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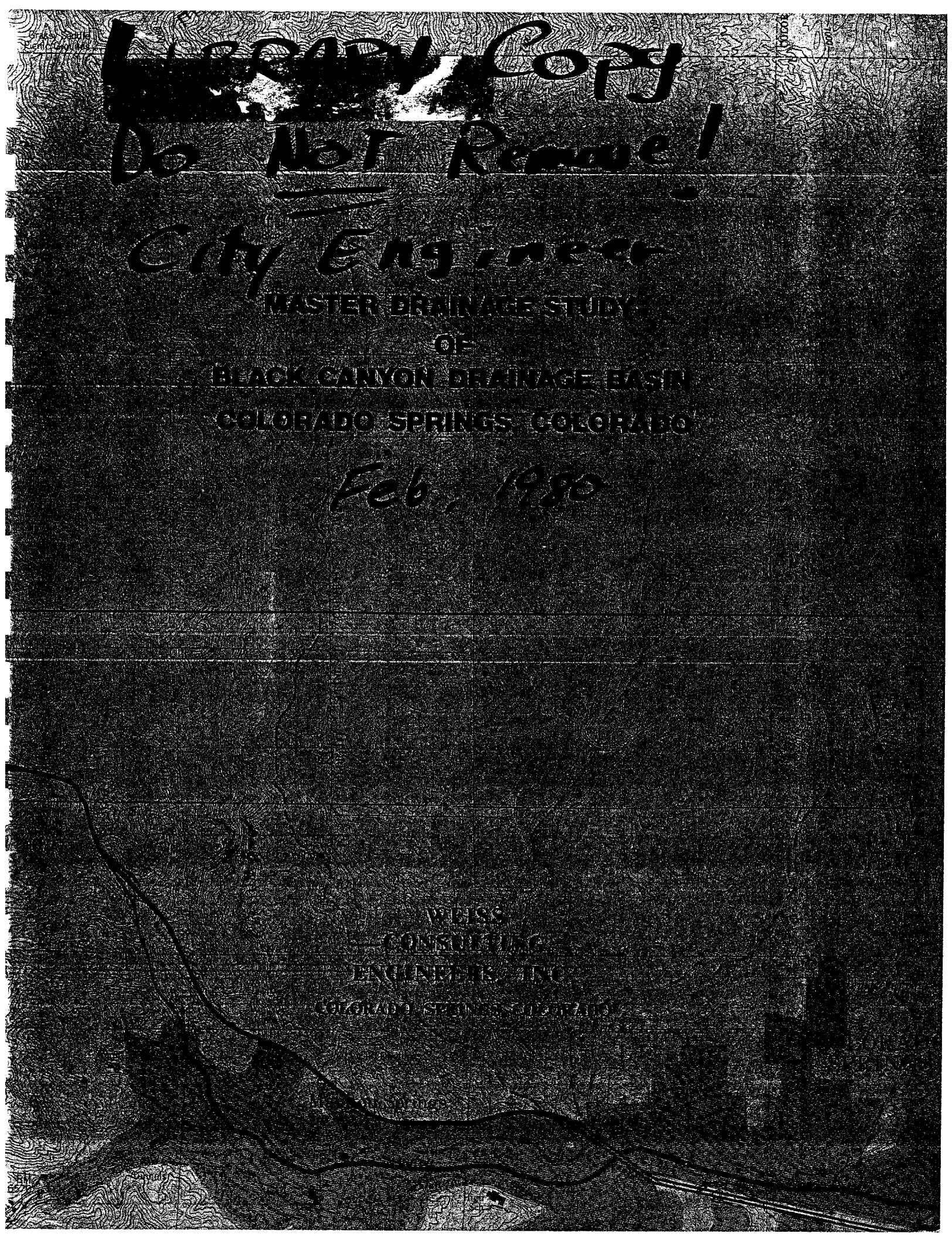
City Engineer

MASTER DRAINAGE STUDY
OF
BLACK CANYON DRAINAGE BASIN
COLORADO SPRINGS, COLORADO

Feb., 1980



WEISS
CONSULTING
ENGINEERS, INC.
COLORADO SPRINGS, COLORADO

MASTER DRAINAGE STUDY

OF

BLACK CANYON DRAINAGE BASIN

COLORADO SPRINGS, COLORADO

WEISS CONSULTING ENGINEERS, INC.

1815 North Tejon Colorado Springs, Colo. 80907 (303) 634-0373

July 14, 1980

Mr. Dewitt Miller
Director of Public Works
P. O. Box 1575
Colorado Springs, Colorado 80901

Dear Mr. Miller:

Reference is made to the Master Drainage Study of Black Canyon Drainage Basin, dated February 7, 1980. In reviewing this report with Mr. Gromko, we have decided that additional stabilization should be installed at the point where the Black Canyon Drainage enters Fountain Creek. This stabilization should be either large rip-rap or the placement of rock gabion baskets with an estimated cost of $10,000.00. This additional item would increase the recommended drainage fee from $1000.00 per acre to $1013.00 per acre.

Please include this letter as an amendment to the original drainage report.

Sincerely,

WEISS CONSULTING ENGINEERS, INC.

G. J. Weiss

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1815 North Tejon Colorado Springs, Colo. 80907 (303) 634-0373

February 7, 1980

Mr. Dewitt Miller
Director of Public Works
P. O. Box 1575
Colorado Springs, Colorado 80901

Dear Mr. Miller:

Transmitted herewith is an Engineering Study of the Black Canyon Drainage Basin, located west of the Garden of the Gods Park and north of Manitou Springs.

This report includes an overview of the basin geology, the rainfall runoff characteristics, calculations for the 5 year and 100 year storms in the developed state and the recommended drainage improvements for the basin.

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. The final size of all structures should be determined by the conditions found at the time of final design.

Sincerely,

WEISS CONSULTING ENGINEERS, INC.

G. J. Weiss P.E. 4124

GJW/sk

SCOPE AND REQUIREMENTS OF THE STUDY

The Black Canyon Drainage Basin has not been studied as a complete unit, insofar as can be determined. A report was prepared in 1972 by Leigh Whitehead and Associates for B & H Development Company of Colorado Springs.

The Rampart Road system was installed through a portion of the basin a number of years ago. The Castle Concrete Company has an access road and a rock quarry in the basin. The Black Canyon Picnic Grounds is located within the area. No land development has taken place on the site at this time, but several roads have been cut in preparation for the proposed Cedar Heights Development.

The purpose of this study was to determine the location and capacity of existing drainage structures, compute the 5 year and 100 year storm flows for the developed state, determine the size and location of any required new drainage structures and recommend a drainage fee for the basin.

The basin is almost totally undeveloped at this stage and the drainage study is based upon the proposed development, as shown on the Master Plan for Cedar Heights.

The major drainage channels through the basin were established by nature and consist mostly of deep rocky gullies. No attempt will be made to change these. Drainage structures will be added at the road crossings and some stream bed stabilization will be required at the lower elevations.

The structure and channel sizes shown in this report have been calculated from flows resulting from the City of Colorado Springs method of Rainfall-Runoff computations. These sizes should be recalculated at the time of final design to insure they fit field conditions at that time.

BASIN DESCRIPTION

The Black Canyon Drainage Basin contains about 1426 acres or just over 2 square miles. The basin is slightly over 3 miles long and 1 mile wide. It contains portions of Sections 20, 28, 29, 32 and 33 in Township 13 South, Range 67 West and portions of Sections 4 and 5 in Township 14 South, Range 67 West. The basin lies on the west side of Colorado Springs.

The proposed Cedar Heights Development falls within and consists of the majority of the basin. Cedar Heights consists of approximately 1100 acres with only about 750 acres being developable. The land outside the proposed Cedar Heights project and within the drainage basin consists of Pike National Forest, Castle Concrete, The Navigators, Cave of the Winds, Garden of the Gods and several small private property owners. Only about 40 acres of the last mentioned land would be considered as developable. The majority of the basin falls within the City Limits for Colorado Springs and a small portion at the outlet is within Manitou Springs.

The basin is well defined with the Camp Creek Drainage Basin lying east and Williams Canyon Drainage Basin lying west of this site. The high elevation on the site is 8280 and the low elevation is 6200.

The topography consists of ridges and valleys trending north-south and northwest-southeast and in general, the area slopes to the south. Numerous and widespread outcrops are indicative of shallow bedrock and thin residual/colluvial.

The basin is mountainous in nature. Erosion has created a fingerlike drainage system with steep valley walls separated by gently rolling divides. The slopes are quite steep. A large part of the basin cannot be developed into housing, due to its ownership and to the roughness of the terrain. The part that can be developed will need to be developed at low density. The only major earthmoving operation required would be for building of roads; the remainder of the area would be left in its natural condition, except for the excavation required for house construction.

GEOLOGIC FORMATION, SOIL TYPES

The northern third of the basin is underlain by the Williams Canyon Limestone of Mississippian Age. The Williams Canyon is a thick-bedded to massive, crystalline, hard, dense, gray limestone. This limestone has been mined or prospected for at about six locations within the proposed subdivision. This northern area is characterized

by very thin residual/colluvial soils and shallow, resistant bedrock. In general, these soils are thinner on ridge tops and slopes and thicker at the toe of slopes and in drainages. The topography in this area consists of alternating ridges and drainages trending northwest-southeast.

The southern two-thirds of the basin is underlain by the Fountain Formation of Permian and Pennsylvanian Age, and soil materials derived from the Fountain Formation. The Fountain Formation is composed of arkosic conglomerates and sandstones with interbedded siltstones and some shales. The Fountain Formation is moderately fractured and jointed, and structurally dips rather uniformly to the southeast. Attitudes of measured bedding plains ranged in strike from N 5 W to N 70 E and in dip from 5 to 30 degrees toward the southeast. Observations in the existing exposures indicate a fairly well developed joint system. The most prominent joint system strikes a few degrees westerly of north and dips at high angles toward the southwest and northeast.

For the most part, existing exposures in the Fountain Formation indicates a relatively shallow residual and colluvial soil profile over weathered and formational bedrock. Due to the relative abundance of sandstones and conglomerates and their degree of competence and induration, residual soils are usually thin over the coarse grained units. Over the siltstones and shales, the residual soils become somewhat deeper.

Thicker accumulations of colluvial and slope wash materials have also been tentatively identified. These deposits generally consist of a mixture of weathered rock in a sand, silt and clay matrix.

Alluvual deposits are present on the site, mostly in the form of thin narrow bands in the drainageways and streams. One large area of alluvium can be found in the extreme northeast portion of the site.

The geologic information was obtained from the Geologic and Soils Report For Cedar Heights Subdivision by Lincoln-Devore, dated January 31, 1980.

An S.C.S. soils map is included with this report showing the classification for the various areas along with the Hydrologic Group for each. Curve numbers for the

computations are determined by the soil group number and type of proposed development. Composite curve numbers were calculated for the sub-basins where different soil types and land uses occur.

The upper part of the basin is classified as X17-F Paunsaugunt-Rock Outcrop Series and falls in Hydrologic Group D. The lower part of the basin is classified as I10-F Fort Wingate - Rock Outcrop Series and falls in Hydrologic Group C.

RAINFALL AND RUNOFF PATTERNS

The basin receives a total precipitation of about 15 inches per year, with approximately one-third of this being in the form of snowfall. The snowfall has a much slower rate of runoff than the average summer thunderstorm.

The major portions of the annual rainfall usually occur during the months of May, June, July and August. The storms come in two forms: (1) The slow, four day "upslope" storm condition, which can produce high precipitation, but over longer periods of time and (2) the intense thunderstorm, of short duration, but of sometimes very high intensity. Of these storm types, the high intensity, short duration thunderstorm will produce the greatest runoff in a small basin and is the storm for which the City of Colorado Springs drainage structures have been designed for many years.

The location of this basin is at the face of the Front Range. The mountainous area does not often receive the intense thunderstorm considered in the design criteria. The subject basin is also a considerable distance from the "major" storm line which the records indicates exists about 10 miles east of the mountain front. However, the existing criteria for the City of Colorado Springs is standard for the entire city and makes no allowances for this condition.

The method of runoff conputation utilized in this report is the MODIFIED SCS METHODOLOGY, outlined in the manual for Determination of Storm Runoff Criteria by the City of Colorado Springs, dated March, 1977.

The calculations were based upon two different frequencies. A five-year frequency six-hour duration storm was used with 2.1 inches of precipitation. Calculations were also made for the one hundred year frequency, six-hour duration storm using 3.5 inches of precipitation.

The type II A storm is a six-hour storm by definition, yet nearly 66% of the rain actually falls within a one-hour period. This is a low intensity storm with a very high intensity burst at about the 1½ hour point.

The City criteria states all drainage structures shall be designed for the 5-year storm up to and including the 500 c.f.s. peak flows for a 100 year storm; thereafter all structures shall be designed to carry the 100-year storm.

The flow arrows on the drainage map show the accumulative flows at various points along the basin. The upper figure in the box indicates the flow based upon the 5-year frequency storm. The lower figure indicates the flow based upon the 100 year storm. No hydrographs were drawn for the basin and the accumulative flows were based upon the assumption that all sub-basins upstream from that point were combined into one larger basin using a composite runoff factor.

For the purpose of this study, it was assumed the storm occurred over the entire basin at the same time.

EXISTING DRAINAGE STRUCTURES AND OUTFALL INTO FOUNTAIN CREEK

A number of small culverts exist under some of the old roads through the area, with most of them being too small. These will be replaced or added to where a larger permanent structure is required.

A 6' x 12' concrete box culvert exists under El Paso Boulevard. This structure will be adequate for the 100 year flow when proper inlet conditions are provided.

The Black Canyon Drainage Basin outfalls into Fountain Creek immediately downstream from the 6' x 12' C.B.C. under El Paso Boulevard. The basin has a total 100 year storm flow of 2225 c.f.s. in the developed stage. The basin in the present undeveloped state would have a total 100 year flow of about 1800 c.f.s.

The Corps of Engineers prepared a Flood Plain Study for Fountain Creek in a report dated August, 1974. This report indicates a flow of 16,000 c.f.s. for the 100 year storm in Fountain Creek downstream from the Black Canyon outfall point. The flood plain map for this area is shown on Plate 5 of the report and a copy of this map is included in the Black Canyon Report.

RECOMMENDATIONS

The natural drainage channels through the basin provide an excellent drainage way. These channels are deep, are mostly in rock and have timber and ground cover along the edges. These channels should be designated as greenbelts or preservation areas when platted, and no encroachment should be permitted that would restrict their use in the natural state.

We would recommend all drainage be left in the natural swales and valleys as the basin is being developed. Culverts should be placed under every road crossing of the drainage ways with the upstream and downstream ends being stabilized as required by the final design condition.

A few areas of the natural channel will require minor stabilization to prevent erosion during the major storms. This stabilization should consist of rock rip-rap or earth tone gunite to maintain the natural look for the development.

The lower 2600 lineal feet of the main channel will require a stabilized ditch. The 400 lineal foot section upstream from the existing box culvert under El Paso Boulevard should be concrete ditch to improve the velocity and entrance condition for the box. The remainder of this stabilized ditch could be either concrete, grouted rip-rap or earth tone gunite. A concrete box culvert will be required where the channel crosses under the entrance road.

The normal city requirement is for the developer to build a maintenance road along any major drainage ways to provide them access. Obviously, this would destroy the natural amenity of the proposed development and would not allow the channel to function as nature had intended.

We would recommend no maintenance road be provided through the areas where the channel would remain in its natural state. These channel areas should be part of the platted lot, be designated as preservation areas and delineated on the subdivision plat and the covenants should provide the owner of the lot be charged with the responsibility for maintenance of this area. This would remove the need for the city to have an access to the drainage way.

We would recommend vehicle access ramps be installed to the main channel stabilized ditch at the point where the ditch crosses under the main access road from the south.

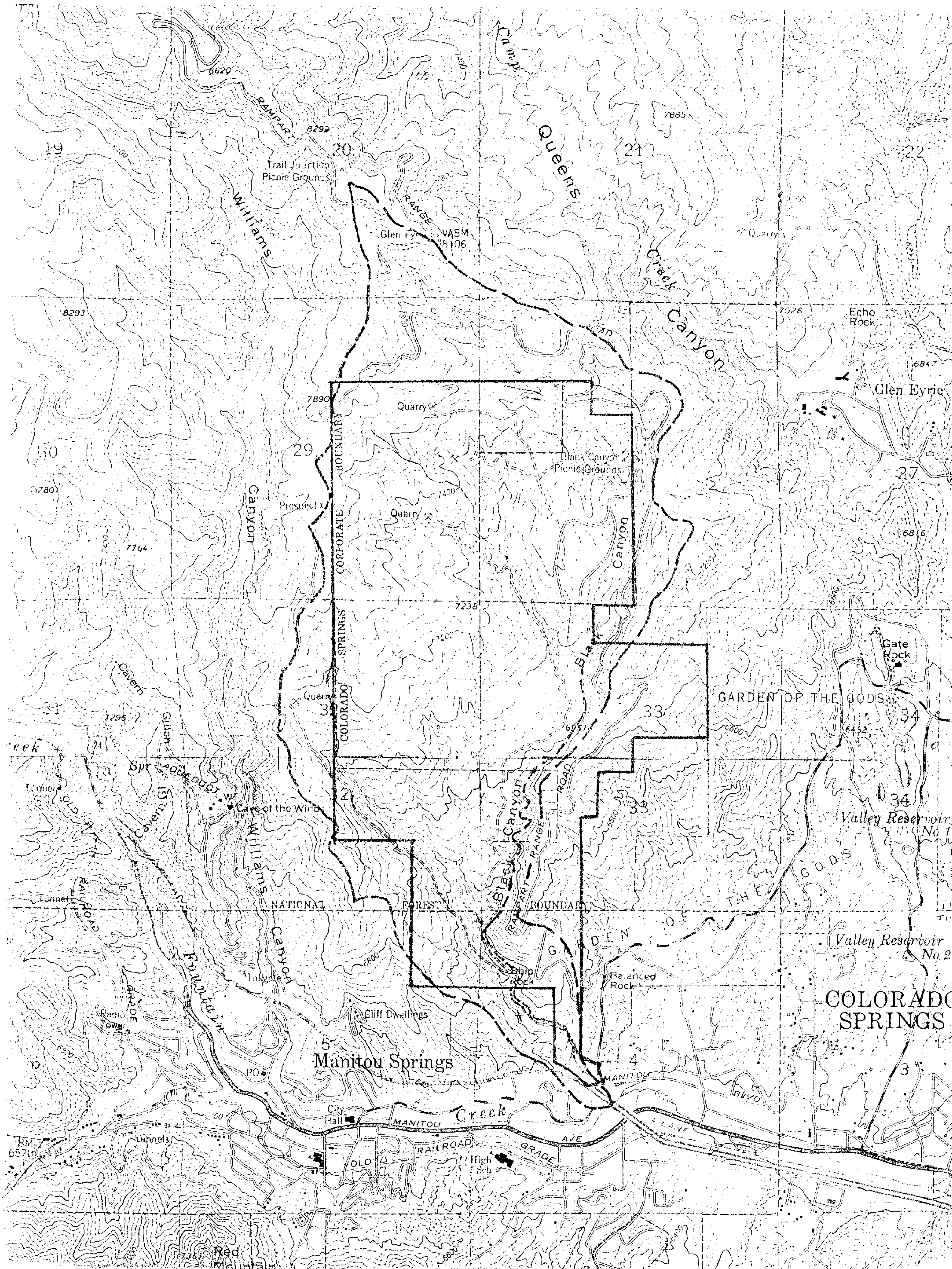
COST ESTIMATE

Listed below are the approximate quantities of drainage improvements that will be required and their estimated cost.

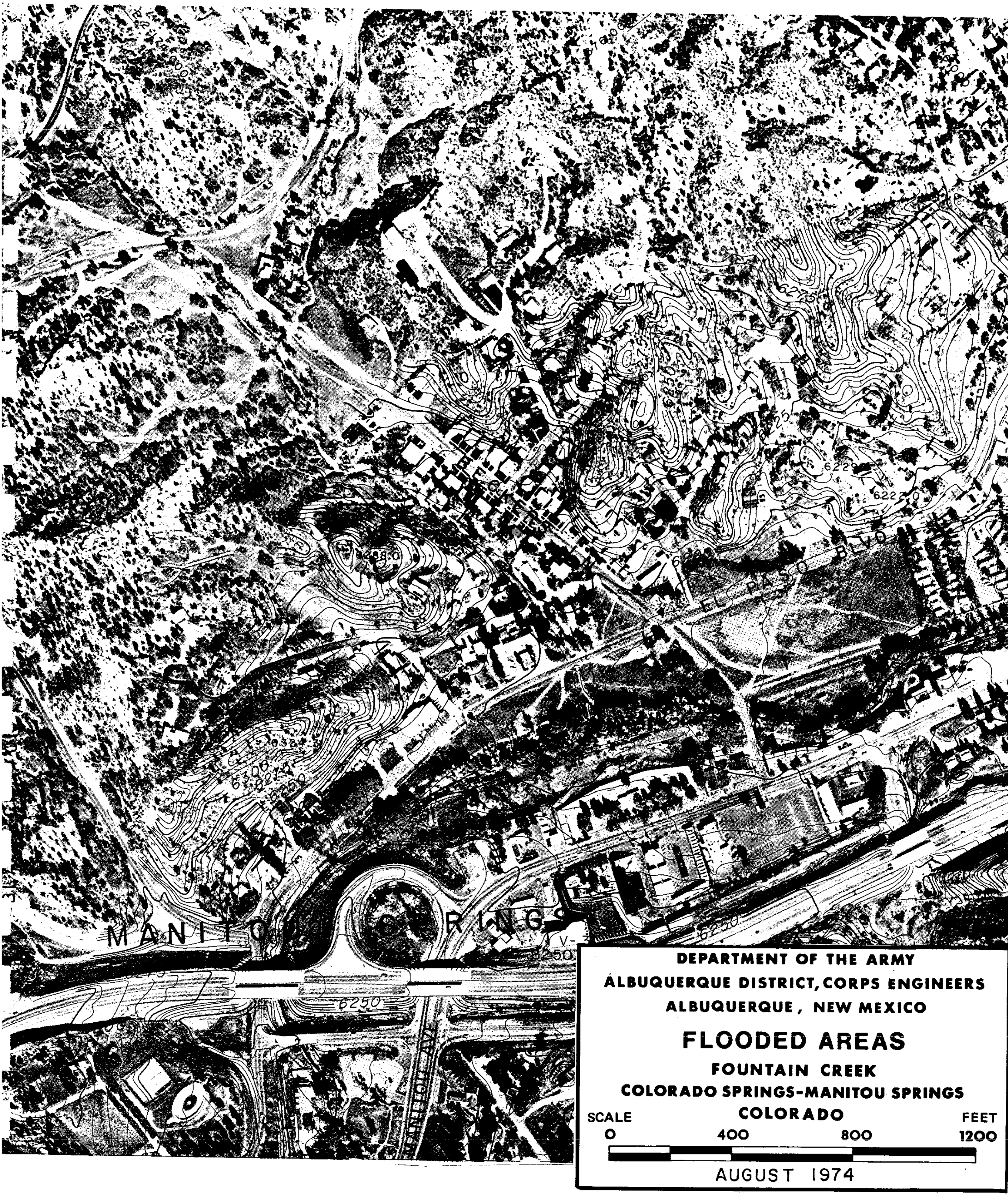
2	Catchbasins		@	$1000.00	=	$ 2,000.00
1520	LF of	18"	CMP @	25.00	=	38,000.00
2290	LF of	24"	CMP @	30.00	=	68,700.00
760	LF of	30"	CMP @	38.00	=	28,880.00
890	LF of	36"	CMP @	45.00	=	40,050.00
130	LF of	42"	CMP @	50.00	=	6,500.00
360	LF of	48"	CMP @	60.00	=	21,600.00
260	LF of	54"	CMP @	75.00	=	19,500.00
70	LF of	60"	CMP @	81.00	=	5,670.00
250	LF of	72"	CMP @	95.00	=	23,750.00
70	LF of	78"	CMP @	127.00	=	8,890.00
90	LF of	96"	CMP @	156.00	=	14,040.00
100	LF of	108"	CMP @	185.00	=	18,500.00
	Sub Total					$296,080.00
Miscellaneous Stabilization						30,094.00
100 LF of 8'x 12' CBC @				400.00	=	40,000.00
2600 LF of 6'x 12'ditch @				110.00	=	286,000.00
						$652,174.00
add 15% for Engineering and contingency						97,826.00
						$750,000.00

This report will assume only 750 acres of the land within the basin will be paying drainage fees. On that basis, the drainage fees would be $1000.00 per acre. We would recommend this fee be established for Black Canyon Drainage Basin.

It appears only one land developer will be doing development work in this basin. They will be building all of the required facilities and also paying all of the drainage fees. The major cost expenditure will be in the downstream end of the basin. This work will probably be done early in the project since it is adjacent to the major access road. If the fees appear to be either too high or too low at a later date, they can be adjusted at that time, since only one developer is involved in the project.



Camp
Queens
Creek
Canyon
RAMPART
RANGE
ROAD
Trail Junction
Picnic Grounds
Glen Eyrie
VABM
8106
Williams
Canyon
Quarry
Echo
Rock
Glen Eyrie
COLORADO SPRINGS CORPORATE BOUNDARY
Black Canyon
Picnic Grounds
Prospect
Gate
Rock
GARDEN OF THE GODS
Cavern
Gulch
AQUEDUCT
Cave of the Winds
Tunnel
OLD
RAILROAD
GRADE
Valley Reservoir
No 1
Valley Reservoir
No 2
NATIONAL FOREST BOUNDARY
Ship
Rock
Balanced
Rock
Fountain
Tollgate
Radio
Tower
Cliff Dwellings
COLORADO
SPRINGS
Manitou Springs
MANITOU
BLVD
City
Hall
MANITOU
Creek
4 LANE
AVE
RAILROAD
GRADE
High
Sch
Tunnels
Red
Mountain



DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS ENGINEERS
ALBUQUERQUE, NEW MEXICO

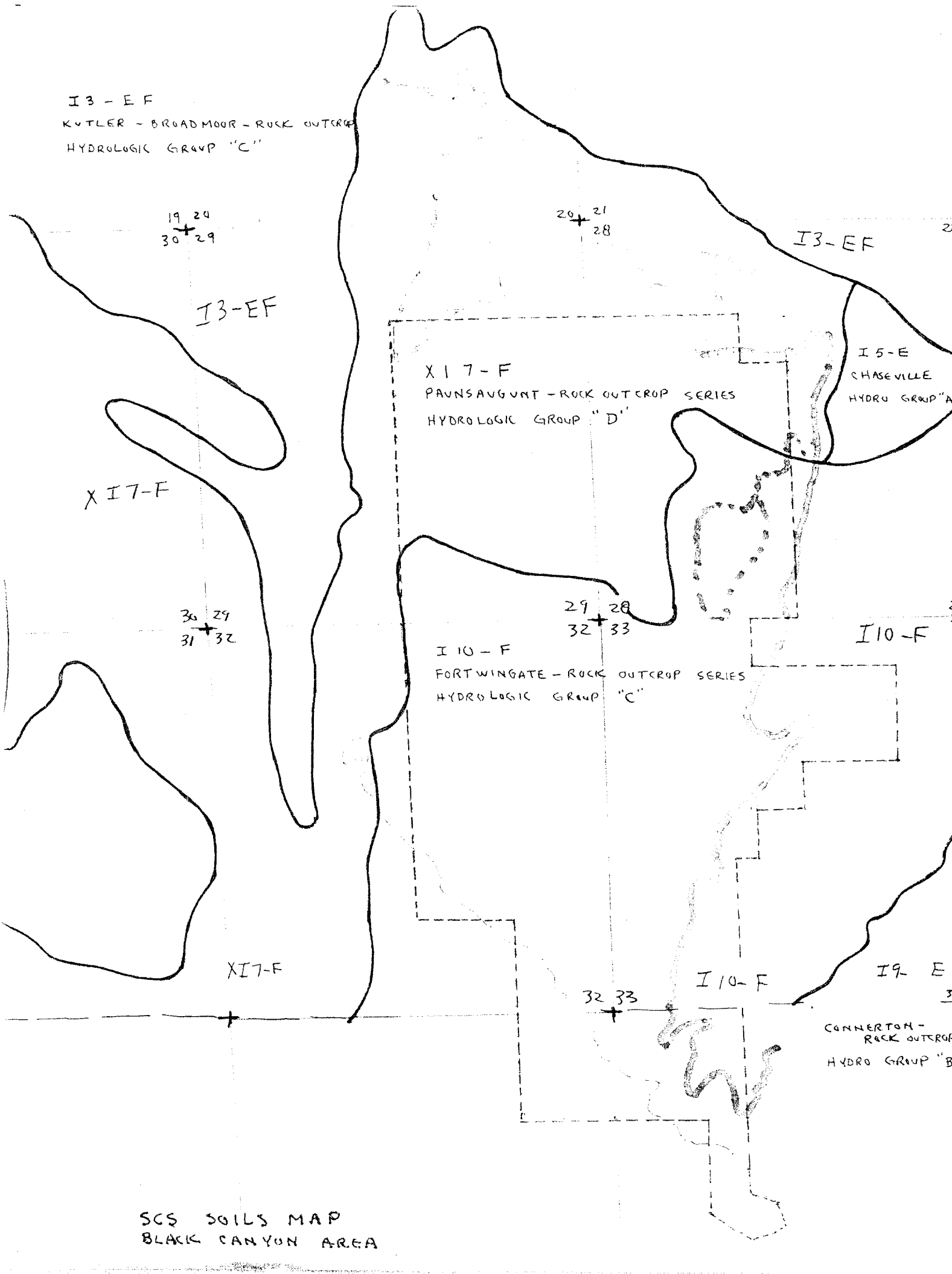
FLOODED AREAS

FOUNTAIN CREEK
COLORADO SPRINGS-MANITOU SPRINGS
COLORADO

SCALE 0 400 800 1200 FEET

AUGUST 1974

PLATE 5



SCS SOILS MAP
BLACK CANYON AREA

PAUNSAUGUNT SERIES

UT0120

RECREATION

CAMP AREAS	10-15%: MODERATE-SLOPE, SMALL STONES 15+%: SEVERE-SLOPE	PLAYGROUNDS	SEVERE-SLOPE, SMALL STONES, DEPTH TO ROCK
PICNIC AREAS	10-15%: MODERATE-SLOPE, SMALL STONES 15+%: SEVERE-SLOPE	PATHS AND TRAILS	10-15%: MODERATE-SMALL STONES 15-25%: MODERATE-SLOPE, SMALL STONES 25+%: SEVERE-SLOPE

CAPABILITY AND PREDICTED YIELDS -- CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
ALL	7S																

WOODLAND SUITABILITY

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDEX	TREES TO PLANT
HIGH PPT	6D	MODERATE	SLIGHT	MODERATE	SLIGHT	SLIGHT	PONDEROSA PINE	50 *	PONDEROSA PINE

WINDBREAKS

CLASS-DETERMING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
	NONE							

WILDLIFE HABITAT SUITABILITY

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
ALL	V. POOR	V. POOR	POOR	-	V. POOR	POOR	V. POOR	V. POOR	V. POOR	POOR	V. POOR	POOR

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NRCS PN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: LOW PPT	HIGH PPT					
SEDGE	CAREX	5	3/					
MUTTONGRASS	POFE	3	3/					
NEVADA BLUEGRASS	PONE3	3	3/					
OTHER PERENNIAL GRASSES	PPGG	4	3/					
OTHER PERENNIAL FORBS	PPFF	10	3/					
GAMBEL OAK 2/	QUGA	15	3/					
GREENLEAF MANZANITA 2/	ARPA6	15	3/					
PONDEROSA PINE 2/	PIPO	20	3/					
SASKATOON SERVICEBERRY	AMAL2	5	3/					
UTAH JUNIPER 2/	JUOS	5	3/					
OTHER SHRUBS	SSSS	15	3/					
POTENTIAL PRODUCTION (LBS./AC. DRY WT): FAVORABLE YEARS		1500						
NORMAL YEARS								
UNFAVORABLE YEARS		500						

FOOTNOTES

BORROW AREAS MAY BE DIFFICULT TO REVEGETATE.

2 NOT USUALLY UTILIZED BY SHEEP AND CATTLE.

COMPOSITION VARIABLE.

SITE INDEX IS A SUMMARY OF 5 OR MORE MEASUREMENTS ON THIS SOIL.

UT0120 SOIL SURVEY INTERPRETATIONS X17-F

PAUNSAUGUNT SERIES

MLRA(S): 35, 47, 48
REV. PEO, 5-75
LITHIC HAPLOBOROLLS, LOAMY-SKELETAL, MIXED

THE PAUNSAUGUNT SERIES CONSISTS OF SHALLOW SOMEWHAT EXCESSIVELY-DRAINED SOILS FORMED IN RESIDUUM FROM LIMESTONE ON MOUNTAIN SLOPES UNDER NEVADA BLUEGRASS, INDIAN RICEGRASS, PONDEROSA PINE AND GAMBEL OAK. MAAT IS 42 TO 45 F. AAP IS 10 TO 16 INCHES. FFP IS 90 TO 120 DAYS. A TYPICAL PROFILE HAS A DARK GRAYISH-BROWN, GRAVELLY LOAM SURFACE LAYER 3 INCHES THICK. THE UNDERLYING LAYER IS DARK GRAYISH-BROWN COBBLY SANDY LOAM 12 INCHES THICK OVER BEDROCK. SLOPES ARE 10 TO 50 PERCENT.

ESTIMATED SOIL PROPERTIES

DEPTH (IN.)	USCA TEXTURE	UNIFIED	AASHTO	FRACT >3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-3	GR-L	GM-GC	A-4	0-5	50-60	45-55	45-55	40-50	20-30	5-10
~~0-3~~	~~GR-SIL~~	~~GM-GC~~	~~A-4~~	~~0-5~~	~~50-60~~	~~50-60~~	~~45-65~~	~~45-65~~	~~20-30~~	~~5-10~~
3-15	CB-SL	SM	A-1, A-2	30-45	75-85	70-80	40-50	20-30	15-20	NP-5

DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CONCRETE	EROSION FACTORS K	T	WIND EROD. GROUP
0-3	0.6-2.0	0.12-0.14	7.4-8.4	<2	LOW	HIGH	MODERATE	.20	1	8
~~0-3~~	~~0.6-2.0~~	~~0.13-0.15~~	~~7.4-8.4~~	~~<2~~	~~LOW~~	~~HIGH~~	~~MODERATE~~	~~.20~~	~~1~~	~~8~~
~~3-15~~	2.0-6.0	0.06-0.08	7.4-8.4	<2	LOW	HIGH	MODERATE	.17		

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INIT. (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
NONE			>6.0			-		10-20	HARD	-		D	MODERATE

SANITARY FACILITIES

SEPTIC TANK ABSORPTION FIELDS	10-15%: SEVERE-DEPTH TO ROCK 15+%: SEVERE-SLOPE,DEPTH TO ROCK
SEWAGE LAGOON AREAS	SEVERE-SLOPE,DEPTH TO ROCK,SEEPAGE
SANITARY LANDFILL (TRENCH)	10-25%: SEVERE-DEPTH TO ROCK 25+%: SEVERE-SLOPE,DEPTH TO ROCK
SANITARY LANDFILL (AREA)	10-15%: SEVERE-SEEPAGE 15+%: SEVERE-SLOPE,SEEPAGE
DAILY COVER FOR LANDFILL	10-15%: POOR-THIN LAYER,SMALL STONES 15+%: POOR-SLOPE,THIN LAYER,SMALL STONES

COMMUNITY DEVELOPMENT

SHALLOW EXCAVATIONS	10-15%: SEVERE-DEPTH TO ROCK 15+%: SEVERE-SLOPE,DEPTH TO ROCK
DWELLINGS WITHOUT BASEMENTS	10-15%: SEVERE-DEPTH TO ROCK 15+%: SEVERE-SLOPE,DEPTH TO ROCK
DWELLINGS WITH BASEMENTS	10-15%: SEVERE-DEPTH TO ROCK 15+%: SEVERE-SLOPE,DEPTH TO ROCK
SMALL COMMERCIAL BUILDINGS	SEVERE-SLOPE,DEPTH TO ROCK
LOCAL ROADS AND STREETS	10-15%: SEVERE-DEPTH TO ROCK 15+%: SEVERE-SLOPE,DEPTH TO ROCK
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	

SOURCE MATERIAL

ROADFILL	10-25%: POOR-THIN LAYER 25+%: POOR-SLOPE,THIN LAYER 25+%: POOR-SLOPE
SAND	UNSUITED
GRAVEL	UNSUITED
TOPSOIL	10-15%: POOR-SMALL STONES 15+%: POOR-SLOPE,SMALL STONES

WATER MANAGEMENT

POND RESERVOIR AREA	DEPTH TO ROCK,SLOPE,SEEPAGE
EMBANKMENTS DIKES AND LEVEES	THIN LAYER,SEEPAGE,PIPING
EXCAVATED PONDS AQUIFER FED	NO WATER
DRAINAGE	
IRRIGATION	
TERRACES AND DIVERSIONS	SLOPE,DEPTH TO ROCK
GRASSED WATERWAYS	SLOPE,ROOTING DEPTH

REGIONAL INTERPRETATIONS

NM0159 SOIL SURVEY INTERPRETATIONS FORTWINGATE SERIES

MLRA(S): 35, 48
DSP, 4-74
TYPIC EUTICBOPALFS, FINE, MONTMORILLONITIC

THE FORTWINGATE SERIES CONSISTS OF MODERATELY DEEP WELL DRAINED SOILS. THEY FORMED IN MATERIAL WEATHERED FROM SANDSTONE ON MOUNTAIN UPLANDS. SLOPES ARE 2 TO 40 PERCENT. ELEVATIONS RANGE FROM 7000 TO 8500 FEET. MEAN ANNUAL PRECIPITATION IS 18 TO 20 INCHES. MEAN ANNUAL AIR TEMPERATURE IS 42 TO 45F, AND THE FROST FREE SEASON IS 100 TO 120 DAYS. TYPICALLY THE SURFACE LAYER IS A BROWN LOAM TO LIGHT BROWN SANDY CLAY LOAM ABOUT 13 INCHES THICK. THE SUBSOIL IS A REDDISH BROWN SANDY CLAY AND CLAY ABOVE 19 INCHES THICK OVER SANDSTONE.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHO	FRACT >3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-6	~~0-13~~ L, ~~FSL~~	SM, ML	A-4	0	100	100	95-100	40-75	-	NP
	~~0-13~~ ST-L, ST-FSL	~~SM, ML~~	~~A-4~~	~~26-60~~	~~CC-100~~	~~86-100~~	~~70-100~~	~~35-75~~	-	NP
6-23	~~13-23~~ SC, CL, ST-CL	GC, CL	A-2, A-6, ~~A-7~~	0-30	65-100	60-100	55-100	30-80	25-40	10-20
23-38	~~23-38~~ C, CL, ST-CL	GC, CL	A-6, ~~A-7~~	0-30	65-100	60-100	55-100	40-80	25-40	10-20
38	~~38~~ UWB								40	

DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND ERODIBILITY GROUP
0-6	~~0-13~~ 0.6-2.0	0.13-0.18	5.6-7.3	-	LOW	LOW	LOW	.37	2	-
	~~0-13~~ ~~0.6-2.0~~	~~0.10-0.14~~	~~5.6-7.3~~		~~LOW~~	~~LOW~~	~~LOW~~	~~.28~~	~~2~~	-
6-23	~~13-23~~ 0.2-0.6	0.14-0.16	5.6-7.3	-	HIGH	HIGH	LOW	.28		
23-38	~~23-38~~ 0.06-0.2	0.14-0.16	6.1-7.8	-	HIGH	HIGH	LOW	.28		
38	~~38~~									

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INIT. (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENT'L FROST ACTION
NONE			>6.0			-		20-40	HARD	-		C	LOW

SANITARY FACILITIES

SEPTIC TANK ABSORPTION FIELDS	2-15%: SEVERE-DEPTH TO ROCK,PERCS SLOWLY 15+%: SEVERE-DEPTH TO ROCK,PERCS SLOWLY, SLOPE
SEWAGE LAGOON AREAS	2-7%: SEVERE-DEPTH TO ROCK 7+%: SEVERE-DEPTH TO ROCK,SLOPE
SANITARY LANDFILL (TRENCH)	2-25%: SEVERE-DEPTH TO ROCK 25+%: SEVERE-DEPTH TO ROCK,SLOPE
SANITARY LANDFILL (AREA)	2-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE
DAILY COVER FOR LANDFILL	2-8%: FAIR-THIN LAYER 8-15%: FAIR-SLOPE,THIN LAYER 15+%: POOR-SLOPE

COMMUNITY DEVELOPMENT

SHALLOW EXCAVATIONS	2-15%: SEVERE-DEPTH TO ROCK 15+%: SEVERE-DEPTH TO ROCK,SLOPE
DWELLINGS WITHOUT BASEMENTS	2-15%: SEVERE-SHRINK-SWELL 15+%: SEVERE-SHRINK-SWELL,SLOPE
DWELLINGS WITH BASEMENTS	2-15%: SEVERE-DEPTH TO ROCK,SHRINK-SWELL 15+%: SEVERE-DEPTH TO ROCK,SHRINK-SWELL, SLOPE
SMALL COMMERCIAL BUILDINGS	2-8%: SEVERE-SHRINK-SWELL 8+%: SEVERE-SHRINK-SWELL,SLOPE
LOCAL ROADS AND STREETS	2-15%: SEVERE-SHRINK-SWELL,LOW STRENGTH 15+%: SEVERE-SHRINK-SWELL,SLOPE,LOW STRENGTH

REGIONAL INTERPRETATIONS

SOURCE MATERIAL

ROADFILL	2-25%: POOR-SHRINK-SWELL,THIN LAYER, LOW STRENGTH 25+%: POOR-LOW STRENGTH,SLOPE,THIN LAYER
SAND	UNSUITED
GRAVEL	UNSUITED
TOPSOIL	2-8% L,FSL: FAIR-THIN LAYER ST-L,ST-FSL: POOR-LARGE STONES 8-15% L,FSL: FAIR-THIN LAYER,SLOPE 15+%: POOR-SLOPE

WATER MANAGEMENT

POND RESERVOIR AREA	DEPTH TO ROCK,SLOPE
EMBANKMENTS DIKES AND LEVEES	LOW STRENGTH,THIN LAYER,SHRINK-SWELL
EXCAVATED PONDS AQUIFER FED	NO WATER
DRAINAGE	
IRRIGATION	
TERRACES AND DIVERSIONS	DEPTH TO ROCK,SLOPE
GRASSED WATERWAYS	SLOPE,DROUGHTY

FORTWINGATE SERIES

NM0159

RECREATION

CAMP AREAS	2-8%: MODERATE-PERCS SLOWLY 8-15%: MODERATE-PERCS SLOWLY, SLOPE 15+%: SEVERE-SLOPE	PLAYGROUNDS	2-6%: MODERATE-DEPTH TO ROCK, SLOPE, PERCS SLOWLY 6+%: SEVERE-SLOPE
PICNIC AREAS	2-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE	PATHS AND TRAILS	2-15%: SLIGHT 15-25%: MODERATE-SLOPE 25+%: SEVERE-SLOPE

CAPABILITY AND PREDICTED YIELDS -- CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPA-BILITY	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
2-5%	6S																
5-10%	6E																
10+%	7E																

WOODLAND SUITABILITY

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDX	TREES TO PLANT
2-5%	6O	SLIGHT	MODERATE	SLIGHT	MODERATE	MODERATE	PONDEROSA PINE	55	PONDEROSA PINE
5-10%	6O	MODERATE	MODERATE	SLIGHT	MODERATE	MODERATE	PONDEROSA PINE	55	PONDEROSA PINE
10-30%	6O	SEVERE	MODERATE	SLIGHT	MODERATE	MODERATE	PONDEROSA PINE	55	PONDEROSA PINE
30+%	6R	SEVERE	SEVERE	SLIGHT	MODERATE	MODERATE	PONDEROSA PINE	55	PONDEROSA PINE

WINDBREAKS

CLASS-DETERMIN'G PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
	NONE							

WILDLIFE HABITAT SUITABILITY

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
2-5%	POOR	POOR	GOOD	-	FAIR	FAIR	POOR	POOR	FAIR	~~FAIR~~	V. POOR	GOOD
5-10%	POOR	POOR	GOOD	-	FAIR	FAIR	POOR	V. POOR	FAIR	~~FAIR~~	V. POOR	GOOD
10+%	V. POOR	V. POOR	GOOD	-	FAIR	FAIR	V. POOR	V. POOR	POOR	~~FAIR~~	V. POOR	GOOD

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NRCS)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: ALL
MOUNTAIN MUHLY	MUMO	
ARIZONA FESCUE	FEAR2	
PRAIRIE JUNEGRASS	KOCR	5
BOTTLEBRUSH SQUIRRELTAIL	SIHY	
PINE DROPSEED	BLTR	
BLUE GRAMA	BOGR2	15
APACHEPLUME	FAPA	
CLIFFROSE	COWAN	
GAMBEL OAK 1/	QUGA	
MOUNTAIN-MAHOGANY	CEMO2	3
OREGONGRAPE 2/	BERE	
ALLIGATOR JUNIPER 2/	JUDE2	
PINYON PINE 2/	PIED	
POTENTIAL PRODUCTION (LBS./AC. DRY WT):		
FAVORABLE YEARS		1100
NORMAL YEARS		850
UNFAVORABLE YEARS		700

FOOTNOTES

A ESTIMATES OF ENGINEERING PROPERTIES ARE BASED ON TEST DATA OF 3 PEDONS FROM VALENCIA AND MCKINLEY COUNTIES, NM.

1 LITTLE USE BY CATTLE, USED BY SHEEP.

2 NOT USUALLY UTILIZED BY CATTLE AND SHEEP.

MAJOR BASIN	SUB BASIN	AREA Planim Read	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	DITCH LENGTH	DITCH SLOPE		CN	FLOW Q 5 YR	FLOW Q 100	FLOW qp	q 5 YR	q 100
A	1a	33.61	0.05251	3120	540	0.12				80	0.62	1.64	1240	40	107
	1b	22.22	0.034722	2500	500	0.10				80	0.62	1.64	1280	28	73
	1c	12.08	0.018868	1500	240	0.08				80	0.62	1.64	1280	15	40
	2a	40.96	0.06399	3320	610	0.12				77	0.50	1.43	1240	46	113
	2b	73.92	0.11550	4400	850	0.16				77	0.50	1.43	1150	66	190
	2c	16.44	0.02568	1940	380	0.08				77	0.50	1.43	1280	16	47
ACCUM A	1 & 2	199.27	0.311268	5620	1000	0.20				78	0.54	1.50	1070	180	500
A	3	39.03	0.060979	3850	390	0.19				82	0.71	1.78	1080	47	117
ACCUM A	1,2 & 3	238.24	0.372241	8700	1250	0.30				79	0.58	1.57	920	199	538
A	4	37.10	0.057966	3200	390	0.14				82	0.71	1.78	1180	49	122
	5a	22.77	0.035583	2100	350	0.10				78	0.54	1.50	1280	25	68
	5b	44.63	0.06973	3900	570	0.16				78	0.54	1.50	1150	43	120
	5c	22.96	0.03587	2400	100	0.18				80	0.62	1.64	1100	24	65

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: BLACK CANYON MASTER DRAINAGE By: GJW

Date: 1-7-80

WEISS CONSULTING ENGINEERS, INC.

MAJOR BASIN	SUB BASIN	AREA Planim. Read	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	DITCH LENGTH	DITCH SLOPE	V	CN	FLOW Q 5 yr.	FLOW Q 100	FLOW qp	q 5 yr.	q 100
ACCUM A	5a,b,c	90.36	0.14 1183	5560	870	0.20				79	0.58	1.57	1070	88	237
ACCUM A	1 thru 5	345.7	0.57 1396	8700	1250	0.30				79	0.58	1.57	920	305	825
A	6	39.03	0.060979	2740	270	0.145				78	0.54	1.50	1170	39	107
	7	22.96	0.03587	2280	225	0.12				72	0.34	1.12	1230	15	49
ACCUM A	1 thru 7	427.68	0.668245	10,100	1325	0.35				78.5	0.56	1.54	870	326	895
A	8	25.71	0.040174	2000	300	0.10				74	0.40	1.24	1280	21	64
ACCUM A	1 thru 8	453.39	0.708419	11,300	1435	0.37				78.3	0.55	1.52	860	335	926

HYDROLOGIC COMPUTATION — BASIC DATA

PROJ: BLACK CANYON MASTER DRAINAGE

By: G JW

Date: 1-7-80

WEISS CONSULTING ENGINEERS, INC.

MAJOR BASIN	SUB BASIN	AREA Planim Read	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	DITCH LENGTH	DITCH SLOPE	V	CN	FLOW Q 5yr	FLOW Q 100	FLOW qp	q 5yr	q 100
B	1	35.63	0.05567	4100	600	0.17				80	0.62	1.64	1120	39	102
B	2a	17.91	0.027979	1200	305	0.05				82	0.71	1.78	1280	25	64
	2b	13.31	0.020805	1750	430	0.08				82	0.71	1.78	1280	19	47
	2c	16.35	0.025539	2200	435	0.09				80	0.62	1.64	1280	20	54
	2d	13.50	0.02109	1600	420	0.06				80	0.62	1.64	1280	17	44
	2e	31.59	0.049357	2400	475	0.10				80	0.62	1.64	1280	39	104
ACCUM B	2a thru 2e	92.65	0.14477	3350	700	0.12				80.7	0.65	1.69	1230	116	301
B	2f	24.24	0.037878	2400	410	0.10				82	0.71	1.78	1280	34	86
ACCUM B	2a thru 2f	116.89	0.182649	5150	700	0.20				80.95	0.66	1.71	1070	129	334
B	3a	20.66	0.032283	2400	520	0.09				82	0.71	1.78	1280	29	74
	3b	9.55	0.014922	1400	350	0.06				80	0.62	1.64	1280	12	31
	3c	8.26	0.012913	1120	260	0.05				80	0.62	1.64	1280	10	27
	3d	10.74	0.016787	1200	290	0.05				82	0.71	1.78	1280	15	38
ACCUM B	3a thru 3d	49.22	0.076905	3120	630	0.12				81.26	0.677	1.73	1230	64	164
	3e	25.71	0.040174	2000	365	0.09				80	0.62	1.64	1280	32	84

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: BLACK CANYON MASTER DRAINAGE By: GJW Date: 1-7-80

WEISS CONSULTING ENGINEERS, INC.

MAJOR BASIN	SUB BASIN	AREA Planim Read	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	DITCH LENGTH	DITCH SLOPE	V	CN	FLOW Q 5yr	FLOW Q 100	FLOW qp	q 5yr	q 100
ACCUM B	3a thru 3e	74.93	0.117079	4150	760	0.15				80.83	0.66	1.70	1170	90	233
B	3f	26.63	0.041609	2100	325	0.10				80	0.62	1.64	1280	33	87
ACCUM B	3a thru 3f	101.56	0.1586875	5150	855	0.18				80.61	0.65	1.68	1100	113	293
ACCUM B	1 thru 3	254.08	0.397007	5150	780	0.20				80.68	0.65	1.68	1070	276	714
B	4	54.18	0.08465	3000	510	0.12				80.0	0.62	1.64	1240	65	172
ACCUM B	1 thru 4	308.26	0.481657	7550	1055	0.26				80.56	0.65	1.68	980	307	793
ACCUM A & B		761.65	1.190076	11,300	1435	0.37				79.21	0.59	1.58	850	597	1598

HYDROLOGIC COMPUTATION — BASIC DATA

PROJ: BLACK CANYON MASTER DRAINAGE By: GJW

Date: 1-7-80

WEISS CONSULTING ENGINEERS, INC.

MAJOR BASIN	SUB BASIN	AREA Planim Read	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	DITCH LENGTH	DITCH SLOPE	V	CN	FLOW Q 5yr	FLOW Q 100	FLOW qp	q 5yr	q 100
C	1	59.69	0.093262	3500	500	0.14				80	0.62	1.64	1180	68	180
ACCUM A, B, C-1		821.34	1.283338	13,100	1565	0.43				79.27	0.59	1.59	780	590	1592
C	2	34.44	0.053805	2800	290	0.13				80	0.62	1.64	1200	40	106
	3	14.23	0.022239	1700	240	0.08				80	0.62	1.64	1280	18	47
ACCUM A, B & C		870.00	1.359382	15,600	1750	0.49				79.30	0.59	1.59	735	590	1589

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: BLACK CANYON MASTER DRAINAGE

By: G J W

Date: 1-8-80

WEISS CONSULTING ENGINEERS, INC.

MAJOR BASIN	SUB BASIN	AREA Planim Read	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	DITCH LENGTH	DITCH SLOPE	V	CN	FLOW Q 5 YR	FLOW Q 100	FLOW qp	q 5 YR	q 100
D	1a	14.88	0.0232438	2000	365	0.09				78	0.54	1.50	1280	16	45
	1b	11.94	0.0186524	2200	370	0.10				78	0.54	1.50	1280	13	36
ACCUM D	1a, 1b	26.81	0.041896	3900	660	0.15				78	0.54	1.50	1160	26	73
D	2a	17.45	0.027261	1900	300	0.09				78	0.54	1.50	1280	19	52
	2b	11.02	0.0172176	2000	315	0.09				78	0.54	1.50	1280	12	33
ACCUM D	2a, 2b	28.47	0.044786	3600	590	0.14				78	0.54	1.50	1180	28	79
ACCUM D	1 & 2	55.28	0.086375	3900	660	0.15				78	0.54	1.50	1160	54	150
D	3	21.58	0.0337179	2520	400	0.11				78	0.54	1.50	1250	23	63
ACCUM D	1, 2 & 3	76.86	0.120093	5900	925	0.21				78	0.54	1.50	1050	68	189
ACCUM A, B, C, D		946.86	1.479475	15,600	1750	0.48				79.19	0.59	1.58	740	646	1730
E	1	19.74	0.030848	1700	280	0.08				78	0.54	1.50	1280	21	59
ACCUM A, B, C, D, E		966.61	1.510323	17,040	1900	0.51				79.16	0.59	1.58	720	641	1718

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: BLACK CANYON MASTER DRAINAGE By: G JW Date: 1-8-80

WEISS CONSULTING ENGINEERS, INC.

MAJOR BASIN	SUB BASIN	AREA Planim Read	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	DITCH LENGTH	DITCH SLOPE	V	CN	FLOW Q 5 YR	FLOW Q 100	FLOW qp	q 5 YR	q 100
F	1	27.55	0.0430441	2600	490	0.10				76	0.47	1.36	1280	26	75
	2a	20.20	0.031566	2100	360	0.09				78	0.54	1.50	1280	22	61
	2b	11.20	0.0175046	1700	310	0.08				78	0.54	1.50	1280	12	33
ACCUM F	1 & 2	58.95	0.0921147	3500	600	0.13				77.07	0.51	1.43	1200	56	158
F	3	28.47	0.044479	2400	470	0.10				78	0.54	1.50	1280	31	85
ACCUM F	1,2 & 3	87.42	0.1365936	5800	950	0.21				77.37	0.52	1.44	1050	75	207
G	1	64.65	0.1010101	3720	590	0.15				74	0.40	1.24	1170	47	147
	2	19.74	0.030848	2000	350	0.09				82	0.71	1.78	1280	28	70
ACCUM G	1 & 2	84.39	0.1318584	3720	590	0.15				75.87	0.465	1.35	1170	72	208
G	3	22.50	0.035153	1700	400	0.07				76	0.47	1.36	1280	21	61
G	4	13.96	0.021809	2000	460	0.08				74	0.40	1.24	1280	11	35
ACCUM G	1,2,3,4	120.85	0.1888204	4920	770	0.185				75.68	0.46	1.34	1100	96	278
G	5	50.05	0.0781967	2200	540	0.08				76	0.47	1.36	1280	47	136
	6	19.74	0.030848	2900	550	0.11				76	0.47	1.36	1250	18	52
	7	6.89	0.010761	1000	300	0.04				76	0.47	1.36	1280	6	19
ACCUM G	1 thru 7	197.52	0.308626	6840	1010	0.24				75.81	0.46	1.35	1000	145	420

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: BLACK CANYON MASTER DRAINAGE By: GJW Date: 1-8-80

WEISS CONSULTING ENGINEERS, INC.

MAJOR BASIN	SUB BASIN	AREA Planim Read	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	DITCH LENGTH	DITCH SLOPE	V	CN	FLOW Q 5 YR	FLOW Q 100	FLOW qp	q 5 YR	q 100
ACCUM F & G		284.94	0.44522	6840	1010	0.24				76.29	0.48	1.38	1000	214	614
H	1	41.32	0.064566	2900	660	0.11				78	0.54	1.50	1250	44	121
ACCUM F, G & H		326.26	0.509786	8150	1150	0.30				76.50	0.49	1.395	920	230	654
ACCUM A thru H		1292.87	2.0201	17,040	1900	0.51				78.49	0.56	1.53	715	809	2210
I	1	58.31	0.091099	3100	590	0.12				92	1.33	2.64	1220	148	293
	2	22.04	0.034435	2000	330	0.09				78	0.54	1.50	1280	24	66
	3	29.38	0.0459137	2800	400	0.12				72	0.34	1.12	1220	19	63
ACCUM A thru I	(I-3)	1402.59	2.191548	19,930	2030	0.60				78.91	0.58	1.56	680	864	2325
I	4	23.42	0.03659	2300	320	0.11				80	0.62	1.64	1250	28	75
ACCUM A thru I		1426	2.228135	21,450	2100	0.66				78.93	0.58	1.56	640	827	2225

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: BLACK CANYON MASTER DRAINAGE By: GJW Date: 1-8-80

WEISS CONSULTING ENGINEERS, INC.