CITY ENGR COPY

See page 12 for summary

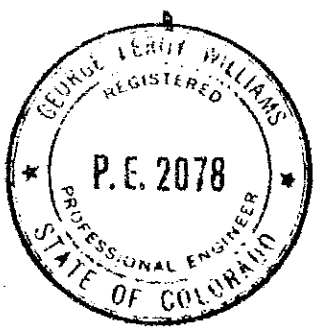
COSTILLA DRAINAGE BASIN STUDY

PREPARED FOR THE COLORADO SPRINGS DEPARTMENT OF PUBLIC WORKS

George L. Williams - Consulting Engineer

321½ South Tejon Street

Colorado Springs, Colorado 80902



INDEX

George L. Williams - Consulting Engineer
321½ S. Tejon St., Colorado Springs, Colo.

Sept. 23, 1968

Mr. M.R. Pearce
Director of Public Works
City of Colorado Springs
City Hall
Colorado Springs, Colorado

Dear Mr. Pearce:

Submitted herewith are 25 copies of the Costilla Drainage Basin Study, as contracted for by your office.

The study includes relevant maps, area development assumptions, runoff computations, facilities checking and/or design for sizing purposes, cost estimates for determining probable basin drainage costs, and other pertinent details.

Respectfully submitted,

George L. Williams
Consulting Engineer

GENERAL

The Costilla Drainage Basin contains about 178 acres of land. As shown on the map exhibits it lies west of 8th Street; southwest of Fountain Creek, east of 21st Street, and north of the proposed westerly extension of Fountain Creek Boulevard.

Roughly the west half of this basin is a part of the mill tailings plateau area presently intended for development by George Stiner and his associates as Villa De Mesa. The east half of the basin includes hillside and valley areas together with some relatively flat areas, these latter being mostly the result of grading operations and partial development efforts.

The old mill tailing material is a fine sand, uniformly sized as a result of the milling operation. It has spilled over the edge of the mesa area and become mixed with disintegrated granite "float" from the Front Range to the west and with the weathered gray shale which underlies the basin below elevation 6050.

A few modest homes and small commercial buildings have been constructed in the lower portion of the east half of the basin, along with gravel streets and surprisingly well-sized and well-constructed drainage structures. In the northeast portion of the basin El Paso County has recently surfaced about a quarter mile of Busch Avenue, westerly and northwesterly from 8th Street, and provided drainage from the low point in this improved surface to Fountain Creek by way of a 30" RCP Culvert.

ASSUMPTIONS

In view of the largely undeveloped condition of the land in this drainage basin, and the necessity of sizing drainage facilities for ultimate use, it has been necessary to make certain assumptions regarding future land use in the basin.

1. The western half of the basin, the plateau area, will probably be developed as a residential area, whether the Villa De Mesa plans carry through completely or not. The large low area on the plateau, which presently acts as a lake without an outlet after each storm until the rainfall sinks in or evaporates, will remain, but the stormwater will be conveyed via culvert to a small lake scheduled for construction near the east side of the plateau. On the assumption that this lake is full at the time of the "design" storm, the full runoff from the west half of the drainage basin is assumed to flow easterly to the lower elevations and to Fountain Creek. For many years, of course, this will not be the case, and essentially no runoff will come from the plateau.

2. The eastern half of the basin, despite its steeply sloping terrain, will gradually be constrained by economic forces to develop into commercial operations and multiple family housing occupancy. Costilla Street and Busch Avenue will be improved and extended to the west, the latter as a frontage road to parallel the Midland Expressway; and both will carry much more traffic than at present. Costilla is planned for a 40' trafficway in a 60' R/W and Busch for a 60' trafficway in an 80' R/W.

3. The existing drainage ditches and structures will remain and become a part of the permanent drainage system, with the exception of the small wood bridge which crosses a ditch in the alley between 10th and 11th Streets.

FLOW PATTERN

The flow from sub-basins 1 and 2 on the plateau area converges in the valley area just south of the west end of Costilla Street, and thence flows easterly. It is in a natural drainage channel to 11th Street, goes under 11th Street in an existing 72" CMP culvert, continues in a natural drainage channel to and under the small wood bridge previously mentioned and on to 10th Street in said channel, goes under 10th Street in a 6' x 6' Concrete box culvert set on a 45^{0} skew to the east side of 10th Street, thence in a rubble-concrete lined ditch northerly to the corner of 10th and Costilla Streets, thence angles about 60^{0} to the right and goes under Costilla Street northeasterly in 6' x 5' Concrete box culvert, thence continues in an open ditch for about 200' across private land, thence passes through a 72" CMP culvert under private land and Busch Avenue, and finally is conveyed to Fountain Creek through a 4' x 4' Concrete box culvert. Along the way the flow is augmented by runoff from sub-basins 3 and 4, on the surface of the ground or in small and irregular ditches. In the future this side runoff will no doubt be controlled in curb and gutter construction.

The flow from sub-basin 5 gathers in Costilla Street, Busch Avenue, and 8th Street, and is then conveyed to Fountain Creek at the

southwest corner of the 8th Street Bridge. In the future this side of road flow will no doubt be controlled in curb and gutter construction.

The flow from sub-basin 6 gathers in Busch Avenue at a low point in the northeast side of the pavement, and from this point is conveyed northeasterly to Fountain Creek through a 30" RCP culvert recently installed by the El Paso County Road Department.

The flow from sub-basin 7 goes overland directly to the bank of Fountain Creek, all in private commercial property, and may be disregarded.

FLOW QUANTITIES

From sub-basin 1, at point A.	143.1 cfs.
From sub-basin 2, at point B.	34.3 cfs.
From sub-basins 1 and 2, at point C	177.4 cfs.
From half of sub-basin 3 and half of sub-basin 4.	53.4 cfs.
From sub-basins: 1, 2, $\frac{1}{2}$ of 3, and $\frac{1}{2}$ of 4, at point D . . .	230.8 cfs.
From half of sub-basin 4 and $\frac{1}{4}$ of sub-basin 3	44.2 cfs.
From sub-basins: 1,2, 3/4 of 3, and 4, at point E	275.0 cfs.
From $\frac{1}{4}$ of sub basin 3	9.3 cfs.
From sub-basins: 1,2,3, and 4, at point F	284.3 cfs.
From sub basin 5, at point G	23.9 cfs.
From sub basin 6, at point H	66.2 cfs.
From sub-basin 7, distributed along the creek bank	13.2 cfs.
Total runoff from all sub-basins	387.6 cfs.

REQUIREMENTS FOR EXISTING AND PROPOSED DRAINAGE FACILITIES

In this summation we will work upstream from discharge points, in reverse order from that used in the section on flow quantities.

Point H; flow is 66.2 cfs; existing culvert capacity is 65.3 cfs.

Point G; flow is 23.9 cfs; existing gutter capacity (designed) on the west side of 8th Street is 44.6 cfs. About 18 cfs will flow in 8th Street, the other 5.9 cfs (split two ways) on Busch Avenue, obviously no strain on its capacity. The flow will spill over the edge of the bridge abutment, which will have to be altered to provide adequate turning radius into Busch Avenue; the spillage section can be provided as part of this alteration; no drainage facility expense incurred.

Point F; flow is 284.3 cfs; existing culvert capacity is 287.3 cfs.

Point E; flow is 275.0 cfs; existing culvert capacity is 1,384 cfs, far above required capacity. Between point F and the downstream end of the 5' x 6' box culvert under Costilla Street a vee ditch will be required; a concrete ditch 8' across the top and 4' deep has a capacity of 396 cfs and will be more than adequate, and may be used for minimum drainage structure costing. Actually, if present plans for the Daniels Motors installation come to fruition the ditch will be occupied by a 72" CMP culvert with a capacity of 285 cfs, so that the area may be backfilled and used for driveway.

Point D; flow is 230.8 cfs; existing culvert capacity is 250 cfs. Between point E and the downstream end of this culvert are the following. First, the skewed 6' x 6' box culvert under 10th Street

with a more than ample capacity of about 1,600 cfs, then an unlined natural channel which should be improved as a concrete vee ditch 8' across the top and 4' deep, having a capacity of about 356 cfs, with headwall improvements at west end. If the alley midway along this ditch is eliminated in subsequent re-development, the existing wood bridge will not be required. If the alley is retained the cost of replacement or improvement of the bridge should be included in necessary street improvements since the bridge does cross a natural watercourse.

Point C; flow is 177.4 cfs. From point D upstream to point C the natural drainage should be improved with a concrete ditch, again 8' across the top and 4' deep, having a capacity of 297 cfs, and with a headwall improvement at the lower end.

Point B; 34.3 cfs. From point C upstream to point B this relatively small flow can be handled in a number of ways, dependent on the manner in which the area is utilized: in culvert, paved side ditch, a series of landscaped check dams, a grassed swale, etc. street ?

Point A; flow is 143.1 cfs. From point C upstream to point A this rather considerable flow can again be handled in several ways. If the proposed Villa de Mesa dam is constructed just above point A, it is unlikely that residences will be placed immediately below it; rather the most attractive landscaping might be a series of small dams and ponds which could act as stilling basins and whose spillways could act as chutes. If the Villa de Mesa dam is not constructed, the natural ditch should be improved with a concrete ditch 6' across the top and 3' deep with a capacity on its probable minimum slope of about 160 cfs. Because of the steep

To this figure should be added 10% for unforeseen contingencies resulting from changes in anticipated usage or in design; $3,295.50 for a recommended total of $36,250.50.

If all of the 178 acre area in this basin is allowed, the drainage cost per acre will be 36,250.50/178 or ~~,203.65 per acre.~~ MISC. 1977 FEES $1109.00

Since approx. 30 acres are now presently platted and partly built upon, the Drainage Board may elect to allow only 148 acres of drainage basin acreage in computing the cost per acre, and in that event the figure will be 36,250.50/148 or ~~$244.94 per acre.~~ MISC.

BIBLIOGRAPHY

R. Keith Hook & Assoc.; Preliminary Drainage Report for the Villa de Mesa Complex; December, 1966.

Weather Bureau, U.S. Dept. of Commerce; Rainfall Frequency Atlas Of The United States; May, 1961.

U.S. Bureau Of Reclamation; Design Of Small Dams; 1960.

Soil Conservation Service, U.S. Dept. of Agriculture; Hydrology, Part I, Watershed Planning; August, 1964.

Soil Conservation Service, U.S. Dept. of Agriculture; A Method For Estimating Volume And Rate of Runoff In Small Watersheds; January, 1968.

Elwyn E. Seelye; Data Book For Civil Engineers, Design, Volume One; Second Edition, October, 1956.

COMPUTATIONS

The Soil Conservation Service Synthetic Hydrograph method for determining peak runoff, as modified by the Bureau Of Reclamation, was used in determining the runoff quantities previously noted for checking the adequacy of existing drainage structures and sizing the ones

To this figure should be added 10% for unforeseen contingencies resulting from changes in anticipated usage or in design; $4,450.50, for a recommended total of $48,955.50.

If all of the 178 acre area in this basin is allowed, the drainage cost per acre will be 48,955.50/178 or $275.03 per acre.

Since part of the basin is now presently platted and partly built upon, the Drainage Board may elect to allow only part of the total drainage basin acreage in computing the cost per acre, and in that event the figure will be higher than $275.03 per acre.

BIBLIOGRAPHY

R. Keith Hook & Assoc.; Preliminary Drainage Report for the Villa de Mesa Complex; December, 1966.

Weather Bureau, U.S. Dept. of Commerce; Rainfall Frequency Atlas Of The United States; May, 1961.

U.S. Bureau Of Reclamation; Design Of Small Dams; 1960.

Soil Conservation Service, U.S. Dept. of Agriculture; Hydrology, Part I, Watershed Planning; August, 1964.

Soil Conservation Service, U.S. Dept. of Agriculture; A Method For Estimating Volume And Rate of Runoff In Small Watersheds; January, 1968.

Elwyn E. Seelye; Data Book For Civil Engineers, Design, Volume One; Second Edition, October, 1956.

COMPUTATIONS

The Soil Conservation Service Synthetic Hydrograph method for determining peak runoff, as modified by the Bureau Of Reclamation, was used in determining the runoff quantities previously noted for checking the adequacy of existing drainage structures and sizing the ones

that will be required. The basic degree of risk assumption is that design is for 2 inches of rainfall in one hour over the entire basin, this representing approximately a 50 year storm frequency, as shown in the Rainfall Frequency Atlas. From the same source it appears that 1.6 inches of rainfall may be expected in 30 minutes, for a 50 year storm frequency, or a rate of 3.2 inches of rainfall per hour as a possibility during a half hour period. For smaller time periods the rate could be higher yet.

From Design Of Small Dams the basic equation used is $Q_p = 484\ AQ/T_p$ in which Q_p is peak flow at point of interest in cfs, A is area of drainage net above point of interest in square miles, Q is total runoff in inches, and T_p is the time in hours from the start of rise until the peak rate of runoff is reached. In these computations, per the usage established by R.K. Hook previously, a value of 1.7 inches is used for Q. T_p is derived from $T_p = D/2 + 0.6T_c$ in which D is duration of rainfall, assumed as one hour, and T_c is the time of concentration of runoff at the point of interest from the most distant point of the drainage net, derived from the nomograph on Page 47, Design Of Small Dams. For use of this nomograph the factor L is the length of the longest watercourse in the drainage net and the factor H is the difference in elevation in the drainage net, both in feet. In these computations the critical assumption is obviously that of using 1.7 as the value for Q, as established by Hook. Using the SCS Graphical Solution for the relationship between direct runoff Q and potential runoff (or rainfall) P, shown as Fig. 10.1 in Hydrology, Part I, Watershed Planning, a Q value of 1.7 resulting

from a P value of 2 inches per hour requires a curve number of about 97 which would normally be applicable only to impervious surfaces. However, if one assumes that the "half hour" rate of 3.2 inches per hour is used as a P value, then for a Q value of 1.7 only a curve number of about 86 is required; and this seems more reasonable, though still conservative, for urban development areas such as this one. The computations for runoff result in the following:

Sub-basin	Area-Acres	Area-Sq.Mi.	L-Feet	H-Feet	T_c-Hours	T_p-Hours	Q-inches	Q_p-C.F.S.
1	69.7	0.108	2,900	106	0.22	0.62	1.7	143.1
2	16.3	0.025	2,500	110	0.17	0.60	1.7	34.3
3	16.5	0.026	1,600	90	0.12	0.57	1.7	37.4
4	31.3	0.049	2,200	140	0.14	0.58	1.7	69.5
5	10.0	0.016	1,200	70	0.09	0.55	1.7	23.9
6	28.6	0.045	1,400	90	0.10	0.56	1.7	66.2
7	5.5	0.008	300	10	0.02	0.50	1.7	13.2
Totals	177.9							387.6

Ditch and culvert capacity computations were based on the Manning Formula and cross-checked against manufacturer's handbook data. For concrete surfaces an "n" value of 0.015 was selected.

CONCLUSIONS

Unless some extraordinary circumstances over the next few years result in very high density building construction with accompanying impervious parking areas over a high percentage of the drainage basin considered here, the runoff figures used should represent a 50 year storm frequency risk as a basis for drainage facility design. On this basis

the existing drainage structures all are adequate and some are considerably oversized. Nearest to critical, perhaps, is the 4' x 4' box culvert which presently carries the major portion of the runoff of this drainage area to Fountain Creek; but because of its position at the low end of the system it can function as a pressure conduit should the necessity arise.

(should be enlarged)

In running a comparison of runoff figures by the Rational Method on the assumption that the "half hour" rainfall rate of 3.2 inches per hour would prevail, the several sub-basins showed runoff coefficients ranging from 64% to 75%; reasonable for this sort of development.

1. General report is OK
2. The 4x4' box section should be enlarged
3. The 48" CMP pipe should be replaced by ditch @ ½ the cost
4. Some cost should be allocated for improvement of [illegible] creek channel. The cost per acre should be increased to allow for these items as well as detailing some of the acreage that is already developed, since we cannot collect fees on these.

[illegible signature]

slope just below the proposed dam location, a stilling basin of some sort will be in order at the transition from steep slope to relatively flat valley section, and can best be determined by the designer at that time.

Westerly from the Villa de Mesa dam and lake there will be required about 1,050' of concrete ditch 6' across the top and 3' deep with a capacity on minimum slope of about 92.5 cfs. Of the total flow in the easterly 550 feet will be 96.9 cfs, and in the westerly 500 feet will be 83.7 cfs. The remaining flow in sub-basin I will be overland to the lake, and will amount to 51.2 cfs. On the possibility that the dam may not be constructed, the proposed concrete ditch from point C to point A could be extended some 520 feet to the outfall of the above mentioned culvert. In addition to these major facilities the grassed swales to be developed as part of the park and walkway portion of the Villa de Mesa will require numerous smaller culverts under walkways and drives, perhaps 400' of 18" CMP average size.

COST ESTIMATE

Above point F:	275'	concrete ditch @	10.00	2,750.00
Above point E:	335'	concrete ditch @	9.00	3,015.00
	1	headwall @	350.00	350.00
Above point D:	500'	concrete ditch @	9.00	4,500.00
	1	headwall @	350.00	350.00
Point C to point B:	480'	concrete ditch @	7.00	3,360.00
Point C to point A:	440'	concrete ditch @	8.00	3,520.00
Above point A:	1,050'	concrete ditch @	7.00	7,350.00
	2	drop inlets @	400.00	800.00
	400'	18" (av.) CMP @	7.00	2,800.00
	520'	concrete ditch @	8.00	4,160.00
Total estimated costs for this basin				$32,955.00

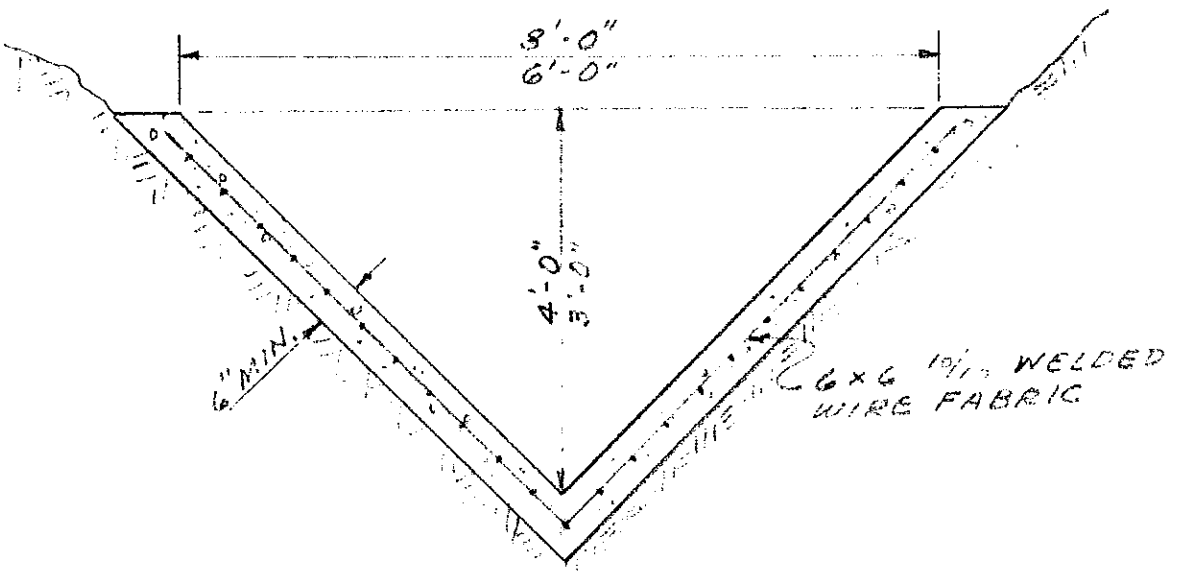
slope just below the proposed dam location, a stilling basin of some sort will be in order at the transition from steep slope to relatively flat valley section, and can best be determined by the designer at that time.

Westerly from the Villa de Mesa dam and lake there will be required about 1,050' of 42" RCP or 48" CMP with one drop inlet about 550 feet west of the lake and another one 500 feet farther on. Flow in the easterly 550 feet will be 96.9 cfs, and in the westerly 500 feet will be 83.7 cfs. The remaining flow in sub-basin I will be overland to the lake, and will amount to 51.2 cfs. On the possibility that the dam may not be constructed, the proposed concrete ditch from point C to point A could be extended some 520 feet to the outfall of the above mentioned culvert. In addition to these major facilities the grassed swales to be developed as part of the park and walkway portion of the Villa de Mesa will require numerous smaller culverts under walkways and drives, perhaps 400' of 18" CMP average size.

COST ESTIMATE

Above point F:	275'	concrete ditch @	10.00	2,750.00
Above point E:	335'	concrete ditch @	9.00	3,015.00
	1	headwall @	350.00	350.00
Above point D:	500'	concrete ditch @	9.00	4,500.00
	1	headwall @	350.00	350.00
Point C to point B:	480'	concrete ditch @	7.00	3,360.00
Point C to point A:	440'	concrete ditch @	8.00	3,520.00
Above point A:	1,050'	48" CMP @	18.00	18,900.00
	2	drop inlets @	400.00	800.00
	400'	18" (av.) CMP @	7.00	2,800.00
	520'	concrete ditch @	8.00	4,160.00
Total estimated costs for this basin				$44,505.00

why not ditch @ $8.00/FT ?



NO SCALE

DITCH DETAILS

N

SCALE 1"=500'

6100

6000

5200

FREEWAY

FTN. CREEK

VILLA DE MESA DEVELOPMENTS

1

2

3

4

5

6

7

66.2

143.1

34.3

68.5

3.2

30"ϕ

72"ϕ

4'x4'

5'x4'

6'x6'

A

B

C

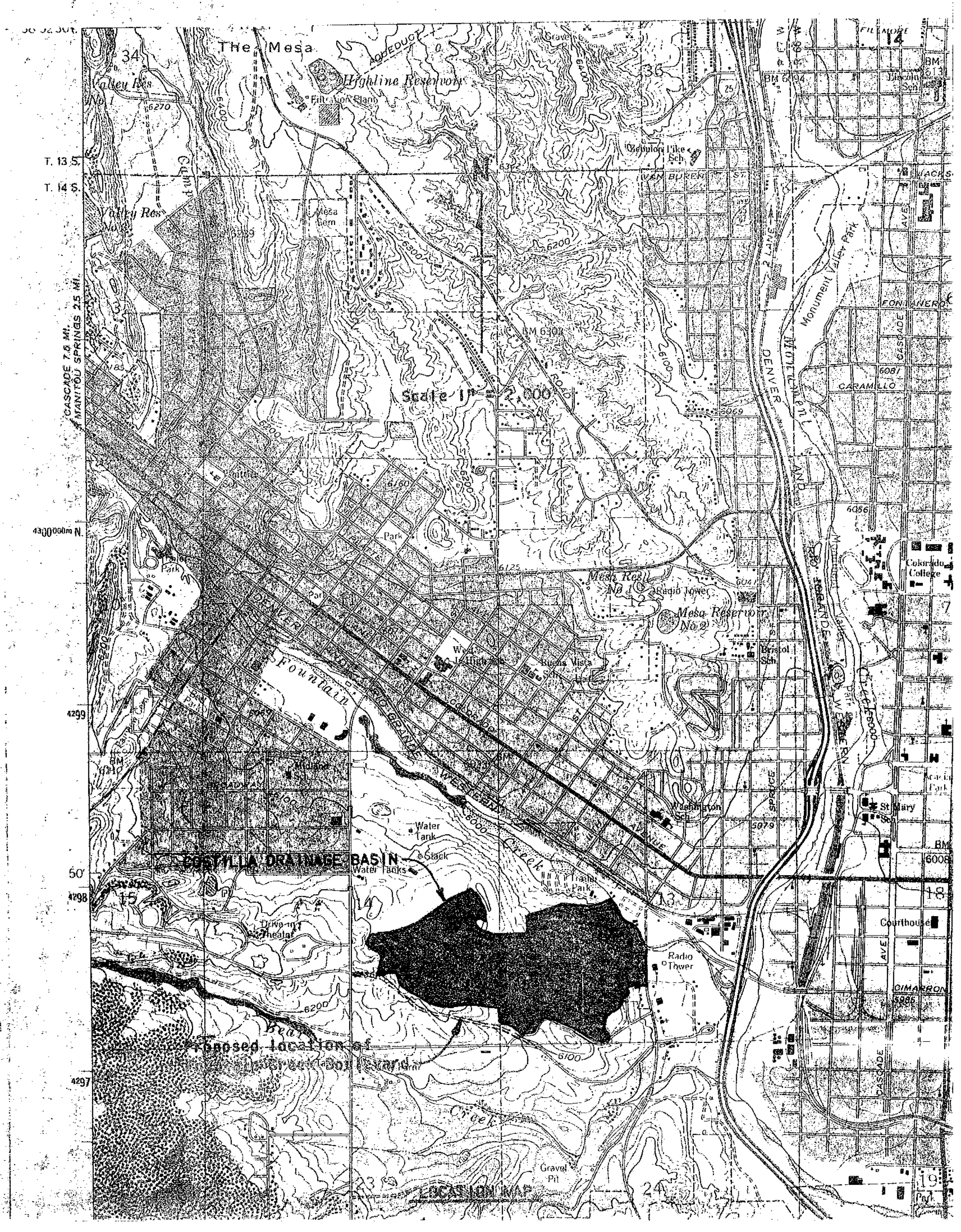
D

E

F

H

BASIN MAP



The Mesa
Highline Reservoir
Filtration Plant
T. 13 S.
T. 14 S.
Valley Res No 1
Mesa Cem
CASCADE 7.5 MI.
MANITOU SPRINGS 2.5 MI.
Scale 1" = 2,000'
DENVER
Monument Valley Park
FONTANERO
CARAMILLO
Mesa Res No 1
Radio Tower
Mesa Reservoir No 2
Colorado College
Bristol Sch
Buena Vista Sch
Fountain
Creek
Midland Sch
Washington Sch
Water Tank
Stack
Water Tanks
COSTILLA DRAINAGE BASIN
Trailer Park
Radio Tower
Courthouse
CIMARRON
Proposed location of
Gravel Pit
LOCATION MAP
4300000m N.
4299
4298
4297