ENGINEERING STUDY
OF
SOUTHWEST AREA DRAINAGE BASIN
(CHEYENNE CREEK, CHEYENNE RUN,
AND SPRING RUN)
COLORADO SPRINGS, COLORADO

PREPARED FOR
Director of Public Works and
Drainage Board of
the City of Colorado Springs
30 South Nevada Avenue
Colorado Springs, CO 80903

PREPARED BY
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February 29, 1984

Director of Public Works and
Drainage Board of the City of Colorado Springs
30 South Nevada Avenue
Colorado Springs, Colorado 80903

Re:

ENGINEERING STUDY
of
SOUTHWEST AREA DRAINAGE BASIN
(CHEYENNE CREEK, CHEYENNE RUN,
and SPRING RUN)

COLORADO SPRINGS, COLORADO

Gentlemen:

Enclosed is the report of the engineering study of the Southwest Area Drainage Basin, authorized by the City Council of the City of Colorado Springs, the Colorado Springs Drainage Board and the Public Works Department of the City of Colorado Springs.

The Southwest Area Basin includes the Cheyenne Creek, Cheyenne Run and Spring Run Drainage Basins. This study includes an overview of basin geology, rainfall/runoff characteristics, hydrologic history and of the drainage improvements existing in the basin. Additional improvements for local drainage and some Main Channel improvements are discussed and recommended in the report. The hydrologic background for computed flow and improvements is given in an Technical Appendix.

The study may be used as a master guide for drainage improvements within the basin. The included recommendations should be used as a guide, not as an inflexible design.

respectfully submitted,
LINCOLN-DEVORE TESTING LAB

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I. INTRODUCTION

Scope of Study:

The Southwest Basin as defined for this study includes the drainage area of Cheyenne Canyon and Ivywild, drained by Cheyenne Creek and its major tributary referred to in this report by its old name, Cheyenne Run. To determine probable flows entering this basin, the contributing basins of North and South Cheyenne Canyon were studied on a non-detailed basis. In addition, the Southwest Basin contains the basin of Spring Run. This creek drains the older Broadmoor area in the west and the Southgate-Stratton Meadows area in the east. Runoff from all of these basins eventually discharges into Fountain Creek.

This study was authorized by the Engineering Department, Department of Public Works of the City of Colorado Springs. The study was to be detailed in the developed portion of the basins of Cheyenne Creek and Spring Run. The upper basins were to be studied only to the point of determining the discharge into the upper end of the developed area.

In the areas to be studied in detail, all known drainage reports were to be reviewed and existing drainage facilities were to be mapped and studied for hydrologic adequacy. Using the selected design storm, the runoff was to be routed through each stream with peak values given at each junction and major control point. Recommendations for upgrading existing drainage structures and for new facilities were to be made where possible. These details were to be reported, mapped and listed with cost estimates to result in a
drainage plan and fee for the Southwest Basin. No design of structures or drainage appurtenances were included in the study contract.

Watershed History:

Development in the two study basins began shortly after the founding of Colorado Springs. A few "ranches" were in the area prior to that time, but major development has generally paralleled the growth of Colorado Springs. The Ivywild area began as a series of small-lot subdivisions clustered along the channel of Cheyenne Creek and Run. This area was irrigated by at least three known irrigation canals. Some evidence of these still exists in both basins.

The Cheyenne Canyon area first developed as a long string of residences placed along the course of Cheyenne Creek. Building was not continuous since open areas such as Three Eagles Ranch were also along the Creek banks. However, the string of residences reached as far as the present entry to North Cheyenne Canyon Park by 1900.

The Ivywild-Cheyenne Canyon area has thus been exposed to the potential of high water and flooding for nearly 120 years. Expansion in these areas generally amounted to filling in vacant land along the stream channels and some growth of the business area along Nevada Avenue until 1948. After that date, the Ivywild-Cheyenne Canyon area began to expand into then-open areas on higher ground above the stream channels. This expansion produced more rapid drainage of the higher ground,
destroyed the various irrigation systems and increased the potential for flooding in the lower areas along the stream channels. Examples of this action are well illustrated by the flood histories of the Foothills Subdivision and of the Lower Skyway Park Subdivision.

Base flow down the main stream channel was reduced by construction of the Brookside and the Cheyenne Canyon water systems. These systems both took water from North Cheyenne Canyon to supply the growing district. The extraction of this water from streamflow and the construction of structures to store snowmelt on Mt. Almagre combined to reduce stream flow to a very few cubic feet per second under normal conditions. The stream has flooded on a number of occasions, however, the most recent of these being in 1967 and 1978. This is described in greater detail in the Technical Appendix to this report.

The basin of Spring Run developed at about the same time, but in a different manner. The Broadmoor area was built on higher ground and was generally not subject to flooding by Spring Run. The stream was controlled early by two irrigation storage reservoirs--Spring Run No. 1, now removed, and Spring Run No. 2, which still exists as the Big Stratton Reservoir. Both these reservoirs and a series of canals were used to supply irrigation water to the Stratton Homestead farms for many years.

Encroachment onto the channel of Spring Run has been relatively recent. Shortly after 1900, some residences were built along the channel, changing its flow to some degree and eventually causing abandonment of Spring Run.
Reservoir No. 1. The Broadmoor Golf Course obliterated the channel of Spring Run during the period of the 1920's. The presence of an open, unstable alluvial fan above the golf course dictated a varying channel by producing flow in numerous, changing small gullies which changed course regularly with each "flood" event. When development began on this fan starting about 1949, the changeable nature of flow on the fan was ignored. This has led to a number of very localized but damaging flood events.

For the most part, the Lower Spring Run basin (east of Nevada Avenue) was undeveloped except for truck garden farming until about 1948. After this year, the Stratton Meadows Subdivisions were developed rapidly and with little thought given to potential flow in the main channel. Development has been steady since that date, until at the present time, little open land remains in the Lower Spring Run basin. Flooding along Spring Run has generally been localized and has been predominantly in the Stratton Meadows area and in the area around Penrose Boulevard.

Most of the area remaining for development lies on the alluvial fan and mountain front above Skyway Park and the Broadmoor Golf Course and in the Harms Ranch area along 8th Street. Some tracts are available for "infilling" in the developed areas but these are generally of a small size and are scattered through the basins. Two relatively small parks, Stratton Park on Cheyenne Creek and Meadow Park on Spring Run, help control water movement along the respective channels and restrain development. These are about the only open areas left along the channels, however.
Flood events have taken place in both Basins III and IV since the start of development. However, general flood events have been rare, localized and affecting only relatively small areas along the streams. In the past, spreading along the streams was allowed by some open land along the streams. The result of a century of low flow in the streams with relatively light flooding has left a public impression that flooding will not occur in either Cheyenne Creek or Spring Run. This is not the case.

Watershed Problems:

The major water-related difficulty in both stream basins revolves around the fact that both basins are almost completely developed and that the developments for nearly 100 years have not considered the potential for flooding along the two streams. Stream flow potential in Cheyenne Creek is greater than the existing channel capacity. Bridges constructed along the channel are not large enough to pass this potential flow.

Cheyenne Run is nearly capable of carrying the proposed flow except at some isolated reaches and at one bridge crossing. However, the Run has been obliterated in the area of the lower Skyway Park Subdivisions and the constructed streets cannot carry the potential flow.

Due to the geometry of Basin III, detention will not be very effective and is not recommended in this report. The existing Spring Run detention system, while not originally intended for that purpose, reduces flooding considerably and should be retained.
Most streets in both basins either already exist or are planned for certain locations and patterns. At this time, little can be done in the way of increasing street capacity to help local drainage. Some streets fit the prevailing drainage pattern and some do not, dictating that required drainage improvements will generally be in the form of storm sewers or culverts.

The adequacy of existing drainage structures and drainageways is estimated in this study. Recommendations for general improvements and changes required for safe disposal of runoff are presented, where this was found to be possible. It is the conclusion of this report that major channel changes along Cheyenne Creek are not possible at this time.

The study was conducted in two parts. The upper basin, generally in the National Forest, was studied only to the extent of determining the major stream flow and the effects of present and potential constrictions in the channel. The lower basin of Cheyenne Creek, partially developable, was studied in detail. The entire basin of Spring Run was studied in detail since it has no upper basin for all practical purposes.

This study is designed to show the probable runoff flow at points throughout each studied basin. This is as determined by a variation of City of Colorado Springs rainfall/runoff criteria. The upper basins (I and II) of Cheyenne Creek were studied using the City criteria, the FEMA criteria and a "most likely case" condition found by combining studies of various agencies. The rainfall in this area was adjusted to NOAA data and to data developed by studies of the
Big Thompson Flood, 1976. Diversion of part of the water by the City Utility Department was considered as were special effects such as swampy areas, debris flow blockages, rock faces on canyon walls and subflow at higher elevations. Consideration of these factors produce what we believe to be the most likely case runoff from the two canyon basins. Flows in this report reflect this value.

The City of Colorado Springs drainage criterion requires computation of both the 5-year frequency and 100-year frequency storms. Until the runoff from the 100-year storm reaches 500 cfs, drainage appurtenances and structures are designed for the 5-year runoff. When the 100-year runoff exceeds 500 cfs, such structures must be designed for the 100-year event.

The intent of a study of this type cannot be to establish precise locations, sizes or details of design for storm sewers, ditches, culverts and other appurtenances. This can be done at points of major structures along the main channel, but is not practical in other areas. It is intended to establish the need, general location and probable size of required systems. The major channels have been formed by nature except where changed by encroachment and exist as the main streams of Cheyenne Creek, Cheyenne Run and Spring Run. Most of the off-stream sites of storm drainage improvement can be designed in various ways. This overall plan is not intended to restrict methods or innovations in design and should not be used in that manner.
II. BASINS I AND II - UPPER CHEYENNE CREEK

Basin Description:

These basins are mountain-type basins which are the upper source of water flowing in Cheyenne Creek. The two basins are generally referred to as North Cheyenne Canyon (I) and South Cheyenne Canyon (II) and will be referred to by these names in this report. Both canyons together comprise a large collection area of approximately 21.5 square miles all draining to a single point of outfall into Basin III (Point 12).

The topography of the basins varies considerably. In general, Basin I is long and narrow with steep sided canyon or mountain walls along both sides of North Cheyenne Creek. The main stream has several tributaries but all are relatively small. Most tributaries to this stream are on steep hill-sides and are restricted in drainage area. Buffalo Canyon is the largest of these tributaries. Basin I has its highest point on the crest of Mt. Almagre at an elevation of approximately 12,370 feet above mean sea level. The lowest point in the basin is the outfall (Point 12) at an elevation of approximately 6260. Near the summit of Mt. Almagre, the Stratton Reservoir collects water from snowmelt and originally was built to supply water to the Ivywild and Cheyenne Canyon communities.

Basin II, of South Cheyenne Creek, is lower in general elevation, is nearly as wide as it is long and the main channel has several large tributaries. In general, the terrain is somewhat more open with few deep canyons. As a result, this basin contains a number of roads--one of which was a railroad grade originally. The highest point in Basin II is the
Summit of Mt. Rosa at an elevation of approximately 11,500 feet above mean sea level. Cheyenne Mountain forms the eastern boundary, forcing runoff to the same point of outfall used by Basin I.

Geology and Soil Type:

Basins I and II are almost entirely west of the line of the Ute Pass Fault so the exposed formations are those of the uplifted mountains. Most of the area is underlain by the Pikes Peak Granite. Some other varieties of granite are also found in the area in scattered locations. The most important of these are the Mt. Rosa Granite, the granite of Almagre Mountain and the granite of Nelson Camp.

These formational materials are found both in a lightly weathered, but formational condition (rock) and in a highly weathered, decomposing condition (clayey sands and gravel). Jointing is prominent in all these materials in the unweathered condition. These granites usually weather by mechanical means. Decomposition starts in the joints and fractures and gradually breaks down the rock mass by frost action, mass movement and other miscellaneous actions. Steeper slopes of lightly weathered material are prone to rockfalls and rock avalanches. Some debris fans are located in this basin in areas of weathered rock. In a narrow canyon of this type, such debris flows and avalanches can block the stream temporarily. Large areas of exposed rock are found in both basins but particularly in Basin I where the steep slopes have exposed large areas of rock.
In Basin II, slopes are not as steep and a larger percentage of weathered material is found. In this area, weathered slopes of clayey sand, together with some alluvial deposits, tend to allow some infiltration and decrease immediate storm runoff. This tendency is reinforced by the number of tributary streams in this basin. Even so, the sand and gravel material tends to be thin and clayey with bare rock exposed in a number of places. The shape of this basin tends to allow faster collection than Basin I. The result of this is that the peak flow from Basin II reaches the outfall point before the peak from Basin I. The outflow from the two basins tend to reinforce each other, therefore.

The silty sands and gravels of the weathered formation are classified hydrologically by the SCS as B/C soil. In some conditions, infiltration is fairly high and the soil is classed hydrologically as B. In other conditions, clay quantities are greater and the soil is classed hydrologically as C. Bare rock faces are, of course, classified hydrologically as D. A few swampy areas must be classified as D since the water surface is at or above the ground surface.

The Forest Service classifies all these soils hydrologically as C and D soils. We could not determine the basis for this high classification. We speculate that the Forest Service is averaging the exposed ground in the given area. If so, this would average the D classification of exposed rock with the B and C classification of the clayey sand and gravel weathered materials.
Channel Conditions:

Channels in both basins are well-defined. In Basin I, the main channel can be easily identified all the way to Stratton Reservoir near the summit of Mt. Almagre. A small swampy area exists near Nelson Camp but even here the stream can be easily traced. Through most of Basin I, the stream is restricted by steep slopes on each side. At a few locations, the stream has been blocked by past debris flows from the side slopes. Since the stream is restricted to a relatively narrow course, it has cut through these flow dams without excessive meandering. In the lower portion of Basin I, below Helen Hunt Falls, the stream is narrowly confined by very steep, high canyon walls, together with a roadfill. Debris dams in this area have the result of causing more damage but do not affect the flow a great deal due to lack of storage space. About a quarter mile above Point 12 the stream emerges from the deep canyon and enters a wider area with a less-steep gradient. For most of its length, the stream channel contains brush, willows and some scrub. The channel bottom is rocky.

Channels in Basin 2 are of practically the same general gradient as those in Basin I. This basin is not as high, but the channels are shorter, leaving the gradient about the same. The various stream channels in Basin 2 are meandering since some room remains in the valleys to allow this. Gradients are sufficiently steep that meandering is not a major flow factor, however. This basin is heavily wooded and the channels contain some trees and considerable amounts of brush and weeds. The bottom of the channel tends to contain boulders, but
is not excessively rocky above Seven Falls. About a half mile above Seven Falls, the stream passes into a deeper canyon and becomes more similar to North Cheyenne Creek prior to its crossing the front of Mt. Cutler. From this point, the valley widens and becomes less-steep to its junction with North Cheyenne Creek at Point 12.

Hydrology:

Studies made of Front Range mountain basins similar to this have concluded that the Type IIA storm rarely occurs within mountainous areas and almost never above an elevation of 8000 feet. Such a rule is, of course, somewhat arbitrary, but does match experience in the area. This study indicates that the worst flooding would probably occur if a Type II storm above approximately 8000 feet elevation took place starting about \( \frac{1}{2} \) to 1 hour prior to a Type IIA storm commencing in the lower basin. Storms in this area generally move from west to east, so that such an event is possible. Snowmelt is not a major factor in flood runoff from this basin. It does affect the antecedent moisture condition of the soils and provides a base flow to the creek. These basins combined are sufficiently large that a size distribution reduction may be used for rainfall.

A number of storm, soil and runoff conditions were tried for runoff calculations. The trials included various combinations of Type II and IIA storms, antecedent moisture conditions of II and III, Forest Service soil hydrologic numbers and SCS soil hydrologic numbers. Considerable differences
were found in the various combinations of factors. The SCS computations were made using a modified SCS computer program. The U. S. Corps of Engineers HEC-1 computer program was used as a check and to try other combinations of base data. The SCS program routed the runoff using the Muskingum method of routing while the HEC-1 programs were set to route the flow using the Kinematic wave method of routing. When using the same base data, the two programs yielded acceptably similar results.

The possibility of debris flows and debris avalanches blocking the stream exist and were investigated. Such a debris occurrence during a sizable storm does affect the stream hydrograph, particularly in timing. It is problematical whether it would affect the peak flow to any degree sufficient to lower flooding potential in Basin III.

For a more complete discussion of the upper basin hydrology, the factors used and the combinations tried, your attention is directed to the Technical Appendix. In that volume, we discuss these items in more detail, together with the reasons for selecting the design runoff used throughout this report.

**Hydrologic Method Used:**

In summary, we believe the most likely case to be that of the factors listed by number below.

1. A Type II, 6-hour, 3.5 inch intensity snowfall over the upper basins above 8000 feet elevation, timed to begin about 1/2-hour before the storm over Basin III. This storm should be corrected for the size of the basins.
2. A Type IIA, 6-hour, 1.5-inch storm was used over the lower basin (III) and over that portion of Basins I and II below the 8000-foot elevation. This storm was centered at about Point 13 and was timed to begin about 1/2-hour after the upper basin storm.

3. AMC II soil conditions were used throughout the basins.

4. The SCS soil classifications were used for individual soil types at the surface of the ground and believed to extend more than 3 feet below the surface. (An A classification sand will not absorb much water if it is only a foot or two deep over Pierre Shale.)

5. The soil types and conditions were taken as water producing units as recommended by the SCS National Engineering Handbook, Section 4.

Although the assumption of a Type IIA storm over the entire basin gives runoff results that are similar, but somewhat higher, we believe the combined storm is in better agreement with known data concerning mountain basins.

It must be noted that the method followed for this study is completely valid only for a runoff flow with little or no debris or sediment load. If the flow does have a large debris or sediment load, its action and timing will differ from that predicted.

Engineering Options for Runoff and Debris Control: (Upper Basins)

Definite limitations exist in Basins I and II for structural control of runoff and debris. Parts of these basins are in Teller County. Nearly all of these two basins are within the Pike National Forest boundary. Small areas are privately owned within the national Forest. Parts of the basins are in the North Cheyenne Canyon City Park. Jurisdictional constraints to construction in the basins are numerous.
For construction to take place, additional roads are required for both supply and maintenance. Such roads are not economical and are aesthetically undesirable. The practicality of maintaining large structures in the upper basins is questionable. To be effective, such construction must control as much of the runoff as possible. The best locations to accomplish this are in the lower parts of the basins which are the sites of a City park and of privately held land. Neither location would be aesthetically pleasing.

Detention Basins:

One effective method of controlling runoff from the basins would be construction of medium sized detention reservoirs. This method has a proven record of effectiveness and could control relatively large flows. However, detention reservoirs cannot be recommended due to the jurisdictional and maintenance constraints noted in the preceding section.

In addition, sites for such detention works are scarce in both basins. At least one site is located on North Cheyenne Creek. However, it is too high in the basin to control large amounts of runoff and would be ineffective in reducing runoff to Basin III. Two sites were located in the basin of South Cheyenne Creek. The first of these is too high in the basin to be effective. The second site would be effective in cutting runoff at the outfall by 40%. This site is so located that it is aesthetically unacceptable, however.
Even if the last site were acceptable aesthetically, there is no easy access. This would increase both construction and maintenance costs to an unacceptable level. It must be noted that a detention structure requires continual cleaning and maintenance. The cost/benefit ratio of such a structure in this area is considered poor.

Channel Grade Control:

Grade control structures could be placed along the channels to lower velocities and increase the time to hydrograph peak. This is an ambitious and expensive program. A large number of structures would be required since the natural gradient of all the streams is high. To effectively control velocity would require that the existing gradient be reduced by at least half.

Although these structures are relatively small, they are still subject to the problems of access for both construction and maintenance. Such structures would also significantly alter the flow characteristics of the stream but would have little effect on the total flow through the channels. This type of structure is probably not cost-effective and is difficult to maintain.

Sedimentation Spreading:

A combination spreading area and debris control system in the low gradient area above Point 12 is believed to be cost-effective. The area is much less steep than any of the stream channels above and the construction required is
of a small scale. This area has access at the present time and, although it is in the City park, the design could be such as to reduce aesthetic objections.

Such a system must be site-specifically designed and cannot be detailed in this report because of lack of topographic data. However, as a general description, this lower gradient area could be transformed into a series of dikes and level areas to trap debris. Evans Avenue could be transformed into such a dike, for example.

The outlet of such dikes is designed as a self-cleaning outlet and overflow to allow water to pass, but to retain most sediment and debris during the storm flow. The cleaning action takes place after the storm. Several types of such outlets are in use. Technology developed by the Los Angeles County Flood Control District and the Swiss Institute for Landslide Control (hydraulics section) both resulted in more or less standard designs for such outlets. A recent study at Colorado State University tested a modification of the Swiss slotted debris structure and recommended modifications for effective use in the Rocky Mountain area. Such structures, called "rectangular split dams" by CSU, could be placed in gullies entering the large sedimentation area and in the main stream channels.

This type of system has several advantages. Being unused most of the time, it leaves the park land more or less in its natural, usable condition. Construction of such a system requires no major changes to the park. Of greatest importance, removal of debris from the flow at this point would benefit all residents along the channel in Basin III.
The disadvantages of such a spreading and collection system are few. The system would require regular and periodic maintenance with some cleaning. The area should be kept in a condition to trap flood sediment and debris even when no flood has occurred for a number of years. The various structures and shaping of land are believed to be cost effective but this should be studied carefully at the time of design.

We believe that a properly designed and constructed sedimentation spreading and debris control area above Point 12 is warranted. It would have little effect on the water runoff and would not prevent flooding along Cheyenne Creek. It would, however, remove a great deal of the sediment and debris from the upper basin flow. Basin III would benefit from this by less frequent plugging of bridge openings and less sediment damage downstream.
III. SUBBASIN III (CHEYENNE CREEK)

Basin Description:

The developed Basin III is the area drained by Cheyenne Creek below the mountain face outfall at Point 12. This basin is almost fully developed and contains the communities of Ivywild, Cheyenne Canyon and lower Skyway Park. The basin is divided into two drainage sections. The southern portion of the basin is nearly fully developed and drains directly into the main channel of Cheyenne Creek. The northern portion of the basin is heavily developed but contains most of the remaining developable land within the basin. This northern portion drains into a stream channel which was known as Cheyenne Run about 40 years ago. "Cheyenne Run" and the main channel of Cheyenne Creek join at Point 19, near Tejon Street and Navajo.

The basin is of irregular shape, bordered on the north by a ridge separating it from the Bear Creek Basin. It is bordered on the south by the ridge of the Broadmoor Mesa and on the west by a ridge following the mountain front. For all practical purposes, the eastern boundary of this basin is defined by the east line of Nevada Avenue. A low ridge runs through the center of the basin from west to east, separating the main channel of Cheyenne Creek from the channel of "Cheyenne Run".

The entire basin is rough and hilly except for the two channels and the extreme easterly end. Even on the flatter ground, east-west street grades vary from 2% to 4% upward to the west. The highest point of this basin is at approximate elevation of 7500 feet above mean sea level in the
northwestern corner of the site. The lowest point of the basin is at approximate elevation 5905 at the outfall into Fountain Creek. The north, south and west boundaries are quite steep.

Geology and Soil Type:

Most of this basin is underlain by the Pierre Shale Formation. This is a clay formation with very low permeability. This claystone is covered with a shallow alluvium in the stream valleys. Hill tops are capped with the remnants of an old sand/gravel deposit which classifies as a silty and clayey sand. As a result, this material is only of moderate permeability. The sandy, alluvial deposit becomes thicker toward the west and surface signs of the clays of the Pierre Shale are not common west of 21st Street (Cresta Road). East of 21st Street, clays are found at or near the surface throughout the lower basin.

The sandy deposits west of 21st Street are a combination of slopewash and a series of fans derived from the granites of the Front Range. The southerly extension of the Ute Pass Fault is located a short distance west of the Mesa Water Storage Reservoir No. 2. West of this fault, the base rock is granite, serving as the source of the sandy soils at lower elevations.

The effect of the fault zone on runoff from the west is indirect and only partially understood. It is known that the fault tends to trap subsurface water from the Pikes Peak Granite in an area near Mesa Reservoir No. 2. When properly tapped, it tends to produce relatively large

-20-
amounts of water. If this is true along the full length of the fault, the effect would be to reduce the amount of a "permanent" water table in the alluvial deposits to the east. The dependence of these deposits on seasonal weather for production of a water table indicates that some blockage of normal seepage is created by the presence of the fault.

From the hydrologic point of view, the sandy soils of the mountain face classify as a "B/C" soil, due to a large amount of bare rock in this area. The sandy soils of the alluvium and fan material west of 21st Street generally classifies as an "A/B" soil type with local variations. The alluvium in the stream beds also classifies as an "A/B" soil, but this material is thin and considerable variation in hydrologic classification can be found. The clay soils classify hydrologically as a "D" soil.

Basin-wide soils tend to have hydrologic characteristics closely related to their position within the basin. Alluvium capping the hills and ridges generally have "A/B" or "B" classifications and tend to retain moisture. The alluvium along the stream beds is also classified as an "A/B" soil type. However, this material usually contains high moisture levels and tends to be swampy in places. It is also relatively thin. The combination of these positional factors results in the stream alluvium acting commonly with a "B/C" or "C" classification. The exposed clays on the hillsides and in eroded areas are mostly classified as a "D" soil type.
Channels:

The main channel of Cheyenne Creek is well defined. It is almost entirely privately owned in this basin and individual development has changed the natural channel by filling or moving in numerous locations through the basin. The channel of Cheyenne Run can be described in the same way east of 8th Street but becomes almost indistinguishable west of 8th Street. Development in Lower Skyway Park has almost obliterated the channel for a distance of approximately one-half mile. Above Vista Place, the channel can still be traced but consists mainly of small native stream channels descending the face of the Front Range.

All channels are quite variable in depth, width and general shape throughout their length. In general, they can be described as poor hydraulic conduits. In their existing state, water flow will be quite turbulent as long as the flow is confined to the channel section. It should be noted that the main channel of Cheyenne Creek has changed several times and is now very nearly at its southernmost possible location throughout most of the basin.

Subbasin Development:

The Ivywild and Cheyenne Canyon areas have been settled for over a hundred years. Early development took place along the channels of both Cheyenne Creek and Cheyenne Run and was mostly in low-lying portions of the basin. As the area grew, development of the hills and ridges followed.
In the past 50 years, this early development has been filled in until both channels are now surrounded by residential and some commercial development. The lots were sold, for the most part, including the channel. For this reason, most of the channels are privately owned with no rights-of-way available.

Those areas which have not been developed are mostly on the high ground of the Front Range face west of Vista Place. The majority of this undeveloped land drains naturally into the "Cheyenne Run" channel. A few smaller tracts are still available for development in the lower areas, but these are scattered and will not affect channel flow to any great extent.

Most of the land remaining for development has been assumed to develop into one-half to one-acre tract sizes. Most of the remaining scattered tracts have been assumed to develop in the same manner as the immediately surrounding land—that is, into city-type residential or commercial units. The channel flows given in this analysis also assume that relatively unobstructed runoff will take place and that no detention will be used in the remaining open areas.

Rainfall:

The average annual precipitation within the Cheyenne Creek drainage basin is a bit higher than that for other portions of Colorado Springs. Total average annual precipitation is believed to be approximately 15.8 inches (40.13 cm) although only unofficial records exist. The central weather bureau station is at Peterson Field, approximately 10 miles east.
of the central basin area. About 45% of the precipitation falls in the form of snow, with greater amounts of snow falling on the higher mountain slopes.

Slightly over half of the annual precipitation within the basin occurs in May, June, July and August. The major rainstorms are of two types: (1) the slow, 3- to 4-day "upslope" condition which can produce high precipitation, but over a longer period of time; and, (2) the intense, summer thunderstorm of high intensity but of short duration. The high intensity, short duration thunderstorm will produce the highest peak flow in runoff under most conditions of antecedent moisture. The Type IIA storm has been developed to simulate this condition of high peak flow and has been used in essentially its present form since 1975 by the City of Colorado Springs. Its principal use is the determination of flood flow, for design purposes, within larger area channels.

The total rainfall for a storm of this type given by the City of Colorado Springs criteria is:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>5-year Frequency</th>
<th>100-year Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.10 inches</td>
<td>3.50 inches</td>
</tr>
</tbody>
</table>

This study uses the City criteria for a Type IIA storm over the entire area of Subbasin III. The area of Subbasin III is only about 3.5 square miles so no reduction factors are justified. Storms in this area generally move from west to east, tending to reinforce peak flows in the main channels. After trying several combinations of storm, it was determined that peak flow within the main channel is greatest if the storm is centered over Point
13 at the time of greatest intensity. This pattern was used in preparing this study, assuming AMCII soil conditions.

Channel Runoff:

For the purposes of this report, Subbasin III is divided into that area draining into the Cheyenne Creek channel and that portion draining into the "Cheyenne Run" channel. The two areas are discussed separately.

Cheyenne Creek Flood Hazards: A Type IIA storm extending only over Subbasin III was considered. It was found that the runoff exceeds 500 cfs at Point 13 and increases at lower points even considering streamflow attenuation. Adding this local storm to the runoff from the upper basins, it is apparent that the City criterion requires the use of the 100-year event for the full length of the Subbasin III main channel.

Differences in timing of the upper basin storm and lower basin storm result in considerable variations in the runoff peak flowing through the existing channel. Regardless of the timing, however, it is apparent that the channel is not sufficiently large or improved to contain any combination of upper and lower basin storms. The main channel contains numerous bends, overhangs and other debris traps and is crossed by a number of bridges—all of inadequate size to pass any combination basin flow.

The floodplain varies considerably in width along the channel length, being generally wider to the east. With a few exceptions, both the channel and the floodplain
are privately held and extensively built over. In many areas, the channel is literally confined by buildings, both residential, commercial and schools. As discussed at greater length in the appendix, this restriction of the channel and encroachment on the floodplain is not perceived as dangerous by the residents due to the record of low flow. The confining structures, undersized bridges, channel vegetation and other obstructions act as debris collectors during major flood events which will increase the severity of any given flood. These exist at numerous places along the channel and will not be enumerated in this section of the report.

Some channel improvements have been constructed at various points along the channel. Most of these are of insufficient size. The presence of occasional channel improvements is generally ineffective and tends to induce turbulence. These may protect one small reach of the channel to a degree while increasing damage potential at other locations.

Debris accumulations cannot be readily mitigated along the main channel in Subbasin III. The best available locations for debris control structures are in Subbasins I and II above Point 12. Debris accumulating in Subbasin III must be allowed to gather and be cleaned up after the storm event from sheer necessity. The only possibility of preventing debris accumulation along the lower channel is a preventive program of cleaning the existing channel banks and removing as much potential debris as possible.
Cheyenne Run Flood Hazards: At the present time, the channel of Cheyenne Run exists only east of 8th Street. That portion of the channel west of 8th Street was filled in or diverted over 20 years ago. Due to construction in the Lower Skyway Park area, this channel must be rebuilt as a storm sewer system.

East of 8th Street, this channel is of adequate size to pass the 100-year flood provided it is cleared of vegetation and debris along the banks. A few short reaches of the channel are inadequate, mostly due to lack of maintenance, but these can be resized easily and inexpensively. With two exceptions, bridges and other debris-catching structures are adequately sized and require no enlargement. Debris accumulation, with its resulting overbank flooding, is less severe along this channel than along Cheyenne Creek.

This channel has the same problems of private ownership and encroaching structures as the main channel. The conditions are much less severe, however, and can be more easily controlled. The existing culverts at 8th Street and at Woodburn Street are too small to pass the 100-year flood.

Flood Control Options:

Drainage basin plans in other areas of the city typically provide for preserving and improving the existing main channels. Most of these require widening of main channels, lining them in some manner and perhaps straightening the channels. This effort usually results in an unimpeded main channel to which all other drainage appurtenances can be directed.
Most other city basins, however, do not have the ownership problems associated with this basin. A wide channel with slower moving flow, typical of many basins, is not possible in Subbasin III. The cost of such a construction would be very high. A great deal of property must be purchased to construct such a channel and all bridges and culverts along Cheyenne Creek would require replacement. Such a channel would require a minimum width of 120 feet and would probably be aesthetically unacceptable.

To avoid these disadvantages, a narrow, high velocity, concrete-lined channel was studied. This type of channel is much narrower—being between 25 and 40 feet in width through the channel length. This would avoid some of the property costs. However, the disadvantages of such a channel are numerous. Flow velocity is dangerously high and would require very heavy concrete construction, careful design, particularly at bends, and would also have an unacceptably high cost.

This study indicates that a more acceptable treatment along the Cheyenne Creek channel consists of developing a few communication facilities and generally allowing the channel to remain as it is. We believe that such a program could eventually include:

1. A warning system developed in Subbasin I and II. Such a system must be evaluated to estimate its effectiveness prior to being implemented.

2. A program encouraging cleaning vegetation and debris from the existing channel.

3. Modify curves and bends from Alsace Way to the outfall to maintain existing channel capacity. (This to be done only where required by very small sections.)
4. Rebuild certain bridges of adequate size to maintain communications in the area after a major storm event.

5. Allow no new construction in the channel area unless it can be shown that it will not increase channel flow.

The bridges involved in an emergency net should be selected by the appropriate City Department prior to reconstruction. This study suggests that bridges be enlarged to maintain communications at Evans Avenue, Cresta Road, Cheyenne Road, Cascade Avenue, Ramona Street and Arvada Street.

Off-Stream Drainage Construction:

Major Drainage System: The presently unimproved areas remaining in the basin utilize natural, unimproved channels to remove drainage. When developed, these should be changed to improved, lined channels and storm sewers.

Most of the presently undeveloped land runoff concentrates in the Lower Skyway Park Area, either at Mercury Drive or at South Skyway Boulevard. These streets are presently inadequate to carry the runoff even if the upper areas remain unimproved. Lower lying areas near 8th Street will act as collectors for much of the runoff from the west and north. This area has been the scene of several minor flood events in the Cheyenne Run portion of the subbasin.

The lower Skyway Park area requires a storm drainage system now and it is relatively easy to size this system to be able to control upper basin runoff after this area is developed. A fairly extensive system of storm sewers is needed to control runoff in this area and carry it to outfall, at
8th Street, into the Cheyenne Run channel. This construction would upgrade the existing drainage facilities in this area and these could be abandoned.

**Minor Drainage Systems:** Three minor storm sewer systems are needed in Basin III in addition to this. The first of these would collect runoff in the Poothills Subdivision area and conduct it more rapidly to Cheyenne Run at Lorraine Street. This follows the existing runoff path but removes excess runoff from Lorraine. The streets in this area do not have a high runoff capacity at the present time and should be relieved.

The second system lies at Brookside and Tejon Streets. Street capacity is low in this area also and overflow at this point affects the highway off-ramp at Arvada Street. A small storm drain starting at the openings to Old Ditch No. 11 at Cascade and Brookside and extending to Cheyenne Creek on the north side of Brookside Street would relieve this condition.

The third desirable storm system is the extension of an existing storm sewer on Nevada Avenue to Fountain Creek. At the present time, the existing system is in two pieces, entering Cheyenne Creek at Ramona Street and at Arvada Street. This system is too small and allows occasional flooding on and near Nevada Avenue. It also leads to placing more water in Cheyenne Creek, which is unwise in this low-lying area. Cheyenne Creek is already too small to accept the flow. This storm sewer should be extended from at least Cheyenne Road to Fountain Creek and should be enlarged.
Motor City Drainage: The Motor City area is being studied by others and is shown as Subbasin III-N in this study for location purposes. It must be considered, however, due to its commercial nature and very high runoff potential.

We understand that runoff from this subbasin is to be directed to a series of culverts extending under Interstate Highway 25. We also understand that Interstate 25 is expected to act as a dike, helping to control the flood flow in Fountain Creek. If these conditions can be met, the Cheyenne Creek basin will not be affected by any major outflow from the Motor City area and it can be ignored for purposes of this report.

If, for some reason, these conditions cannot be met, then the majority of discharge from Motor City could flow into the Cheyenne Creek basin at approximately Arvada Street. Since there is no way of preventing this, flooding must be expected along Arvada if runoff removal is not successful in the Motor City area. We note in passing that this Arvada Street area was the area of greatest damage in the 1935 Monument Creek flood.

New Subdivisions in Basin III:

Due to the channel conditions along Cheyenne Creek, the undeveloped areas in Basin III were studied to determine the effect of increased runoff from these areas on the flow in the main channel. Two conditions were considered: (1) Storm in Basin III only and (2) Storm over entire Basins I, II, and III.
Most of the runoff from the presently undeveloped area enters Cheyenne Run and does not enter Cheyenne Creek until the junction of the two at Point 19. The gradient of Cheyenne Run, with its extension through Lower Skyway Park, is greater than the gradient of Cheyenne Creek. Assuming that the storm sewer system through Skyway Park is constructed, runoff from the potential new subdivisions above Skyway Park will reach Point 19 before the peak runoff from Cheyenne Creek. In the case of the storm confined to Basin III, this time differential is on the order of 15 minutes. In the case of the major storm over all three basins, the time differential is on the order of 2½ hours.

There are some possible localized rains which would change this differential timing of flood peaks. These would, however, be relatively unusual. For the more general case, the development of land above Skyway Park will not affect the runoff peak on Cheyenne Creek to any major degree.

When the undeveloped areas are planned, two drainage options are available for use in designing their drainage. First, the drainage could be removed as rapidly as possible, consistent with safety. In this way, the new area peak would reach Fountain Creek before the peak from Cheyenne Canyon. Second, the runoff from the new developments could be detained for a period of 8 hours. By detention, the new area peak would reach Fountain Creek after the peak from Cheyenne Canyon.

The addition of runoff from the newly developed areas will affect that portion of Cheyenne Creek
north of Point 19 to the greatest extent. In this reach, new area detention will be less effective than the method of rapid runoff removal.
Runoff Hydrograph
Point 13
Southwest Area, Basin 3
Lincoln-DeVore Testing Lab., Inc.
Runoff Hydrograph
Point 17C
Southwest Area, Basin 3
Lincoln-DeVore Testing Lab., Inc.
0.00 
0.18 
0.36 
0.54 
0.72 
0.90 
1.07 
1.25 
1.43 
1.61 
1.79 
1.97 
2.15 
2.33 
2.51 
2.69 
2.87 
3.05 
3.23 
3.40 
3.58 
3.76 
3.94 
4.12 
4.30 
4.48 
4.66 
4.84 
5.02 
5.20 
5.38 
5.55 
5.73 
5.91 
6.09 
6.27 
6.45 
6.63 
6.81 
6.99 
7.17 
7.35 
7.53 
7.70 
7.88 
8.06 
8.24 
8.42 
8.60 
8.78 
8.96 
9.14 
9.32 
9.50 
9.67 
9.85 
10.02 
10.21 
10.39 
10.57 
10.75

Runoff Hydrograph
Point 17
Southwest Area, Basin 3
Lincoln-DeVore Testing Lab., Inc.
Runoff Hydrograph
Point 19
Southwest Arroyo, Basin 3
Lincoln-DeVore Testing Lab., Inc.
IV. SUBBASIN IV (SPRING RUN)

Basin Description:

Subbasin IV extends from the crest of Cheyenne Mountain through the developed Broadmoor area, Southgate Shopping Center and Stratton Meadows to its outfall in Fountain Creek near Circle Drive. For drainage purposes, it is a single basin with only one stream. There is a rather distinct difference in flow type between the upper and lower basins, but for all practical purposes, Spring Run has no well-defined tributaries.

The basin boundaries are not as distinct as those of Cheyenne Creek. The northern boundary lies generally along the crest of the "Broadmoor Mesa" to Nevada Avenue. This is a relatively distinct divide. East of Nevada Avenue, however, the basin boundary is low, indistinct and depends a great deal on local grading for its location. The south boundary is similar to the boundary east of Nevada, in that it is not distinct in many places and depends on local subdivision grading and storm sewer location for its exact boundary. In general, it follows a low east-west ridge south of Spring Run Reservoir No. 2 to Nevada Avenue, then along Lake Avenue to Fountain Creek. The east boundary is Fountain Creek. The basin contains 3.7 square miles. Except for the mountain face and alluvial fan complex, the basin is almost fully developed.

In general, this basin is not rough, but consists of four distinct slopes along the course of Spring Run. The mountain face of Cheyenne Mountain is very steep but relatively short. At a point about parallel with the Cheyenne
Mountain Zoo Road, the grades become less steep on a large alluvial fan and landslide complex which extends into the Broadmoor golf course area. Most of these steeper slopes lie outside the city limits. Below these steeper gradients, the basin falls smoothly down to Nevada Avenue. At this point, the stream enters a low gradient, relatively level, alluvial plain which contains Stratton Meadows and commercial areas along I-25. The highest point in this basin is approximately 8450 feet above mean sea level on Cheyenne Mountain and the lowest point in the basin is approximately 5816 at Circle Drive and Fountain Creek.

Geology and Soil Types:

This basin is underlain by the Pierre Shale Formation in all areas east of the extension of the Ute Pass Fault. This clay material is covered through most of the basin area by silty and clayey sands of the Verdos Alluvium and is covered to a greater depth than is the Cheyenne Creek basin. Clays of the Pierre Shale outcrop on hillsides and stream cuts in the central portion of the basin until covered by Fountain Creek alluvium in the Stratton Meadows area. This alluvium is much finer-grained than the Verdos Alluvium in the Broadmoor area, but generally consist of clayey sands also.

The southerly extension of the Ute Pass Fault lies beneath the face of Cheyenne Mountain in this area and is difficult to locate. The mountain face generally consists of the Pikes Peak Granite and a clayey gravel derived from weathering of the granite. Most of the various outcropping of other formations thrust upward by the fault are hidden under
deep alluvial fans and some landslide complexes extending out from Cheyenne Mountain.

This alluvial fan extends east of the mountain front for a distance which varies at different points along the mountain front. It extends into the Broadmoor golf course complex and into Broadmoor Heights. The toe cannot be precisely bounded by streets, but in general, this complex is found west of El Pomar, Penrose and Cheyenne Mountain Boulevards. The soil making up this complex is granular, only slightly clayey and very silty. Such fan deposits tend to retard flow, although the slopes are quite steep, overcoming this retarding effect.

The granites and decomposing granites of the mountain face have an average hydrologic classification of "C". Bare rock faces are classified as "D" soils hydrologically. The silt and slightly clayey sands of the alluvial fan complex have an average hydrologic classification of "B". The upper parts of the fan contain mostly "B" soils with some "C" classification, while the lower parts of the fan contain mostly "B" soils with some "A" classification soils at the surface. The majority of the Verdos Alluvium has hydrologic classification of "B" with occasional areas classified as "C". In general, the Fountain Creek alluvium is classified hydrologically as "C" although areas of "A" and "B" classification can be found. The clays of the Pierre Shale are hydrologically classified as "D".

Channels:

That portion of the basin on the face of Cheyenne Mountain is relatively short but quite steep. It is open, with much exposed rock and no single, well-defined
channel. Upper basin runoff tends to be sheetwash and flow confined to relatively small gullies.

As is typical of alluvial fan deposits, stream channels above the Broadmoor golf course are not well-defined. Major flows tend to move from one channel to another during different storms. As a result, runoff of different storms is directed to different locations and no single, major channel has been developed on the slopes.

In the lowest portion of the fan complex and upper Verdos Alluvium, two broad, swale-like channels have been established. The first of these is located in the north part of the Broadmoor golf course, extending easterly across the course to an outfall at Walnut Avenue. This appears to be the source of the main stream of Spring Run. The second of these is also a broad, swale-like channel formed by the merging of two smaller channels at about Marland Road in Pourtales Addition.

The first channel through the golf course becomes a defined channel at Walnut Avenue, running easterly through the old site of Spring Run Reservoir No. 1 and into Spring Run Reservoir No. 2 (now Big Stratton Reservoir). The second channel remains in a broad, swale-like state through Pourtales Addition and almost to its junction with the main channel a short distance west of Spring Run Reservoir No. 2. From this point east to Mountain Creek, the channel is fairly well defined except where it has been covered by man-made fill or other structures.
Subbasin Development:

The Broadmoor area has been developed in more or less its present outline for nearly 100 years. Lot sizes have been decreased to some degree in the past 40 years, increasing the population per acre. The hotel has expanded its commercial area considerably during that same period. Since 1950, several subdivisions have been constructed on the alluvial fan area above the golf course and new development is taking place on the fan at the present time. The mountain face is mostly privately owned but is so steep as to preclude dense development in this area.

The lower basin was developed into commercial and dense residential areas beginning about 1950 and continuing to the present day. Some areas north and south of the Stratton Meadows Subdivisions have developed more slowly but steadily.

Those areas which have not been fully developed at this time are those on the upper portion of the fan and parts of the mountain face and some smaller areas north and east of the Stratton Meadows Subdivisions. This study assumes full development of the basin with essentially the same population density that exists near each undeveloped piece of land. Exceptions are the mountain face, which is generally too steep for any development other than 1- to 5-acre tracts, and that area immediately below the Spring Run Reservoir No. 2 which should not be developed.
Rainfall and Runoff Patterns:

This basin begins at the crest of Cheyenne Mountain and has no upper elevation, large-scale contributing basin. Technically, Type IIA storms are not known to extend much above an elevation of 8000 feet, and are considered east slope and plains storms. However, the contributing area above 8000 feet elevation is too small to affect the channel flood to any great extent. Therefore, the Type IIA storm was used throughout this basin.

Annual precipitation in the Spring Run basin is slightly greater than for other portions of Colorado Springs. Rainfall data is similar to that of the Cheyenne Creek basin in that most records are unofficial with the central weather station being 10 miles to the east. Total annual precipitation is unofficially believed to be about 15.8 inches (40.13 cm). Over half of this occurs in May, June, July and August. Snowfall can be expected almost any time of year but is not an important factor in runoff quantities.

The long-term, upslope storm produces large total quantities of water, but over a larger period of time. Peak flows are, therefore, relatively low. This type of storm does affect peak flows, however, by increasing the antecedent moisture condition of the soils. The high intensity, short duration thunderstorm is the most common high peak runoff storm in this area. The Type IIA storm has been developed by the NOAA and the SCS to simulate this type of rainfall.

The Type IIA storm cannot be easily categorized, due to the intense, 1-hour burst of rainfall used.
It is listed as a 6-hour duration, 3.5-inch total rainfall, storm. The total rainfall for a storm of this type by the City of Colorado Springs criterion is:

<table>
<thead>
<tr>
<th>5-year Frequency</th>
<th>100-year Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 inches</td>
<td>3.5 inches</td>
</tr>
</tbody>
</table>

These values correlate well with the NOAA values.

The Spring Run basin contains about 3.7 square miles and could be easily covered by a single Type IIA storm. No reduction in rainfall was used in the calculations. Storms in this area tend to move easterly and it was determined that the maximum peak runoff was obtained if the storm were centered along Spring Run between Points 30 and 31 at the time of highest rainfall.

City of Colorado Springs criteria for calculating runoff were followed in this basin with a few exceptions. The storm used was a Type IIA, 6-hour duration, 5-year and 100-year frequency and appropriate intensity shown above. The soil was assumed to be in an AMCII condition as being most normal for this area. The soil areas were taken as water producing units and runoff values obtained for each unit were totaled at the subbasin outfall. In this manner, the high runoff of exposed rock or pavements and the retention characteristics of the golf course, for example, could be assessed. Within channels, the Muskingum method of channel routing was used with characteristics estimated from channel slope and soil types and conditions.
Channel Runoff:

Two problems exist in this basin for accurate hydrologic computations.

1. The mountain face is very steep and is generally classed as a "C" type soil. This produces a very short time to peak which cannot be fully absorbed by the alluvial fan and golf course area below. No accurate runoff measurements have been made in this area. It is, therefore, possible that the time to peak is too short and consequently, the volume of runoff too high at Points 31 and 32A. The difference, if any, is on the side of safety and the computed values were used in this report.

2. The series of reservoirs and ponds near Nevada Avenue is very complex hydraulically and can only be approximately analyzed with the data available. Here again, the results are on the side of safety and are, therefore, used in this report. However, if accurate high water lines are required in the ponds, it must be recommended that a very accurate topographic survey be made of these three areas together with precise elevations of culvert flow lines. After this is completed, the hydraulic action through these ponds can be calculated more accurately.

Channel Flood Hazards:

West of Southgate: The main channel flow exceeds 500 cfs at Point 31 and very nearly exceeds 500 cfs at Point 30. The retention characteristics of the soils combined with the golf course use reduce the problem considerably. For this reason, it is not necessary to design culverts or storm sewers for the 100-year flow above Point 31. From Point 31 to near Point 32, the channel is too small to pass the 100-year flow without flooding some housing. Improvement of the channel and enlargement of several culverts should be accomplished in this reach to reduce flooding possibility.
Runoff from Subbasins E and F to the south of the main channel has been blocked by construction of an elementary school and a subdivision. This runoff is partially contained by a wide, undeveloped area in Pourtales Addition. The overflow from this should be routed through a storm sewer system to the main channel since the street capacity of Cheyenne Mountain Boulevard is not adequate to carry full flow.

Immediately east of the junction of these two flow routes, the Spring Run Reservoir No. 2 exists. Routing of the flow through this reservoir cuts the runoff peak approximately in half. The embankment was partially rebuilt and renamed in 1969. It is now known as the Big Stratton Reservoir, and is considered to be in good condition and with an adequate spillway.

Below this reservoir, the channel flows through a series of low-lying basins separated by Lake Avenue and Nevada Avenue. These will become ponds during storm periods. The culverts beneath the streets are small enough that each low area acts as a detention pond, allowing only part of the water into the next section of the channel. Pond 1, south of Lake Avenue, will flood an area of about 6.2 acres, but no construction exists in this area and damage is limited to Lake Avenue. This area should be kept clear of construction.

Pond 2, north of Lake Avenue and west of Nevada Avenue will flood an area of about 12.3 acres and will affect at least 3 (possibly 4) residential structures. This area should be reshaped to protect the existing structures and still allow the ponding. Other than protecting the affected
houses, the pond area should be kept clear of new construction
and allowed to act as a detention basin.

After crossing Nevada Avenue in a
group of culverts, the flow enters a third pond which is a relic
of the "Mystic Maze" traffic interchange, prior to entering a
system of culverts beneath the Southgate Shopping Center. This
pond also acts as a detention basin and should be protected if at
all possible. There is no existing construction in this pond
area.

The effects of these ponds and
reservoir on channel flow are very beneficial to the Stratton
Meadows area. Reduction in channel flow is nearly 550%, from
1918 cfs to 351 cfs. Without these retention areas, the Stratton
Meadows area would be flooded on almost a regular basis, at least
every 5 to 10 years. The effort should be made to save these
detention areas for hydraulic use. Agreements with Gates Land
Company and the Colorado Highway Department are suggested for
this purpose.

East of Southgate Road: The culvert system beneath Southgate
Shopping Center is subject to some question as to its exact size.
A previous report on the area suggests that it consists of three
sizes of pipe, 11-foot, 60-inch and 72-inch. It could well vary
that much at various points beneath the shopping center. It
unquestionably does vary in size from west end to east. This
report could not identify exact lengths of each size of culvert.
In any event, the flow-through was counted using the head and
size characteristics which would be most applicable.
Beyond the existing culvert on Southgate Road, channel flow and street flow are closely related due to the manner in which the area was developed and the low gradient of the surrounding land. Almost all channels east of Southgate Road are undersized for the 100-year flow and most are undersized for the 5-year flow. The 100-year flow in the channel from Southgate Road to Mt. Werner Circle (East) varies from 351 cfs at the west end to 465 cfs at the east. For this condition, the City criterion is design for a 5-year frequency storm. Considering its position through park land, apartments and residential units, it would be wise to design for the 100-year storm.

Through this area, the channel is undersized at the west end, behind a group of apartments and cannot pass a 5-year storm successfully. The hydraulic design of a channel transition in this area causes backwater and reduces the capacity of the existing channel. The right-of-way is constricted by utility lines, but this could probably be corrected. Parts of the channel are unlined earth of inadequate size. The channel is blocked by at least one fence line which tends to catch debris and cause backwater.

Box culverts at Mt. Werner Circle (East and West) are of adequate size to pass the 100-year runoff, but the west culvert is in very poor physical condition. Considering the location of the main channel and its surroundings, the channel should be upgraded. It should be fully lined for its entire length and should be designed to carry the 100-year flow. The existing culverts should be repaired but resizing should not be necessary.
At the outfall of this channel section, upstream from the intersection of Corona Street and Montrose Avenue, the channel outfall consists of a 24-inch concrete pipe. This outfall pipe is hopelessly inadequate in size to carry either the 5-year or the 100-year flow. This outfall pipe should be rebuilt to the proper size for its full length. This outfall now extends from approximately 200 feet west of Corona to the east line of Cheyenne Road.

From Cheyenne Road to Interstate 25, flow is via a concrete lined channel which is of adequate capacity to carry the 100-year flow. At the east end of this concrete channel, however, additional flow from the south is added and total flow is to the north via an earth-lined borrow ditch to the outfall pipe under Interstate 25. This outfall pipe is, again, a 24-inch pipe which is badly undersized even for the 5-year flow. Water tends to pond in the borrow ditch causing backwater throughout the system below Cheyenne Road, flooding some commercial areas and the southeast portion of Stratton Meadows. The outfall beneath I-25 should be enlarged and the borrow ditch upgraded to carry the flow.

Off-Stream Drainage Construction:

Lower Basin Area: The southeastern portion of the Stratton Meadows Subdivision and adjoining commercial areas have sustained minor flood damage on several occasions. The streets in this area have low gradients and low water-carrying capacity. A report in 1968 recommended an overall storm sewer system for this area which was not constructed. Such a storm sewer system is needed for this
area and should be constructed. A proposed system is shown in the report, although the precise design could vary considerably. In addition, Subbasin L-2 should be removed from the contributing basin. At the present time, this subbasin drains to Lake avenue then follows a series of culverts and ditches along the south side of Lake Avenue. A 5-year storm, for example, never enters the Spring Run basin and this was evidently the plan behind the culvert locations. However, during a 100-year event, approximately 35% of the runoff crosses Lake Avenue and enters Stratton Meadows. Although this is technically not within the Spring Run basin, the ditches and culverts on the south side of Lake Avenue should be enlarged and upgraded to keep 100-year storm runoff out of Stratton Meadows and within the basin to the south.

Drainage from part of the commercial area near Nevada Avenue and in northern Stratton Meadows now discharges down East Cheyenne Road to a small ditch entering the west borrow ditch of Interstate 25 near Point 39. The street capacity of East Cheyenne Road is small and should be reinforced by a storm sewer system for very nearly the full length of the street east of Waahatch Avenue.

In addition, a small storm sewer is required on Waahatch Avenue and Arvada Street to carry Subbasin III-M into the Interstate 25 borrow ditch and on to an outfall to Fountain Creek. This subbasin was, at one time, in the Cheyenne Creek basin. Construction since 1960 has changed the area into an isolated basin which most easily can be drained into Subbasin 0 of the Spring Run basin.
Upper Basin: Very few storm sewer systems exist west of Nevada Avenue. A large number of individual culverts exist, but none of these appear to be lengthy enough to classify as storm sewers. Elm Street in Broadmoor appears to contain a small storm sewer system of some sort. We have not been able to trace it to an outfall, however. In fact, it cannot even be traced to a continuous group of sewers. Individual catch basins with some pipe have been located, but a continuous system cannot be identified. Fortunately, Elm Street does not require a storm sewer system.

A small storm sewer system exists on Polo Pony Drive, crossing 7th Street to a natural channel running to Nevada Avenue. The system on Polo Pony is adequate as it is constructed. The outfall east of 7th Street should be enlarged to carry full flow to the gully.

A small storm sewer system is needed to relieve Broadmoor Avenue and carry the flow into Spring Run Reservoir No. 2. Broadmoor Avenue happens to be in a collection area and is a small street incapable of carrying the total flow possible in a 5-year storm.

Other than minor road culverts, no other major drainage appurtenances exist or are needed in the basin west of Nevada Avenue.
Runoff Hydrograph
Point 33 (spillway)
Southwest Area, Basin 4
Lincoln-DeVore Testing Lab., Inc.
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Runoff Hydrograph
Point 37
Southwest Area, Basin 4
Lincoln-DeVore Testing Lab., Inc.
V. SUMMARY OF INDIVIDUAL IMPROVEMENTS

Attention is directed to Appendices C, D, E and F which list existing drainage structures within the basins and improvements or additions to the system believed to be needed. A set of maps is attached to this report, showing existing and recommended drainage improvements within the Cheyenne Creek and Spring Run basins.

Individual basins were studied separately and in flow line groups to their outlets. In developed areas, the runoff was compared with the existing street capacity according to City standards for street capacity. Street routing was considered following normal surface flow collection procedures. Where the street capacity becomes less than the applicable runoff, the street was assumed to carry its allowable maximum flow and the remainder was placed in a storm sewer system.

In the major developable areas in Basins III and IV, the major drainage is now carried in relatively small, natural gullies. The proposed street patterns are generally parallel with the topography, hence, perpendicular to these gullies. In these areas, the flow was left in the gullies, improved to lined or riprapped ditches and culverts shown crossing the roads.

Except along major drainageways, the developed areas require drainage design for the 5-year runoff only. In the Skyway Park area, the extension of Cheyenne Run westerly will require drainage design for the 100-year runoff. The major channel in Spring Run east of Southgate Road should also be designed for the 100-year runoff.
Individual improvements believed to be the most important within the basins are listed by area in the following discussion.

Basins I and II - North and South Cheyenne Canyon:
Subbasins I-J and II-T: Debris collection and control structures. These must be designed specifically to the sites and will vary in type. In general, they should be designed to allow water flow but to catch most debris from the upper basins.

Basin III - Cheyenne Creek:
Subbasin G-2: Three culverts and an outfall ditch are needed to carry drainage from Penrose Boulevard to Cheyenne Creek.

Subbasin G-1: Two culverts, a riprapped ditch and a short storm sewer are needed to carry runoff from a newly developed area across Cheyenne Boulevard and Road into Cheyenne Creek.

Subbasin F: Five culverts, a riprapped ditch and a concrete lined-ditch are needed to drain a newly developed area to Cheyenne Boulevard and to improve the flow to Cheyenne Creek.

Subbasin J: A small storm sewer is needed to drain Pierce Drive into Cheyenne Creek and improve drainage on Woodburn.

Subbasin L: A short storm sewer is needed on Brookside from Cascade to Cheyenne Creek to relieve surface flooding on Tejon Street and help Arvada Street.
A storm sewer is needed on Nevada Avenue to enlarge the existing sewer and carry the flow to Fountain Creek rather than to Cheyenne Creek.

Bridges required for improvement are not listed under Basin III - Cheyenne Creek since the bridges required for communication have not been selected. Cheyenne Creek should be designated as an area requiring removal of potential debris.

Basin III - Cheyenne Run:

Subbasin A-1 and A-2: Two lines of lined ditches and appropriate culverts are needed in this area after development. A short branch storm sewer line is needed to further protect Cheyenne High School.

Subbasin B-1: One culvert and a lined ditch are needed to carry runoff through the new development from 21st Street to Mercury Drive.

A storm sewer system is needed on Mercury Drive to Point 17C.

Subbasin B-2: A storm sewer system is needed to carry runoff from 21st Street to South Skyway Boulevard at Point 17C.

Subbasin B-3: A storm sewer system extending runoff from Point 17C to Point 17 on 8th Street.

Subbasin C-3: A combined ditch and storm sewer system is needed to carry runoff from Skyway and Parkview Boulevards to Point 17A on Arcturus Drive.
The existing ditch extending from Point 17A to Point 17 at 8th Street needs enlarging and concrete lining.

The existing culvert at Point 17 on 8th Street needs to be enlarged to prevent ponding above.

Subbasin D-1: A storm sewer system is needed along Lorraine Street to relieve street flow and carry the flow to Cheyenne Run.

Subbasin E: The existing stream crossing at Woodburn and Cheyenne Run needs to be enlarged. Cheyenne Run, from Point 17 to Point 19 needs to be contoured for smooth flow, cleaned, devegetated and riprapped for erosion protection.

Basin IV - Spring Run:
Subbasin B: The existing culvert at Walnut Street (Point 31) needs to be enlarged to carry the main stream.

Subbasin C: The existing culvert at 2nd Street needs to be enlarged to carry the main stream. The crossing at Hutton Lane needs to be enlarged or rebuilt as an RCB to carry the main stream.

Subbasin D: A short storm sewer is needed to relieve flow on Broadmoor Avenue.

Subbasin F: A storm sewer is needed along Cheyenne Mountain Road to relieve flow in the road and protect an elementary school.
An RCB on Old Broadmoor Road should be enlarged to carry the main stream.

From Point 31 to Spring Run Reservoir No. 2, the main stream needs to be enlarged, riprapped and smoothed.

Subbasin G: A short storm sewer system is needed to relieve Elm Street and 7th Street.

Subbasin H: Three low-lying detention areas around the intersection of Lake Avenue and Nevada Avenue should be purchased or agreements made with owners to prevent development of the detention areas.

Subbasin J-1: The existing collection storm sewer along Southgate Road needs extension to the north.

Subbasin J-2: The channel from Point 35 to Point 36 needs to be enlarged and lined. The RCB at Mt. Werner Circle needs repair.

A storm sewer is needed on Montrose Avenue to Corona Street, entering the main channel storm sewer.

Subbasin L-1: A major storm sewer system is needed in the southeastern portion of Stratton Meadows to relieve the streets in this area and protect Dusty Drive and I-25 interchange.

Subbasin K: A short storm sewer system is needed to relieve Aspen Street and East Cheyenne Road.
The outfall pipe from Mt. Werner Circle (East) to Cheyenne Road needs to be enlarged to carry the main channel flow. The outfall culvert under Interstate 25 at Point 37 needs to be enlarged to carry main channel flow.

Subbasin O: A major storm sewer along East Cheyenne Road is needed to relieve the Road and northern portion of Stratton Meadows.

The west borrow ditch of Interstate 25 from Arvada to Lake Avenue should be lined and shaped for smooth hydraulic flow.

In general, any storm sewer or ditch system entering major drainageways should be paved to eliminate erosion at the point of entry. Such entry points should be angled with the major channel flow to allow as smooth a merger as possible. Bridges or RCB's placed across channels should be constructed with dropout boxes on the downstream side to drain the streets above.

Inlet structures must be site-specifically designed. Inlet design is extremely dependent on site conditions. Probably the majority of existing inlets are poorly placed or undersized. The standard DIOR inlet was used in this report and sized to allow interception of the required amount of runoff. It is quite possible that site conditions will require larger inlets or changes in location. Site conditions must be specifically investigated. This report presents a plan for evaluation, not a design for construction and should not be used as a design.
For the purposes of this report, reinforced concrete pipe is used throughout to calculate required new or replacement sizes and for estimate purposes. The City standard DIOR curb inlet is used for size and cost estimates. Other types of pipe and inlets may well be more efficient for certain purposes. If so, other types of materials should be used.

In this portion of the report and in the tabulation of probable costs, a number of items have been taken into consideration due to the type of basin development existing. Both subbasins are highly developed with some development being very old. The area utilities were placed by different owners at different times, as were many of the existing drainage structures.

The existing utility construction increases new construction costs considerably. A sizeable amount has been added to the cost of all construction in older areas to allow for replacement of utilities. The cost of repaving ditch areas has been estimated using normal ditch width and the present cost of such pavement. The cost of removal of existing structures is considered and the utility estimate increased for this condition. The cost estimates for these factors have been added to all estimated costs in this report.
TYPICAL RESIDENTIAL DITCH SECTIONS

THE LINCOLN DEVORE TESTING LABORATORY
TYPICAL DRAINAGE DITCH SECTIONS
THE LINCOLN DevORE TESTING LABORATORY
**NOTES:**

Connection pipe or outlet pipe may vary as to location within inlet.

Curvature of lip at gutter and side openings shall be made with curved forms. If catch basin depth is greater than 8'-0" wall design shall be approved by the City Engineer. Depth and length of inlet may vary. Length should vary by increments of 2'-0". Wall thickness should increase to 8" if depth is greater than 4'-0" and to 10" at depths over 8'-0".

Floor of inlet shall be troweled to a smooth hard surface and shall slope towards outlet.

Manhole should be located as shown along back wall. Outlet pipe to be trimmed to final shape and set in place before inlet is poured.

All steel shall be free of rust and dirt.

When depth is greater than 4'-0" steps will be placed 17" apart with top step 6" below inside cover.

Steps shall be cast iron or extruded aluminum, 100 lb capacity, 12" wide with non-skid grooves and drop front on safety noses, in accordance with approved OSHA requirements.

Top slab shall have min. 1/4" per ft slope toward street.

Concrete shall be of 3000 P.S.I. at 28 days (strength). If opening is greater than 6'-0" support bars will be required at 3' intervals.

Top of inlet to be constructed to match curb gutter design grades at each location.

This dwg replaces catch basin Nos. 1, 2, and 3 as shown on dwgs D-10, D-11, and D-12.
NOTE:
1. WATER TO BE PUMPED TO COLORADO SPRINGS WASTEWATER TREATMENT PLANT
2. REFER TO PLANS AND SPECIFICATIONS FOR LOCATION AND DIMENSIONS OF STRUCTURAL STEEL.
3. STRUCTURAL STEEL TO BE FABRICATED IN ACCORDANCE WITH LOCAL CODES.

CITY OF COLORADO SPRINGS
GRAFTED INLET

DATE: July 1, 2023
SIGNED:

[Signature]

[Title]

[Company]
VI. SPECIFIC PROBLEM AREAS

A number of especially critical problem areas exist in these basins, mostly related to the older development in the area. Although these problem areas have been discussed in other portions of the report, an enumeration of the specific critical problems should be helpful in planning construction.

All of the systems and structures enumerated in this report are believed necessary to properly control drainage or provide communications within the basins, but some are needed more urgently than others. Although the order of construction could be altered by changes in planning newly developed areas, the most urgently needed drainage structures appear to be those found on the following list.

Basin I and II - Cheyenne Creek:

1. Establish upper basin high water alarm and warning system to alert the lower Basin III if this is judged feasible.

2. Design and construct a debris control system near Point 12 at the junction of North and South Cheyenne Creeks.

Basin III - Cheyenne Creek:

1. Enlarge 4 to 6 bridges along the Cheyenne Creek channel to serve as emergency communication crossings.

2. Clean vegetation and debris from the main channel for its full length.

3. Construct sewer system on Nevada Avenue to relieve lower Cheyenne Creek and remove drainage from Nevada more rapidly.
Basin III - Cheyenne Run:

1. Enlarge culvert beneath 8th Street to allow the Skyway Sewer System to be developed with a proper outlet.

2. Construct Lower Skyway Park storm sewer system from Point 17 at 8th Street to Vista Place to relieve the streets in this area and reduce flood potential along the drainage route.

3. Enlarge the crossing at Woodburn Street and Cheyenne Run to allow passage of the Skyway Park runoff without producing backwater and consequent local flooding.

Basin IV - Spring Run:

1. Save the low drainage collection areas near Lake Avenue and Nevada Avenue by purchase or agreement with the existing owners. This is approximately 21.6 acres which should be reserved for detention purposes. Regrade Pond Z to protect the existing residences from flooding.

2. Enlarge outfall sewer beneath Interstate 25 at Point 37 to be large enough to carry the 100-year channel flow without excessive backwater formation.

3. Enlarge 24-inch storm sewer pipe from Point 36 to Cheyenne Road to an adequate size to carry the main channel flow. Use of the 100-year flow for design purposes is recommended.

4. Construction of a storm sewer system in the southeastern Stratton Meadows Subdivisions to relieve the streets and commercial properties in this area. The precise design of this system may vary, but drainage of all streets is required.

5. Enlargement and paving of the main channel of Spring Run between Points 35 and 36. Replace and redesign the undersized transition section existing as well as repairing existing culverts at Mt. Werner Circle.

In general, the main channel of Cheyenne Run should be riprapped and strengthened at curves and other points of energy dissipation. The main channel of Spring Run above the reservoir should be riprapped and strengthened at curves and other points of energy dissipation. The main channel
of Spring Run below Southgate Road should be concrete lined or in underground conduits as required by the street system.

The main channel of Cheyenne Creek at the point of junction with Cheyenne Run (Point 19) needs strengthening against turbulent forces at the junction. Such protection will probably be required for 200 feet up and downstream from the junction.
VII. GENERAL RECOMMENDATIONS

This basin is not typical of foothills basins west of Colorado Springs which have been studied in the past. The basin is almost fully developed on a small lot basis and the developments are relatively old. Some are nearly as old as the City of Colorado Springs. Older development is nearly always adjacent to the main channels and in some cases is on the main channels.

The channels of Cheyenne Run and Spring Run are mostly natural condition beds that should be cleared and selectively riprapped or concrete lined. Some portions of these natural bed streams will require protection to prevent loss of the channel or of surrounding structures. The stream beds vary from clayey sand to clay with a relatively small underflow, so that the beds are reasonably stable. The banks, however, may not be stable under high moisture conditions.

Development of the remaining open land within the basin is feasible from the standpoint of drainage. The slopes of the larger areas remaining are steep and "city sized" lot development is not probable. The potential development will most probably be of average lot sizes in the 1/4-acre to 2-acre range. The total additional runoff will not be large compared to the developed areas.

In addition, the hydrographs of Basin III indicate that a double peaked hydrograph can be expected under the design storm. Since flow from most of the developable land will reach Fountain Creek some time before the major storm peak, the best method of newly developed area drainage is
believed to be rapid runoff. This, of course, assumes that downstream facilities, such as the Skyway Park sewer system, are in place. If the drainage from new areas is detained, it must be detained for at least 8 hours to be effective.

The various offstream structures recommended by this study fit the runoff computed by use of the rainfall/runoff methods described herein. No major overflow was allowed for the applicable storm, other than the amounts allowed in streets by the City flow criterion and along Cheyenne Creek. At this time, it is not economically possible to reduce potential overflow in Cheyenne Creek.

Where structures are not properly sized as existing, they may be removed and replaced with properly sized structures, or a new structure could be added so that the sum of the two is properly sized. All structures on the channels of Cheyenne Run and Spring Run should have the capacity, and should be designed, to carry the full design flow smoothly. Turbulence should be kept to a minimum in these streams. Where possible to lower turbulence easily along Cheyenne Creek, it should be done. It will not generally be possible along this channel, however.

Gradients on the fan and mountain face are steep and ditches must be designed with a relatively large number of velocity checks. Such channels must be carefully selected and not allowed to overflow due to the unstable nature of channels on alluvial fans. The gradient of Cheyenne Run and Spring Run are much less steep so that velocity checks will not be required to any extent.
Concrete in contact with the soils in the lower basin should be made using Type II Cement, due to the sulfate content of the clays. Higher on the fans, the soils do not have a high sulfate content and Type I Cement may be used. Air entrainment should be used in all exposed concrete.

The specific recommendations made by this study are fully outlined in the Appendix and on the attached maps. As stated, exact locations of the structures may vary and must not be taken as exact. Differences in street location and planning will fix these locations and such changes in detail must be allowed if they are reasonable. The general outline should be followed, however.
SOUTHWEST AREA BASIN COST ANALYSIS

Basin III & IV, Land Inventory:
- North Cheyenne Canyon Park (City) 76 acres
- Reservoir Tract (City) 33 acres
- County Jurisdiction 643 acres
- Existing Developed Land (incl. sts. & parks) 3600 acres
- Remaining Private Land in Basins 1060 acres
- Remaining Private Land in City Part of Basins 779 acres

Summary of Costs:

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C) Ditches and Stream Lining</td>
<td>$1,269,333.00</td>
</tr>
<tr>
<td>(D) Storm Sewer Systems</td>
<td>$1,502,030.00</td>
</tr>
<tr>
<td>Engineering (10%)</td>
<td>$300,332.00</td>
</tr>
<tr>
<td>Contingency (10%)</td>
<td>$330,365.00</td>
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<tr>
<td><strong>Total Developer Basin Cost</strong></td>
<td>$3,634,014.00</td>
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</tbody>
</table>

Developer Drainage Fee:

Fee Calculation = \( \frac{3,634,014}{779} = 4664.97 \), Use $4665.00/ac.

II. Direct Basin Costs

<table>
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<th>Category</th>
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<tr>
<td>(D) Storm Sewer Systems</td>
<td>$2,143,318.00</td>
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<tr>
<td>(G) Line Rights-of-way</td>
<td>$475,200.00</td>
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<td>(H) Pond Area Res.</td>
<td>$432,000.00</td>
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<tr>
<td><strong>Total Direct Basin Costs</strong></td>
<td>$6,613,435.00</td>
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III. State Cost:

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<tbody>
<tr>
<td>(C) Ditches and Stream Lining</td>
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<td>(D) Storm Sewer Systems</td>
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<tr>
<td><strong>Total State Costs</strong></td>
<td>$587,060.00</td>
</tr>
</tbody>
</table>
SELECTED BIBLIOGRAPHY


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT, no date, Design manual--debris dams and basins: Los Angeles, 61 p.


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT, no date, Structural design manual for concrete crib channel stabilization structures: Los Angeles, unpublished report, 31 p.


