 115 plus the simultaneous discharge from the areas tributary to Spring Run in the study area. The storm creating this critical flow in Spring Run is of much longer duration than those used when the design of individual storm drainage lines tributary to Spring Run were being made. The reason for this is the long period of time required for peak runoff to occur in the upper portion of Spring Run.

Although the design criteria furnished specified that the maximum flow in Spring Run at Highway 115 was to be 700 cfs, no information had been given as to the shape of the hydrograph of runoff involved. Using the method outlined in Reference 3 for construction of Unitgraphs for ungaged areas, the hydrograph of runoff was constructed based upon the physical characteristics of the drainage area plus the value of peak flow of 700 cfs.

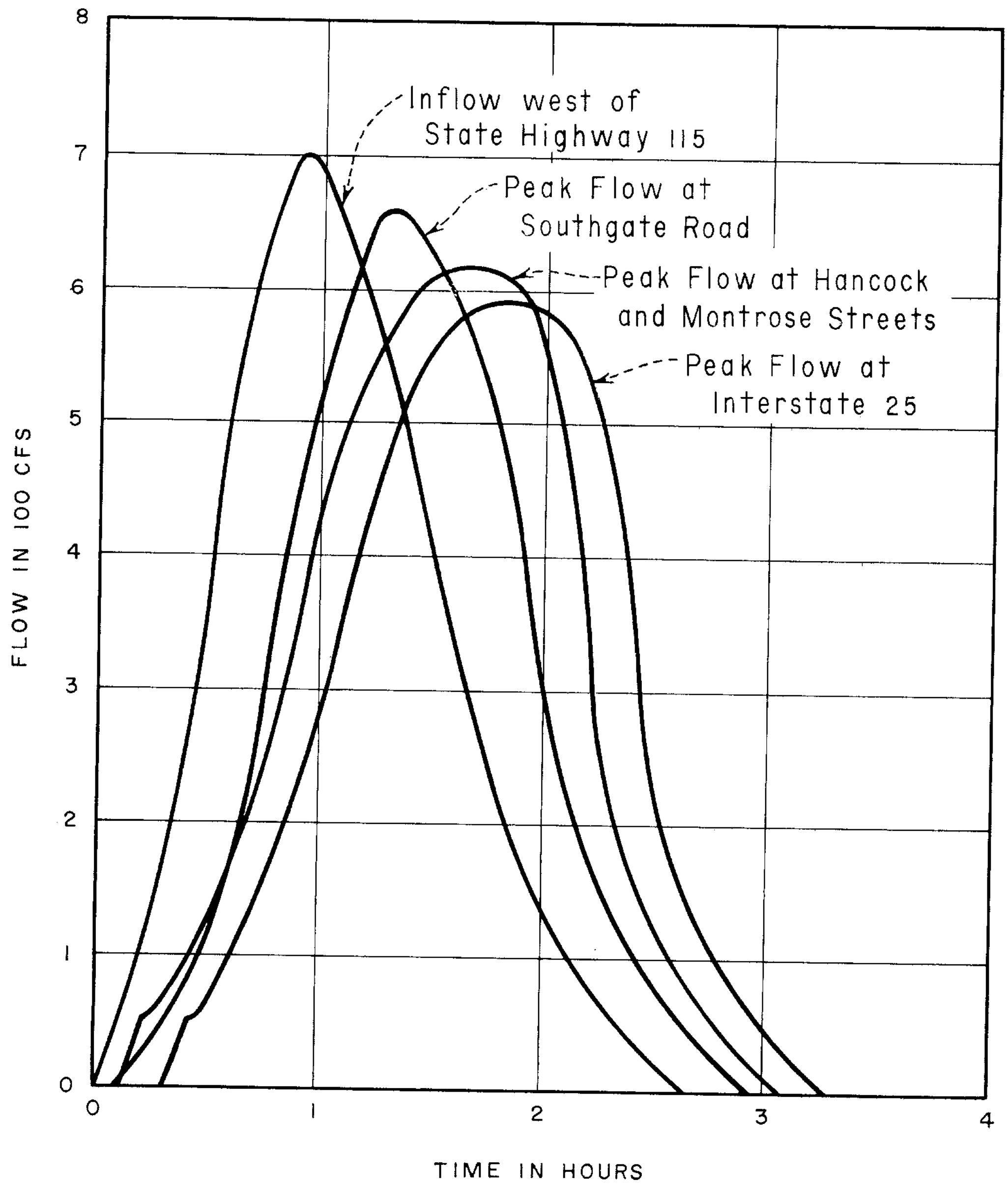
The resulting hydrograph of flows at four critical locations in the channel of Spring Run are shown graphically in Figure 2. The line designated as "Inflow West of State Highway 115" is the basic hydrograph



GUTTER CAPACITY VS. **SLOPE**

(GUTTER 2/3 FULL WITH 8.33 % CROSS SLOPE)

FIGURE 1



LOWER SPRING RUN

HYDROGRAPHS OF PEAK FLOWS

just discussed. The other three curves represent the effect of increased runoff due to inflow from tributary areas, tending to increase the value of peak flow, and the effect of channel storage, which tends to decrease the value of peak flow.

The area beneath individual curves represent the total amount of water flowing past the point in question during the entire storm. For this reason the total area beneath the curve designated as "Peak Flow at Interstate 25" is greater than for the hydrograph of inflow west of Highway 115 by the amount of runoff added to Spring Run by tributary areas along the intervening Spring Run channel. Also, channel storage is sufficiently great so as to reduce peak flow from 700 cfs at Highway 115 to about 595 cfs at Interstate Highway I-25.

The values of maximum flow shown in Figure 2 were the critical values used in the design of various sections of Spring Run through the drainage area. These values include the effect of modifications required to the existing system to provide sufficient capacity to accommodate the design storm.

As discussed under Gutter Storage in the section DESIGN CRITERIA, drainage inlets were to be shown at all points where flow in gutters reached a depth equal to 2/3 of overall gutter depth and at special locations such as intersections. Inlets were assumed to be standard curb type inlets in which the height of inlet opening was 8 inches, depth of gutter depression at inlet was 4 inches, and the total length of inlet was that required to take the entire gutter flow at the point in question but in no case to exceed the flow in the gutter when 2/3 full. Lengths of inlet openings were standardized as multiples of 3'-6" up to a total length of 17'-6". Gutter capacities versus slopes for gutters 2/3 full were obtained from Figure 1 and inlet capacities versus slope were obtained from charts in Reference 5.

Although inlet lengths shown may appear excessive it should be remembered that the design storm specified with frequency of once in every fifty years represents a severe storm for inlet design. Also, the inlet lengths determined are the total lengths required in each stretch and smaller sized inlets spaced throughout the stretch can be used if desired as long as total equivalent capacity is provided.

Size of laterals from inlets to main lines were not shown on Plate A for the reason that lateral size is a function of inlet spacing. An allowance for cost of laterals was included in the preliminary cost estimates, however.

PROPOSED DRAINAGE FACILITIES

Proposed drainage facilities, exclusive of branch lines and laterals, are shown on Plate A. Inlet lengths are the total lengths of 8" high curb inlet openings for 8" high vertical curbs with 4" curb depression at inlet openings. Multiple inlets could be provided in each stretch as along as total equivalent capacity is provided.

The proposed facilities can be divided into three major categories as follows:

1. Improvements to Spring Run

   a. Remove existing 60-inch diameter corrugated metal pipe beneath Highway 115 south-bound and install an 11-foot diameter multiplate corrugated metal pipe.

   b. Install a 72-inch diameter corrugated metal pipe parallel and adjacent to the existing 60-inch diameter pipe beneath the undeveloped area south of Southgate Shopping Center.

   c. Provide a concrete lined open channel through the Park Meadow Subdivision.

d. Remove the existing 24-inch diameter corrugated metal pipe and replace with two 72-inch diameter corrugated metal pipes from Montrose Avenue and Hancock Street to Corona Avenue and Cheyenne Road.

e. Provide a new outfall channel through the undeveloped area from Corona Avenue and Cheyenne Road to the drainage ditch along Interstate Highway 25.

f. Install an 8'-6" diameter multiplate pipe beneath Interstate Highway 25 parallel to the existing 24-inch diameter corrugated metal pipe outfall line.

g. Provide sufficient drainage easements for minimum sizes of open channels as shown with top of channels 5 feet above top of the respective outfall pipes.

2. <u>Diversion of Runoff from Adjacent Areas</u>:

a. Plug the ends of the two 36-inch diameter corrugated metal pipes beneath Highway 85, 87 west of Cheyenne Mountain Boulevard; install a new 42-inch diameter corrugated metal pipe beneath Cheyenne Mountain Boulevard; and modify the roadside ditch along the southwesterly side of Highway 85, 87 to convey storm waters to the major drainage channel immediately to the south of the separation structure. Included in this work is the installation of a new 36-inch diameter corrugated metal pipe beneath the access road west of Cheyenne Mountain Boulevard and south of Highway 85, 87.

b. Plug the south end of the existing 24-inch diameter corrugated metal pipe beneath Highway 29 south of Cheyenne Road.

3. Storm Drainage System for Built-Up Areas

a. The recommended sizes and locations of trunk sewers are shown on Plate A.

b. The recommended inlet lengths shown are the total lengths required to handle storm water runoff. If multiple inlets are desired, equivalent total capacity must be provided.

c. In some cases inlet sizes are indicated where there are no curbs and gutters at the present time. The costs of construction of curbs and gutters and the regarding or resurfacing of existing streets are not included in this report.

PRELIMINARY COST ESTIMATES

The preliminary costs shown below consist of the estimated cost of construction of drainage inlets, laterals and main storm sewers, plus modifications to the existing channel and outfall line for Spring Run. A contingency factor of 15 percent was included to allow for unforeseen items or construction difficulties. Costs are based on 1968 prices.

Costs shown do not include the cost of land or easement rights; legal, engineering or administrative costs; or interest during construction since these items are influenced by scheduling of the work and other factors. Also, costs shown do not include costs of regrading and resurfacing streets or installing curbs and gutters where not presently installed.

Locations and numbers of existing underground utility lines would also have major influences on the cost of construction. For this study it was assumed that locations of existing utilities would be known and that the number of underground lines would be minimal since the Stratton Meadows area is a relatively new subdivision developed since 1946.

TABLE 1

PRELIMINARY COST ESTIMATE
PROPOSED STORM SEWER FACILITIES
EXCLUSIVE OF SPRING RUN
CHANNEL AND OUTFALL

Item (1)	Description (2)	Quantity (3)	Unit (4)	Unit Price (5)	Amount (6)
1.	Excavation, Trench . . .	18,340	CY	$ 3.00	$ 55,020
2.	Backfill	14,820	CY	0.75	11,115
3.	Compaction of Backfill .	14,820	CY	2.00	29,640
4.	Asphalt Surfacing. . . .	12,980	SY	3.00	38,940
	Furnishing and Laying				
5.	12" dia. RCP	8,090	LF	4.00	32,360
6.	15" dia. RCP	5,150	LF	5.00	25,750
7.	18" dia. RCP	6,910	LF	6.20	42,842
8.	21" dia. RCP	1,940	LF	7.30	14,162
9.	24" dia. RCP	2,900	LF	8.50	24,650
10.	27" dia. RCP	3,370	LF	9.70	32,689
11.	33" dia. RCP	2,830	LF	12.50	35,375
12.	36" dia. RCP	1,020	LF	14.25	14,535
13.	39" dia. RCP	560	LF	16.50	9,240
14.	48" dia. RCP	510	LF	26.50	13,515
15.	54" dia. RCP	500	LF	36.00	18,000
	Manholes				
16.	3' depth	48	EA	150.00	7,200
17.	4' depth	21	EA	175.00	3,675
18.	5' depth	9	EA	200.00	1,800
19.	6' depth	3	EA	250.00	750
20.	7' depth	2	EA	275.00	550
21.	8' depth	3	EA	300.00	900
22.	Drain Inlets:				
	3'-6"	84	EA	300.00)	
	7'-0"	84	EA	400.00)	
	10'-6"	20	EA	500.00)	75,500
	14'-0"	10	EA	600.00)	
	17'-6"	1	EA	700.00)	
	SUBTOTAL				$ 488,208
	CONTINGENCIES - 15%±				73,192
	TOTAL				$ 561,400

TABLE 2

PRELIMINARY COST ESTIMATE
IMPROVEMENTS TO SPRING RUN CHANNEL AND OUTFALL

Item (1)	Description (2)	Quantity (3)	Unit (4)	Unit Price (5)	Amount (6)
1.	Excavation, Ditch	34,400	CY	$ 1.50	$ 51,600
2.	Excavation, Trench. . . .	7,810	CY	3.00	23,430
3.	Excavation, Structure . .	590	CY	3.00	1,770
4.	Backfill	4,830	CY	0.75	3,622
5.	Backfill, Structure. . .	260	CY	2.50	650
6.	Compaction	4,830	CY	2.00	9,660
7.	Riprap	845	CY	7.50	6,338
8.	Asphalt Surfacing	1,920	SY	3.00	5,760
9.	Remove 60" dia x 130' CMP and install 11' dia x 130' under Highway 115	1	LS	-	23,000
10.	Jacking 102" CMP under Interstate 25	230	LF	150.00	34,500
11.	Furnish and install 72" dia CMP	2,850	LF	45.00	128,250
12.	Concrete in Structure . .	113	CY	100.00	11,300
13.	Access Bridge	1	EA	4,500.00	4,500
14.	Manhole Rings and Covers.	3	EA	100.00	300
	SUBTOTAL				$ 304,680
	CONTINGENCIES - 15%±				45,720
	TOTAL				$ 350,400

SUMMARY AND CONCLUSIONS

1. The existing channel of Spring Run in the study area is of insufficient capacity to carry the specified design storm of 700 cfs peak intensity at Highway 115.

2. An appreciable quantity of storm runoff water can be diverted from the study area by diverting such water along the southwesterly side of Highway 85, 87 to the same outflow point as exists for a portion of the present system which is of inadequate capacity.

3. A complete storm drainage system should be provided in built-up residential areas to provide adequate drainage and to prevent excessive deterioration of pavement surfacing and existing curbs and gutters.

4. The specified design storm of 2 inches of rain per hour with a frequency of once in 50 years is considered very conservative for inlet design but is not considered conservative for the design of Spring Run channel.

5. Appreciable savings in cost of improvements to Spring Run channel could be realized if detention ponding of surface runoff waters were to be provided west of Highway 115.

6. Cost of improvements to Spring Run Channel are estimated to be $350,400; costs of all other improvements are estimated to be $561,400. Costs do not include cost of land, legal, engineering or administrative costs; interest during construction; regrading or resurfacing of existing streets or installation of curbs and gutters where not presently provided.

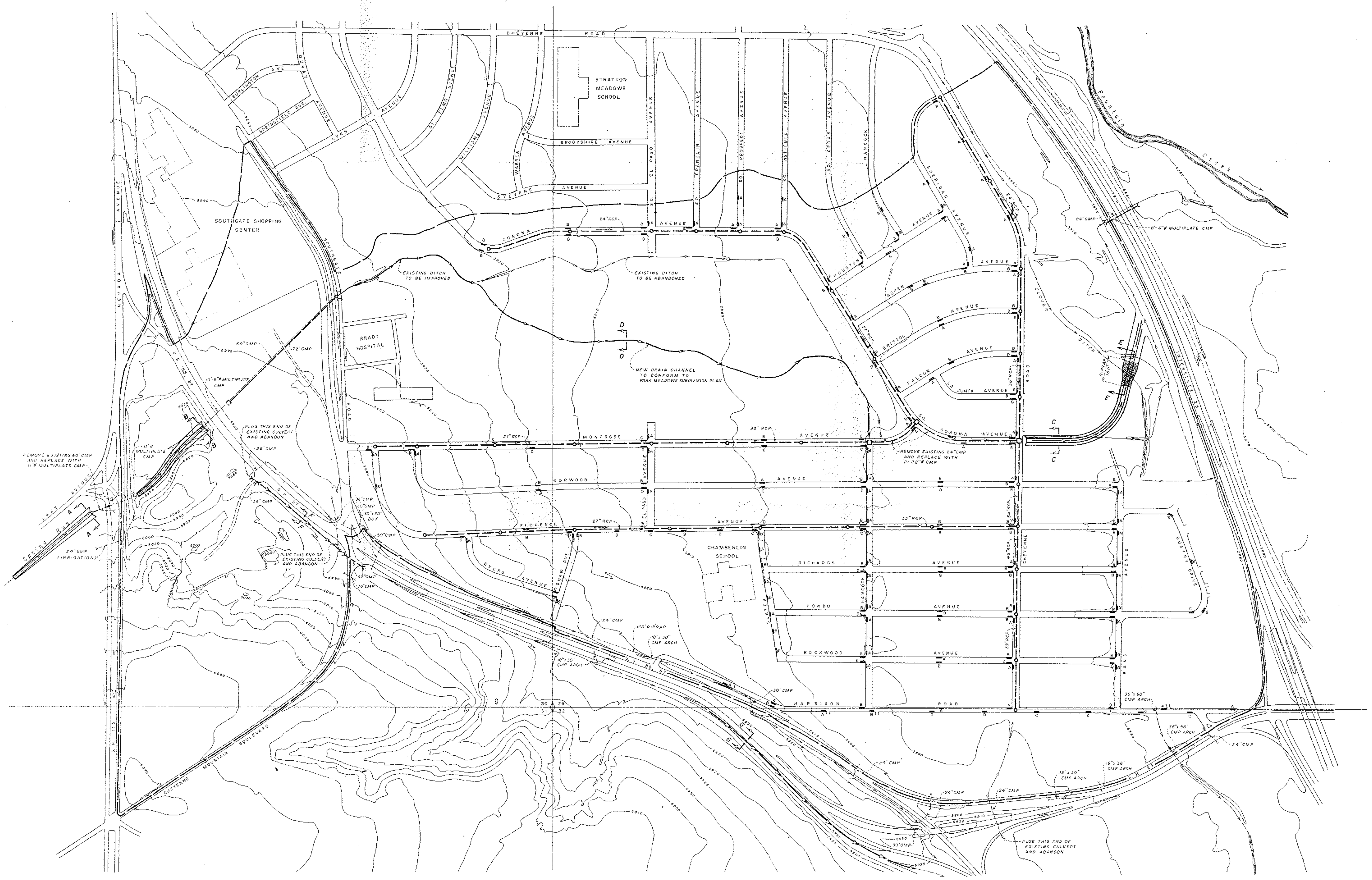
7. The four undeveloped areas are the following:

   1. An area bounded by Highway 115, Highway 85-87 and Cheyenne Mountain Boulevard, consisting of 55.5 acres.
   2. The undeveloped portion of Southgate Shopping Center, consisting of 20.2 acres.
   3. The area lying between State Highway 29 and Harrison Road consisting of 23.4 acres.
   4. The area lying North of Norwood Avenue extended Easterly to Interstate 25, Cheyenne Road and Interstate 25, consisting of 41.5 acres.

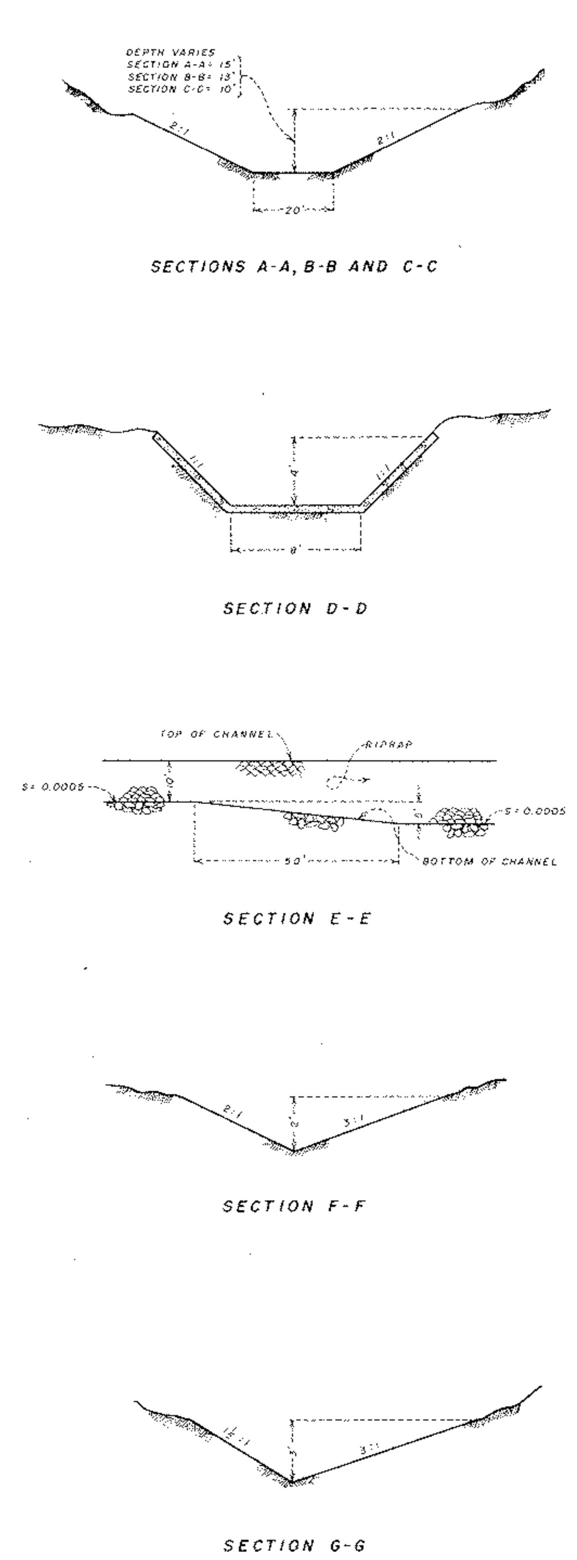
   These areas make a total of 140.6 acres of undeveloped ground.

8. Undeveloped Areas

Undeveloped Areas	140.6 Acres
Total Estimated Cost	$911,800.00
Estimated Cost Per Acre	$ 6,485.06



TYPICAL OPEN DRAIN SECTIONS



LEGEND

- EXISTING DRAINAGE CHANNEL
- 48" CMP — EXISTING CULVERT OR PIPE DRAIN
- NEW OR IMPROVED DRAINAGE CHANNEL
- 21" RCP — NEW CULVERT, PIPE DRAIN OR STORM SEWER TRUNK
- CURB INLET (LETTER INDICATES LENGTH)
- STANDARD MANHOLE
- JUNCTION STRUCTURE WITH MANHOLE
- DRAINAGE BASIN BOUNDARY

DRAIN INLET SIZES

(LENGTH OF 8" HIGH CURB OPENING)

A = 3'-6"
B = 7'-0"
C = 10'-6"
D = 14'-0"
E = 17'-6"

200 0 500 1000
SCALE OF FEET

SPRING RUN DRAINAGE BASIN

HYDROLOGIC ENGINEERING STUDY
FOR THE
CITY OF COLORADO SPRINGS, COLORADO

Prepared by
H. J. KRAETTLI & SONS — CONSULTING ENGINEERS
December, 1968