

CITY ENGINEERING/STORMWATER
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MASTER DEVELOPMENT DRAINAGE PLAN
for
CRESTONE DEVELOPMENT

July, 1997
Revised August, 1997

**MASTER DEVELOPMENT DRAINAGE PLAN
for
CRESTONE DEVELOPMENT**

**July, 1997
Revised August, 1997**

Project No. 97003

Prepared for:

**CRESTONE DEVELOPMENT COMPANY
P.O. Box 1208
Colorado Springs, CO 80901**

Prepared by:

**OBERING, WURTH & ASSOCIATES
Consulting Civil Engineers
Professional Land Surveyors**

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Onsite Facilities Drainage Plan

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Consulting Civil Engineers
Professional Land Surveyors

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August, 1997

Project No. 97003

City of Colorado Springs
Department of Planning & Development
Engineering Division
101 W. Costilla, Suite 22
P.O. Box 1575, Mail Code 1119
Colorado Springs, CO 80901

Attn: Mr. Gary Haynes
Mr. Brian Kelly

Re: Master Development Drainage Plan
Crestone Development/Northwest corner of
Garden of the Gods Road and Centennial Boulevard Intersection

Gentlemen:

Attached for your review and comment is a copy of the Master Development Drainage Plan (MDDP) which has been prepared for the referenced project. It is resubmittal of the report that was originally submitted to the City in July of 1997. The main purpose of the MDDP is to provide an overall plan indicating both existing and proposed drainage facilities that will be utilized to safely convey stormwater runoff to the development's designated design outfall points. All existing and proposed drainage facilities were evaluated in accordance with the criteria presented in the most current edition of the City of Colorado Springs Drainage Criteria Manual.

The attached report is a compilation of information obtained from various construction plans and reports provided by the City of Colorado Springs, various hydrologic and hydraulic evaluation performed by Obering, Wurth & Associates, and decisions jointly made by all parties involved with this project.

Additions to this report include the following:

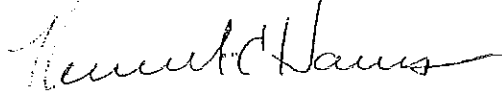
- The City of Colorado Springs review comments have been addressed.
- An "Onsite Facilities Drainage Plan" has been prepared and evaluated.
- Additional analysis of the proposed Velcon outfall storm sewer system has been accomplished.

It is the desire of the Owner/Developer to obtain approval of the MDDP as soon as possible in order that they may proceed with the development of the tract and the installation of the required public drainage facilities.

Hopefully all of the issues have been satisfactorily addressed so that the report can be approved in the near future.

If you need additional information or have any questions, please do not hesitate to contact the undersigned.

Very truly yours,
OBERING, WURTH & ASSOCIATES

A handwritten signature in black ink, appearing to read "Kenneth C. Harrison". The signature is written in a cursive style with a long horizontal flourish at the end.

Kenneth C. Harrison, P.E.

KCH/p

cc: Crestone Development Co., John Gatto

Obering, Wurth & Associates


Consulting Civil Engineers
Professional Land Surveyors

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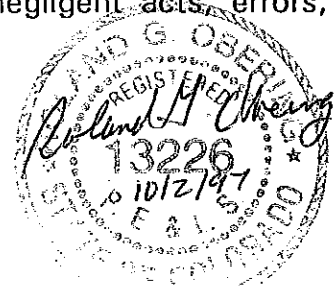
Master Development Drainage Plan
Crestone Development / Northwest
Corner of Garden of the Gods Road and
Centennial Boulevard Intersection
Project No. 97003

ENGINEER'S STATEMENT

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the City for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors, or omissions on my part in preparing this report.



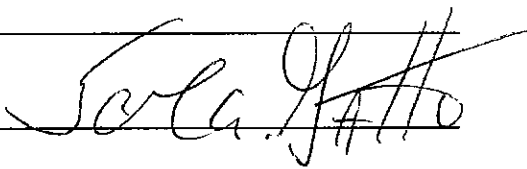
Roland G. Obering, P.E. & P.L.S. Colorado 13226



DEVELOPER'S STATEMENT

I, the Developer, have read and will comply with all the requirements specified in this drainage report and plan.

Business Name
WW2.COM LLC

By


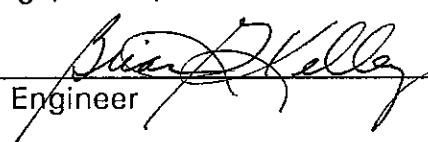
Manager
Title

Address
P.O. Box 1208

Colorado Springs, CO 80901

CITY OF COLORADO SPRINGS

Filed in accordance with Section 15-3-906 of the Code of the City of Colorado Springs, 1980, as amended.



City Engineer

Date 10/10/97

Conditions:

The public offsite systems for the Velcon outfall and the Garden of the Gods Road are to be installed upon development of any parcel within the 23 acre or 7 acre tract, respectively.

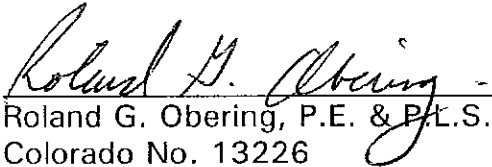
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Master Development Drainage Plan
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FLOODPLAIN STATEMENT

To the best of my knowledge and belief, no portion of the Crestone Development is located within the designated floodplain as designated by the Flood Insurance Rate Map Panel No. 513 of 1300 dated March 17, 1997 (see Appendix, FEMA Exhibit).



Roland G. Obering, P.E. & P.L.S.
Colorado No. 13226

I. PURPOSE

The purpose of the following study is to present an analysis of the drainage characteristics of the Crestone Development site located at the Northwest corner of the Garden of the Gods Road and Centennial Boulevard intersection. Both existing and developed conditions were evaluated. The following will be provided in this report:

- A limited hydrologic analysis of offsite areas that impact either the project's onsite or outfall drainage facilities.
- A limited hydraulic analysis of existing drainage facilities in order to identify issues that may effect the ability of the project's outfall system to accommodate additional stormwater runoff.
- A hydrologic and hydraulic analysis of onsite conditions and facilities in sufficient detail so as to prepare an overall drainage plan. This plan will specify drainage facilities that will be required to safely convey developed flow to acceptable offsite drainage facilities.

The analysis was preformed with the use of pertinent information obtained from the major drainage basin planning study, final drainage reports prepared for developments that impact the drainage characteristics of the project site, and available construction plans prepared for existing drainage facilities that will be utilized as part of the project's drainage plan.

II. GENERAL

A. LOCATION

The Crestone development project is located along the Garden of the Gods Road corridor, West of Interstate 25 in Section 23, Township 13 South, Range 67 West. (See Vicinity Map, Appendix.) The development is bounded on the North by Centennial Boulevard and Pinon Valley Industrial Park Filing No. 1; on the East by Centennial Boulevard, on the South by Garden of the Gods Road, and on the West by the undeveloped portion of the Kaman Sciences property.

B. PROJECT DESCRIPTION

The Crestone Development project consists of approximately 30 acres of undeveloped property. The site generally slopes from the Northwest to the Southeast with an average cross slope of approximately 2.5%. Vegetation generally consists of native grasses and weeds. Onsite soils consist of predominantly Ascalon Sandy Loam and Chaseville gravelly loam which are included in the Hydrologic Soil Group B and A respectively. These soils types are typically well drained with a high erosive potential. (See SCS Soils Map Exhibit, Appendix.)

C. LAND USE

The entire project area, approximately 30 acres, is currently unplatted and undeveloped. A concept plan (File Number CPC P97-78) was approved by City Planning Commission on March 6, 1997. City Council also approved the rezoning on April 8, 1997. The property is currently zoned with a combination of PIP-1 and PBC-2 (Planned Industrial Park and Commercial). The concept plan proposes the following land uses; research and development, retail, hotel, and convenience/service centers. The entire site has recently been graded per the Grading/Erosion Control Plan dated 2/21/97.

D. PROJECT PHASING

There is currently no established project phasing plan for the development of the 30 acre tract. Phasing for the development will be accomplished on an "as needed" basis.

III. DATA SUMMARY

Data was obtained from various sources. The data was used to identify outfall drainage facilities, to evaluate the capacities of existing drainage systems, to evaluate hydrologic and hydraulic factors that impact the project site, and to determine street capacities where required. The following is a summary of the data that was obtained and reviewed.

A. DOUGLAS CREEK DRAINAGE BASIN PLANNING STUDY (DBPS)

(Refer to Appendix for Excerpts from the DBPS)

Date Prepared: March 1981

Prepared by: Leigh Whitehead and Associates

Hydrological Method: Modified Soil Conservation Service method with a Type IIA storm with a 5 year and 100 year designation.

Criteria: City of Colorado Springs Criteria for Determination of Storm Runoff, March 1977.

Comments:

The project is located in major Subbasin F2. Runoff from F2 flows across the subbasin in a Southeasterly direction to the Subbasin's Southeasterly corner. At the time the DBPS was prepared a 48 inch storm sewer carried the stormwater under Garden of the Gods Road and discharged it into an existing 48 inch storm sewer system located in Centennial Drive. This system discharged the stormwater in Douglas Creek approximately 2,500 feet South of Garden of the Gods Road. Since the DBPS preparation date several changes to the outfall system have occurred. The 48 inch pipe under Garden of the Gods Road was replaced with a 4 foot high by 7 foot wide reinforced concrete box culvert as part of the most recent Garden of the Gods roadway improvements project.

The following is a summary of the hydrological factors regarding Subbasin F2:

Drainage Area	95 acres
Land Use	Industrial
SCS Curve No.	86 (Industrial Land Use with 72% impervious)
Time of Concentration	20 minutes
Peak Flow 5 year storm	121 cfs
Peak Flow 100 year storm	275 cfs

In accordance with the drainage criteria that was in effect at the time of preparation of the DBPS the 5 year design storm was used to size all storm system facilities. Therefore the storm sewer system located under the Garden of the Gods Road and along Centennial Boulevard was sized for the anticipated 5 year design flow of 121 cfs. The 100 year storm was only analyzed when the anticipated flow was greater than 500 cfs and it was used only to size channels, bridges and major culvert crossings. Therefore, since the anticipated 100 year flow in the DBPS was only 275 cfs, no analysis regarding storm routing, street capacities, and effect on downstream facilities was performed.

Since the date of the DBPS the drainage criteria has changed substantially. The criteria currently requires that the 100 year storm be evaluated with respect to overland routing, allowable street capacities, and effect on downstream drainage facilities. This analysis was performed as part of this report. A summary will be presented in subsequent sections of this report.

**B. GARDEN OF THE GODS ROAD CORRIDOR IMPROVEMENTS
FINAL DRAINAGE STUDY**

(Refer to the Appendix for FDR Excerpts)

Date Prepared: May 18, 1990

Prepared by: Monument Valley Engineering, Inc. (MVE)

Hydrological Method: Rational Method for drainage areas less than 100 acres.

Criteria: City of Colorado Springs Drainage Criteria Manual date 1981.

Comments:

The MVE drainage study was prepared in conjunction with the Garden of the Gods Improvements project that installed roadway and drainage improvements along Garden of the Gods Road to approximately 200 feet West of the Centennial Boulevard intersection. The data in this study was evaluated in order to obtain current information regarding design storm flows at the project outfall. As stated above, the project outfall also coincides with the outfall for Subbasin F2 as designated in the DBPS. Unfortunately only the narrative portion of the M.V.E, Inc. report could be obtained. The drainage map was not available from MVE or the City of Colorado Springs. The following is a summary of the information obtained from the study:

Drainage Area	71.4 acres
Land Use Existing	Vacant/Undeveloped
Runoff Coefficients	$C_{10} = 0.37$; $C_{100} = 0.46$
Future Land Use	Industrial

Runoff Coefficients	$C_{10} = 0.64$; $C_{100} = 0.71$
Time of Concentration (Existing)	36.3 min. to 40.4 min.
Time of Concentration (Future)	19.3 min. to 21.3 min.
Peak Runoff Existing Condition	$Q_{10} = 60.5$ cfs; $Q_{100} = 121.1$ cfs
Peak Runoff Future Condition	$Q_{10} = 150.3$ cfs; $Q_{100} = 262.7$ cfs

The MVE report stated that in order to accommodate the anticipated developed runoff from upstream sources a storm sewer culvert was required to be installed parallel to the existing 48 inch pipe under Garden of the Gods. The report evidently was limited to the evaluation of this culvert since the report also recommended that the existing storm sewer downstream of the Garden of the Gods Road crossing be evaluated for capacity constraints. Based on the information obtained from the narrative portion of the report it was apparent that this Garden of the Gods cross culvert recommendation was based on the anticipated 100 year developed runoff from only the area shown as Subbasin F2 in the DBPS. (See Appendix - Final Drainage Study Exhibits.)

It appears that after the MVE study was approved by the City, a decision was made to replace the existing 48 inch pipe with the 7 foot wide by 4 foot high reinforced concrete box culvert. No hydrologic/hydraulic information was available regarding the sizing of this box culvert.

The above facts were reviewed with the City of Colorado Springs. As a result the City requested that the existing storm sewer system located downstream of the 4 foot by 7 foot RCB be evaluated for capacity constraints.

C. OFFSITE FINAL DRAINAGE REPORTS

In order to evaluate the storm sewer system described above it was necessary to estimate the 100 year runoff amount at the upstream end of the existing 4 foot by 7 foot RCB culvert. This was accomplished by reviewing the drainage reports that had been previously prepared and approved by the City for the properties upstream of the RCB. Since the majority of these reports only addressed the 5 year storm event, an overall analysis of the 100 year storm event was prepared as part of this report. The area that was evaluated is shown on the "Offsite Facilities Drainage Plan" which is included in the map pocket of this report. This area extends well beyond the limits of the F2 Subbasin shown on the DBPS. This extended area was studied since significant bypass occurs at Point #1 and Point #3 for the 100 year storm event.

D. CONSTRUCTION PLANS

Construction plans were obtained for existing offsite drainage systems. They are identified as follows:

- Centennial Boulevard, prepared by UPE dated November 1983.
- Garden of the Gods Roadway Improvement Plans, prepared by MVE, Inc.

Overall storm sewer maps were also obtained from the City of Colorado Springs. Utility maps were also reviewed in order to determine approximate locations of existing utilities that could potentially impact the construction of proposed drainage facilities. Pertinent information that was obtained from these plans were duplicated on the attached drainage plans.

IV. HYDROLOGIC ANALYSIS

A. CRITERIA

The hydrologic criteria used in this analysis was based on the criteria set forth in the current City of Colorado Springs Drainage Criteria Manual for an MDDP level of effort. Previously prepared drainage reports were reviewed in order to verify runoff coefficients, times of concentrations, and anticipated discharges for both the minor 5 year storm event and the major 100 year storm event. Since the majority of the previously prepared drainage reports were prepared under older and now obsolete drainage criteria the entire contributing offsite area was evaluated in accordance with current City of Colorado Springs drainage criteria.

Methods

The Soils Conservation Service Method was used for estimating runoff amounts for offsite flows since the total drainage area was greater than 100 acres. The Rational Method was used for estimating runoff amounts for drainage areas less than 100 acres. This method was mainly used to size onsite storm sewer facilities.

Runoff Coefficients

Runoff coefficients for both hydrological methods were obtained from the City of Colorado Springs Drainage Criteria Manual. These coefficients were also compared with those used in previously prepared reports.

Time of Concentration

Times of concentration were determined by combining travel times for overland flow, channel flow, curb and gutter flow, and storm sewer flow where applicable. Specific charts and formulas, as presented in the DCM and the CDOT Design Manual, were used to determine the appropriate travel time for each of the above components.

Rainfall Intensities

Rainfall intensities for specific times of concentration for both the 5 year and 100 year storm events for the Rational Method were obtained from the Drainage Criteria Manual. The rainfall distribution used for the SCS method was the 24 hour SCS Type IIA storm as designated in the DCM.

B. HYDROLOGICAL ANALYSIS OF EXISTING DEVELOPMENT CONDITIONS

At the city's request, a hydrological analysis was performed for the existing development conditions (refer to Development Conditions #1) of the area upstream of the project's outfall point (Summary Point #4). This outfall point is located at the Northwest corner of the Garden of the Gods Road/Centennial Boulevard intersection. The basic purpose of the analysis was to evaluate the 100 year storm event as it impacts the project's outfall drainage system. This system includes the existing 48 inch storm sewer in Centennial Boulevard South of Garden of the Gods Road, combined with the allowable street capacity in Centennial Boulevard. This analysis was required by the City of Colorado Springs in order to meet requirements stated in the current City of Colorado Springs DCM. The analysis is limited in that it only evaluates existing development conditions of the majority of the contributing subbasin. It is recommended that as undeveloped parcels are platted and developed that individual drainage reports thoroughly address the impacts that the developed runoff will have on downstream drainage facilities.

The limits of the contributing drainage basin were determined from information obtained from field reconnaissance, existing drainage reports, and mapping provided by FIMS. The information that was obtained was summarized on the attached "Offsite Facilities Drainage Plan" which is included in the Map Pocket of this report. In summary, the total area that contributes storm water flow to the project's outfall is considerably larger (288.6 acres) than the acreage used in the DBPS (95 acres) or the acreage used in the Garden of the Gods Roadway Improvements Drainage Study (75 acres). This difference is probably due to the fact that the 100 year storm event was not evaluated in detail in either study.

Estimates for the 100 year storm event were determined at five (5) locations or summary points. A hydrological summary is presented at the end of this section of the report.

Point #1 is located along the North side of Garden of the Gods Road at the Southeast corner of the Hewlett Packard site. At this point an existing double pipe culvert carries a portion of the developed flow across Garden of the Gods discharging it into an existing 60 inch storm sewer system. This storm sewer system eventually discharges stormwater into South Douglas Creek. Storm water not intercepted by the HP outfall system bypasses Point #1 and flows in an Easterly direction to Point #2.

Point #2 is located at the Southeast corner of the Kaman Sciences property. This location corresponds to the Westerly end of a proposed storm sewer which is to be installed along the North side of the Garden of the Gods Road as part of

the Crestone Development project. The estimated storm flow at this point was used to size the proposed storm sewer.

Point #3 is located at the Northeasterly corner of the project site on the Southwest side of Centennial Boulevard. This location corresponds to the downstream end of an existing concrete channel that drains the various filings of the Pinon Valley development. The channel discharges into a 54 inch RCP culvert that crosses Centennial Boulevard in an Easterly direction. A combination 48 inch through 60 inch storm sewer system carries the storm water to North Douglas Creek. Stormwater not intercepted by the Pinon Valley outfall bypasses Point #3 and flows in a Southerly direction to Point #4A and Point #4.

Point #4 is located at the Southeast corner of the Crestone Development project site. This location corresponds to the upstream end of the existing 4 foot high by 7 foot wide concrete box culvert. As previously discussed the storm water passes under Garden of the Gods Road via the culvert and is discharged into an existing 48 inch storm sewer system which carries the water in a Southerly direction, eventually discharging it into the South Douglas Creek Channel. This discharge point is located approximately 2500 feet South of Garden of the Gods along Centennial Boulevard. The resultant flow at Point #4 was determined by estimating the anticipated 100 year storm flow at Point #4 for the entire 285 acre basin and the subtracting the estimated capacities of the existing storm sewer facilities at Summary Points #1 and #3. The results of this analysis will be presented and discussed in subsequent sections of this report.

Point #4A is located on the Westerly side of Centennial approximately 700 feet North of Garden of the Gods Road. This location corresponds to the upstream end of the storm sewer system, identified in this report as the Velcon outfall system. It consists of two (2) twenty foot wide inlets connected by small horizontal elliptical pipe. An 18 inch storm sewer extends in an Easterly direction along the Northerly property line of the Velcon Subdivision and discharges into North Douglas Creek.

A "Hydrologic Summary Table" was prepared and has been included in the "Hydrologic Summary Exhibits" of the Appendix. It presents a summary of the hydrological analysis that was performed based on existing conditions of development (Development Condition #1).

C. HYDROLOGIC ANALYSIS OF FUTURE DEVELOPMENT CONDITIONS

A hydrologic analysis was performed for three (3) future development conditions within the drainage subbasin that contributes stormwater flow to the basin's existing outfall point (Point #4). The first development condition is referred to in this report as Development Condition #1. It is based on existing

development conditions and was addressed in the previous section of this report. The goals of the analysis were established as follows:

- Evaluate capacities of existing storm sewer facilities that transports stormwater outside the boundaries of the drainage subbasin being studied (ie. HP outfall and the Pinon Valley outfall).
- Size proposed storm sewer facilities along the Southerly boundary of the Crestone development.

The analysis was limited to only several development conditions of the area located East of the HP outfall point (Summary Point #1) and South of the Pinon Valley outfall point (Summary Point #3). Analysis of development conditions West of the HP outfall point and North of the Pinon Valley outfall point was beyond the scope of this report. It was assumed that runoff from development to the West of the HP outfall and North of the Pinon Valley outfall would be accommodated by the construction of additional drainage facilities as required so that no bypass would occur by Point #1 and #3. This assumption is consistent with the analysis presented in the Douglas Creek Drainage Basin Planning Study since no bypass of the 100 year storm event was discussed in the DPBS. 100 year storm flows at the Point #4 were estimated by determining the total flow from the entire subbasin and subtracting the anticipated capacities of the HP outfall and the Pinon Valley outfall. The following summarizes the various development conditions analyzed.

Development Condition #2

This development condition reflects existing development of areas West of the HP outfall and North of the Pinon Valley outfall and full development of the 30 acre Crestone Development property. This condition was used to evaluate downstream capacities of the existing 48" drainage system along Centennial Boulevard South of Garden of the Gods Road.

Development Condition #3

This development condition reflects existing development of areas West of the HP outfall and North of the Pinon Valley outfall and full development of all areas East of the HP outfall (Point #1). This includes full development of the remaining portion of the HP tract, the Kaman Sciences tract, and the 30 acre Crestone Development tract. This analysis was used to size the proposed storm sewer facilities which are to be constructed along the Northerly side of Garden of the Gods from the Southeast to the Southwest property corner of the Crestone Development.

Future Development Condition #4

This development condition reflects the same as was described for future development condition #3. The only difference is a change in the location of the outfall point. As will be discussed in subsequent sections of this report, a portion of the runoff from the Crestone Development will be redirected from outfall Point #4 to outfall Point #4A. This was required due to capacity constraints of the existing outfall system downstream of Point #4.

Future Onsite Development Conditions

The Rational method was used to estimate runoff amounts for both the 5 year storm and 100 year storm events from the developed 30 acre Crestone project site. The estimated flows were used to size onsite drainage facilities. An "Onsite Drainage Facilities Plan," included in the map pocket of this report, was prepared based on the approved concept Development Plan. The development conditions that were evaluated for future onsite development conditions reflect those conditions described in "Future Development Condition #3." The anticipated flow at the pertinent design points are shown in tabular form on the attached "Onsite Drainage Facilities Plan."

V. HYDRAULIC ANALYSIS

A. CRITERIA

The following criteria was used in the evaluation of existing and proposed drainage facilities pertinent to the project. These facilities include streets and storm sewers which are to be utilized in the accommodation of developed flow produced by the 100 year storm event. All criteria was obtained from the City of Colorado springs DCM.

Street Capacity Analysis

The streets that were evaluated were Garden of the Gods Road and Centennial Boulevard. Garden of the Gods Road was evaluated along the Southerly property line of the Crestone Development. Centennial Boulevard was evaluated from Garden of the Gods South to the Douglas Creek crossing. This section of Centennial Boulevard was evaluated in order to determine the total combined capacity of both the street section and storm sewer facility. The section of Centennial Boulevard located North of Garden of the Gods Road was not included in this evaluation since runoff from the Crestone site does not impact this section of street. Both Garden of the Gods and Centennial Boulevard were evaluated under the criteria established for the 100 year storm for arterial streets. This criteria is summarized as follows:

- Maximum depth of flow at flowline is 8 inches for street sections on grade.
- Maximum depth of water at low points on sump conditions is 12 inches and 4 inches maximum depth at crown which ever is more restrictive.

The hydraulic capacities of the street sections were evaluated for the 100 year event only. An evaluation of the 5 year storm event within Garden of the Gods Road and Centennial Boulevard was not accomplished since the flow from the project for the 5 year event is to be completely intercepted by the proposed interior storm sewer system prior to leaving the project site. Street flow was established by subtracting the storm sewer capacity where applicable from the estimated 100 year flow being evaluated.

Street capacities for Centennial Boulevard were determined from actual field cross-section obtained by Obering, Wurth & Associates. Overflow conditions at the low point at the Centennial Boulevard/Garden of the Gods intersection were determined also with the use of field information obtained at this intersection.

Storm Sewer Design

Storm sewers, both existing and proposed, were hydraulically evaluated based on principals of uniform open channel flow. It is anticipated that losses through manholes, fittings, etc. will be minimized as a result of the relatively high velocities that typically pass through these structures.

Existing and proposed storm sewer systems are shown on the attached drainage plans. The evaluation of the existing storm sewer located in Centennial Boulevard, South of Garden of the Gods Road, was accomplished with information obtained from the Centennial Boulevard construction plans. The evaluation of the HP outfall system and the Pinon Valley outfall system was accomplished with information obtained from the overall storm sewer facilities maps obtained from the City of Colorado Springs.

B. HYDRAULIC ANALYSIS OF EXISTING DRAINAGE FACILITIES

A hydraulic analysis of the HP outfall system, the Pinon Valley outfall system, and the Centennial Boulevard outfall system was performed per the City of Colorado Springs request. The purpose of the analysis was to estimate bypass amounts for the 100 year storm event at the HP outfall and Pinon Valley outfall points and to determine impact that this bypass would have on the Centennial Boulevard outfall facility. The following summarizes the results of the analysis.

HP Outfall Drainage Facilities

The HP outfall system consists of two 34 inch by 53 inch horizontal elliptical concrete pipes under Garden of the Gods Road at Point #1. These pipes discharge into a 60 inch storm sewer system that extends from Garden of the Gods Road to the outfall into Douglas Creek. The capacity constraints of the existing system were determined based on the anticipated 100 year flow at the upstream end of the double pipe culvert. Based on this assumption it was determined that the double pipe culvert under Garden of the Gods Road was the controlling factor in determining the capacity constraints of this outfall system. The culverts have an estimated capacity of 220 cfs. An evaluation of the efficiency of the existing private and public storm system, located upstream of the double culverts, to intercept the entire 220 cfs is beyond the scope of this report. It is recommended that prior to the development of the properties to the West of the HP outfall that these upstream systems be evaluated. Bypass flows at the HP outfall were determined by subtracting the estimated pipe capacity from the total anticipated flow.

Pinon Valley Outfall Drainage Facilities

The Pinon Valley outfall facility is located at the Northeast corner of the Crestone Development site (Summary Point #3). It consists of a 54 inch RCP culvert under Centennial Boulevard that discharges into a 48 inch pipe. This system outfalls into the North Douglas Creek channel through a section of 60 inch RCP. Upstream of the 54 inch culvert is a small concrete lined channel that carries stormwater runoff from developed properties located West and North of Point #3. The concrete channel has a bottom width of 2.0 feet and a depth of 2.5 feet and is constructed on a slope of 2.8%. Based on this information it is estimated to have a capacity of 195 cfs with 0.5 feet of freeboard. The capacity of the outfall system was determined to be limited by assuming inlet control conditions at the upstream end of the existing 54 inch culvert under Centennial Boulevard. Based on an allowable headwater to depth ratio of 1.2 the capacity of the existing 54 inch culvert is approximately 120 cfs. A total flow for the 100 year event was estimated at 194 cfs at Point #3 under existing developed conditions. Based on estimated capacity of 120 cfs the bypass at Point #3 was estimated to be 74 cfs. It was assumed that this bypass would be prevented from entering the Crestone Development at Point #3 and be directed along the Westerly flow line of Centennial Boulevard where it will flow in a Southerly direction to Point #4A and to Point #4.

Centennial Boulevard Outfall Drainage Facilities

The Centennial Boulevard outfall facilities consist of a 4 foot by 7 foot concrete box culvert under Garden of the Gods Road. This culvert discharges into a 48 inch reinforced concrete pipe storm sewer facility that extends from Garden of the Gods Road, South along the Westerly side of Centennial Boulevard, and eventually outfalling into the Douglas Creek channel along the East side of Centennial Boulevard. This storm sewer outfall facility accommodates stormwater from the Crestone Development site, bypass flow from the HP outfall and Pinon Valley points, and stormwater from various developments located along the Westerly side of Centennial Boulevard and South of Garden of the Gods. These areas are shown on the attached drainage plan.

Based on information obtained from the City of Colorado Springs the culvert under Garden of the Gods was sized to accommodate the anticipated 100 year flow from developed properties upstream of the culvert within drainage subbasin F2. However, the design flow did not include bypass amounts from the HP outfall and the Pinon Valley outfall. It also appears that the 48 inch storm sewer system downstream of the culvert was not evaluated as part of the Garden of the Gods improvement project for capacity constraints. It was assumed that the capacity

of this system would be evaluated by others as upstream properties were developed.

Therefore, per the City's request, a limited hydraulic analysis of the Centennial Boulevard outfall system was performed as part of this report. Information regarding storm sewer characteristics was obtained from the Centennial Boulevard construction plans. The capacity of the 4 foot by 7 foot concrete box culvert was determined to be 158 cfs based on a headwater depth ratio of 1.0. Once the storm water was inside the box the capacity of the box, assuming free outfall conditions, was estimated to be greater than 400 cfs, well in excess of even the developed 100 year flow. The 48 inch storm sewer system in Centennial Boulevard was constructed with slopes ranging from 0.75% to 4.0% with capacities of 135 cfs and 310 cfs respectively. The limiting capacity of the 48 inch storm sewer is 135 cfs which occurs in the section of 48 inch pipe immediately downstream of the box culvert. Therefore since the anticipated flow for the 100 year storm event under existing development conditions is estimated to be 216 cfs, the downstream facilities do not have the capacity to accommodate even existing flows. As a result, several options regarding the installation of additional facilities were investigated.

Velcon Outfall Drainage Facilities

The upstream end of this system is located at Summary Point #4A on the drainage plan. The system consists of two (2) 20 foot wide inlets, a 15 inch reinforced concrete pipe between the inlets and a 24 inch outfall pipe that extends from Centennial Boulevard, along the Northerly side of the Velcon Subdivision, to an outfall point in the North Douglas Creek concrete channel section. This system was installed in conjunction with the Garden of the Gods improvement project and apparently is only sized to accommodate street flows from Centennial Boulevard. Hydrologic or hydraulic information regarding the sizing and/or design of this facility was not made available. In order to evaluate the hydraulic characteristics of the existing drainage system the following analysis was performed.

Street Capacity Centennial Boulevard

Criteria:	8 inches of depth at the flowline for the 100 year storm event
Street Cross-Slope:	2%
Street Longitudinal Slope:	0.5% (from available mapping sources)
Estimated Capacity:	27 cfs

accommodate the 100 year developed flow from developed properties upstream of this point.

- A Master Development Drainage Plan (MDDP) should be prepared for properties West of the HP outfall point in order to determine the anticipated 100 year flow at point #1 for various upstream development conditions.
- The properties that utilize this outfall system should be required to install sufficient drainage facilities so that the 100 year flow can be contained within the storm sewer system.
- All bypass at the outfall point should be eliminated with the construction of sufficient drainage facilities in order to be consistent with the recommendations made in the DBPS.
- A hydraulic analysis of drainage facilities recommended above is beyond the scope of this project.

Pinon Valley Outfall Drainage Facilities

- Evaluate the existing system storm sewer facilities located in Centennial Boulevard upstream of the 54 inch culvert.
- Install additional drainage facilities to prevent bypass of street flow at Point #3 in order to be consistent with the recommendations made in the DBPS.
- Evaluate the 100 year flow from development to the North in order to determine street capacity constraints in Centennial Boulevard.
- A hydraulic analysis of drainage facilities recommended above is beyond the scope of this report.

Centennial Boulevard Outfall Drainage Facilities (South of Garden of the Gods Road)

In order to evaluate the Centennial Boulevard outfall system a determination of the combined capacity of the street cross-section and the 48 inch storm sewer was made at several locations along Centennial Boulevard from Garden of the Gods Road South to the Douglas Creek Crossing. Street capacities were evaluated based on actual field cross-sections of the street. The following assumptions were made and criteria used in this analysis:

- All design flows were based on the 100 year storm event.

- Street capacities were determined based on 8 inches of depth at the curb and gutter flowline.
- Sufficient inlets exist or can be installed in order to allow the maximum runoff to enter the existing storm sewer system in Centennial Boulevard.

The following conclusions were reached based on review of the street cross-sections:

- Superelevated sections from approximate Station 0+00 (located along the South side of Garden of the Gods Road) to about Station 4+50 eliminate the gutter carrying capacity along the East side of the street.
- Superelevated sections from approximately 5+50 to approximately 12+00 eliminate gutter carrying capacity along the West side of the street. It also appears that the majority of the water will cross Centennial Boulevard in an Easterly direction at the median break where the entrance to the Westwind Shopping Center is located.
- Much of the remaining portion of the street South of the Westwind driveway access has steep cross slopes that substantially limits the carrying capacity of the street under current criteria.
- It appears that surface flow along the East side of the street leaves the right-of-way and enters the Centennial West Filing No. 1 Subdivision via driveway opening. This driveway is located approximately 1500 feet South of Garden of the Gods. Therefore any increase in surface flow from the North would result in an increase in flow. This condition would increase the potential of property damage.

A summary of the street capacity analysis at Stations 1+00, 5+00, 10+00 and 16+00 has been included in the "Hydraulic Summary Exhibits" of this report.

As a result of the analysis it was concluded that, in accordance with current City of Colorado Springs Criteria, there is very little capacity in the Centennial outfall system that could be utilized to accommodate additional runoff from the Crestone Development. There was no surface carrying capacity available due to configuration of Centennial Boulevard curbs.

The results of this analysis were discussed with the City of Colorado Springs. It was decided that in order to bring the Centennial Boulevard outfall system into compliance with current criteria a parallel system would need to be constructed from the South side of Garden of the Gods to the Douglas Creek outfall. Due to the cost and this system the following decisions were made:

- Limit runoff from the Crestone Development to the existing (historical) flow.
- Redirect developed runoff from the existing outfall at Point #4, to Point #4A. It was anticipated that with some revisions to the existing Crestone onsite grading plan that this could be accomplished fairly easily.
- The City of Colorado Springs will either construct additional facilities along Centennial Boulevard South of Garden of the Gods or require upstream development to do so in order to provide sufficient outfall facilities for the remaining undeveloped properties located upstream of Point #4.

Velcon Outfall Drainage Facilities

In order to reduce the amount of storm water runoff that drains to the Garden of the Gods and Centennial Boulevard intersection it was decided to drain approximately 23 acres of the project site to Point #17 (see Onsite Facilities Drainage Plan - Map Pocket). In conjunction with the construction of drainage facilities that are required to accommodate runoff from the Crestone project it is recommended that the existing drainage facilities be modified so that additional storm water in Centennial Boulevard can be accommodated. The following analysis was performed and recommendations made:

Summary @ Point #17

Design Flow:	139.7 cfs
Outfall Pipe:	42 inch RCP @ 1.5% minimum

Summary @ Point #18

Design Flow from Point #17:	140 cfs
20 Foot D-10-R Interception Rate:	21.6 cfs
Design Flow @ #18:	161.6 cfs
Capacity of Existing 12" by 18" HERCP =	10 cfs
Remaining Flow:	151.6 cfs
Recommended Facilities:	38" by 60" HERCP

Comments:

A HERCP is recommended due to utility conflicts in Centennial Boulevard. These conflicts were identified in the preparation of a concept storm sewer plan for these outfall facilities. It is also recommended that the existing 20 foot inlet be tied into the proposed 42" or 38" by 60" HERCP via a small pipe in order to utilize the extra hydraulic capacity in the HERCP. It is recommended that the HERCP be connected to the Southerly half of the existing 20 foot wide D-10-R inlet located along the Easterly side of Centennial Boulevard.

Summary @ Point #19

Design Flow From Point #18:	161.6 cfs
Interception Rate of 20' D-10-R:	21.6 cfs
Design Flow @ #19:	183.2 cfs
Capacity of Existing 24" RCP:	34.0 cfs
Remaining Flow:	148.9 cfs
Recommended Facilities:	42" RCP @ 2.0%

Summary @ Point #20 (Centennial Commons Outfall)

Design Flow from Point #19:	183.2 cfs
Design Flow from Centennial Commons (obtained from Centennial Commons FDR):	26.0 cfs
Design Flow @ Point #2:	209.2 cfs
Capacity of Existing 24" RCP:	34.0 cfs
Remaining Flow:	175.2 cfs

Recommended Facilities: 42" RCP @ 2.8%

Comments: It is recommended that the 42" RCP storm sewer facility be installed parallel to and South of the existing 24" RCP where there exists a 7 foot wide drainage easement along the Northerly side of the Velcon property. The proposed facility is to discharge into North Douglas Creek channel located approximately 485 feet East of the Centennial Boulevard.

In summary, the recommended facilities will not only accommodate the runoff from the Crestone project site but will also accommodate additional runoff collected by the existing 20 foot wide inlet located in Centennial Boulevard.

Garden of the Gods Drainage Facilities

It is proposed to install a 48 inch storm sewer along the Northerly right-of-way line of Garden of the Gods from the Southeast to the Southwest property corner of the Crestone Development.

The storm sewer was sized to accommodate flow from the West based on the following assumptions and conditions of development:

- Existing development of properties located West of the HP outfall (Point #1).
- Full development of the properties between Point #1 and Point #2. It was assumed that these properties would be developed for industrial use.
- The street capacity of Garden of the Gods was determined by assuming 8" of depth at the curb line, a longitudinal slope of 1.5%, a cross-slope of 1.5%, and an allowable "water spread width" of 36 feet (3 lanes wide).

The pipe was hydraulically sized based on the following factors:

Total Flow at Point #2	459 cfs (see HEC-2 Runs in Appendix)
Capacity of HP outfall	220 cfs
Remaining Flow at Point #2	239 cfs
Street Capacity of Garden of the Gods Road	61 cfs
Design Flow for Storm Sewer	178 cfs

Recommendation

48" at 1.5%

Onsite Drainage Facilities

The majority of onsite facilities were designed to accommodate runoff from the 5 year storm event. Additional facilities are proposed at and near the vicinity of the development's outfall points in order to accommodate runoff from the 100 year storm event. All hydrologic and hydraulic calculations are summarized in tables indicated in the Appendix of this report or are located on the attached drainage plan.

VI. ENVIRONMENTAL ISSUES

Based on information obtained from field reconnaissance, various reports, and drainage studies, and multiple meetings with the City of Colorado Springs, there does not appear to be any environmental issues that need to be addressed in this report.

VII. CONSTRUCTION COST SUMMARY

Included in this section are Concept Cost Estimates for public drainage facilities to be constructed in Garden of the Gods Road and in Centennial Boulevard along with the Velcon outfall. A concept cost estimate for onsite facilities is also provided for information purposes only.

The offsite systems for the Velcon outfall and the Garden of the Gods Road are to be installed upon development of any parcel within the 23 acre or 7 acre tract, respectively. Currently no development schedule has been established. However, Obering, Wurth & Associates is currently under contract to prepare construction documents for both drainage systems.

Interior drainage systems are to be installed on an "as needed" basis. Currently there are no phasing or development plans for the interior parcels.

Concept Cost Estimate**Velcon Outfall Public Drainage Facilities****Project: Crestone Development #97003****Date: September 15, 1997**

Item No.	Item Description	Approx Quantity	Units	Unit Price	Total Cost	Comments and Assumptions
* 1	Sawcut and Remove 8" Concrete Curb and Gutter	60	lf	\$6.50	\$390.00	Based on a 30' wide trench
* 2	Remove Median Concrete Curb and Gutter	60	lf	\$6.50	\$390.00	Based on 30'wide trench
3	Sawcut and Remove Existing Asphalt Pavement	160	sy	\$7.50	\$1,200.00	Based on 30'wide trench
4	Remove Existing Storm Sewer Manhole	1	ea	\$500.00	\$500.00	
6	Construct Type 1 Concrete Curb and Gutter	60	lf	\$14.50	\$870.00	Based on 30'wide trench
* 7	Construct Median Concrete Curb and Gutter	60	lf	\$14.50	\$870.00	Based on 30'wide trench
8	Asphalt Pavement Repair	160	sy	\$25.00	\$4,000.00	Based on 30'wide trench, Asphalt depth to be verified
9	Install 38" by 60" HERCP Storm Sewer	85	lf	\$130.00	\$11,050.00	
* 10	Install 42" RCP Storm Sewer	485	lf	\$72.00	\$34,920.00	
12	Remove Existing Concrete Channel Wall	11	sy	\$18.00	\$200.00	Tie in to existing Douglas Creek Channel
13	Install Concrete Channel Wall	11	sy	\$85.00	\$935.00	Tie in to existing Douglas Creek Channel
14	Install Type I Concrete Box Base Manhole	1	ea	\$4,200.00	\$4,200.00	Install manhole at grade break
15	16" Waterline Lowering in Centennial Blvd	1	ea	\$20,000.00	\$20,000.00	To be verified by Water Division
16	6" Gasline Adjustment	1	ea	\$4,500.00	\$4,500.00	Estimate obtained from Gas Division
17	8" Gasline Adjustment	1	ea	\$4,500.00	\$4,500.00	Estimate obtained from Gas Division
18	34.5 KV Electric Line Adjustment	1	ea	\$6,000.00	\$6,000.00	To be verified by Electric Division
* 19	15 KV Electric Line Adjustment	1	ea	\$6,000.00	\$6,000.00	To be verified by Electric Division
20	Remove and Replace Existing Irrigation System in Median	1	ls	\$500.00	\$500.00	median irrigation system
* 21	Traffic Control	1	ls	\$6,000.00	\$6,000.00	
	Subtotal				\$107,025.00	
	Engineering & Contingencies (15%)				\$16,053.75	
	Grand Total				\$123,078.75	

Notes

- 1 The above costs do not include the following
- Construction Easements

- additional utility adjustments East of Easterly ROW of Centennial Blvd
 - Construction services
- 2 The above cost assumes that sufficient construction easements, if required, can be obtained from adjacent property owners in order to accommodate installation of the proposed facilities
 - 3 Costs for utility adjustments need to be verified by the City of Colorado Springs.

Concept Cost Estimate**Garden of the Gods Public Drainage Facilities****Project: Crestone Development #97003****Date: September 15, 1997**

Item No.	Item Description	Approx Quantity	Units	Unit Price	Total Cost	Comments and Assumptions
1	Install 48" RCP Storm Sewer	550	lf	\$88.00	\$48,400.00	Size of storm sewer to be verified upon completion of the MDDP
2	Install Type I Concrete Box Base Manhole at Upstream End of Existing CBC	1	ea	\$8,500.00	\$8,500.00	
3	Traffic Control	1	ea	\$3,000.00	\$3,000.00	
	Subtotal				\$59,900.00	
	Engineering & Contingencies (15%)				\$8,985.00	
	Grand Total				\$68,885.00	

Notes

- 1 All construction is to be accomplished North of the Garden of the Gods ROW in a storm sewer easement
- 2 No adjustments of existing utilities
- 3 The above costs do not reflect the following;
 - Land cost for easements
 - Professional services for Construction Phase
- 4 Removal and/or Relocation of existing drainage facilities within the Garden of the Gods and Centennial Blvd ROW are not included in the above estimate

Concept Cost Estimate**Public Drainage Facilities Summary****Project: Crestone Development #97003****Date: September , 1997**

Item No.	Item Description	Total Cost
1	Velcon Outfall Public Drainage Facilities	\$123,100.00
2	Garden of the Gods Public Drainage Facilities	\$68,885.00
	Grand Total Public Drainage Facilities	\$191,985.00

Concept Cost Estimate**Private Onsite Drainage Facilities****Project: Crestone Development #97003****Date: September 15, 1997**

Item No.	Item Description	Approx Quantity	Units	Unit Price	Total Cost	Comments and Assumptions
1	Install 18" RCP Storm Sewer	1900	lf	\$32.00	\$60,800.00	
2	Install 24" RCP Storm Sewer	410	lf	\$40.00	\$16,400.00	
3	Install 30" RCP Storm Sewer	1060	lf	\$45.00	\$47,700.00	
4	Install 36" RCP Storm Sewer	450	lf	\$52.00	\$23,400.00	
5	Install 42" RCP Storm Sewer	290	lf	\$58.00	\$16,820.00	
6	Install Type 1 Box Base Manhole	2	ea	\$3,200.00	\$6,400.00	
7	Install Type 3 Box Base Manhole	4	ea	\$1,800.00	\$7,200.00	
8	Install 5' D 10 R Inlet	15	ea	\$3,200.00	\$48,000.00	
9	Install 8' D 10 R Inlet	1	ea	\$3,800.00	\$3,800.00	
10	Install 12' D 10 R Inlet	1	ea	\$4,600.00	\$4,600.00	
11	Install 15' D 10 R Inlet	2	ea	\$5,200.00	\$10,400.00	
12	Install Box Base Manhole at Upstream End of 4' X 7' RBC	1	ea	\$10,000.00	\$10,000.00	
	Subtotal				\$255,520.00	
	Engineering & Contingencies (15%)				\$38,328.00	
	Grand Total				\$293,848.00	

Notes

VIII. DRAINAGE FEES

Douglas Creek Drainage Basin fees were applied to this project and are summarized as follows:

Drainage Fees: 30 acres @ \$6,133/ac. = \$ 183,990.00

Bridge Fees: 30 acres @ \$135/ac. = \$ 4,050.00

Total Drainage and Bridge Fees: \$ 188,040.00

These fees are approximate and will be finalized as each tract within the 30 acre site is platted and developed.

IX. SUMMARY AND RECOMMENDATIONS

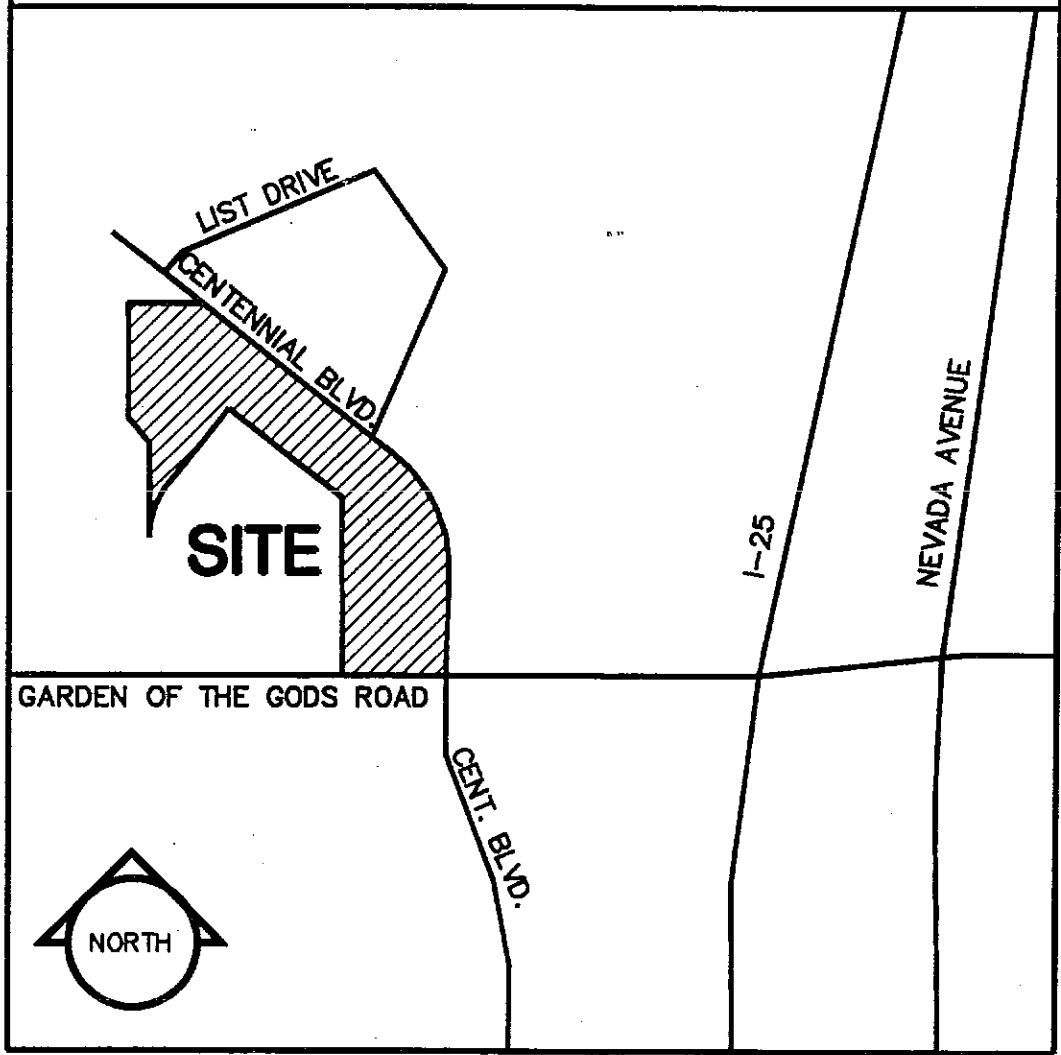
In summary, the Master Development Drainage Plan (MDDP) has established the following:

1. Based on an analysis of the major 100 year storm, the total contributing drainage area to Point #4 is approximately 288 acres which is substantially more than the drainage area determined in the Douglas Creek DBPS and the Garden of the Gods Drainage Study.
2. The increase in drainage area and various changes in drainage criteria significantly impact the drainage outfall conditions for the Crestone Development.
3. Existing drainage facilities located in Centennial Boulevard, South of Garden of the Gods Road, are not adequate to accommodate flows from the 100 year storm event for even the existing developed conditions.
4. Existing conditions along Centennial Boulevard South of Garden of the Gods cause surface flow within the street cross-section to leave the right-of-way.
5. Additional storm sewer facilities will be required to accommodate developed flow from upstream properties.
6. The HP outfall system is not adequate to accommodate developed 100 year flows from upstream properties.
7. The Pinon Valley outfall system is not adequate to accommodate developed 100 year flow from upstream properties.
8. It is recommended that an additional study be accomplished regarding developed conditions upstream of outfall Points #1 and #3.
9. The majority of the developed runoff from the Crestone Development is to be redirected to the Velcon outfall system. This system is to be supplemented with the installation of sufficient onsite drainage facilities to accommodate the developed flow.
10. Public drainage facilities are to be installed in conjunction with this project. These facilities include a 42 inch storm sewer along the Southerly property line of the Crestone Development and drainage facilities at the Velcon outfall.
11. The cost of construction of the proposed public facilities will approximately equal the drainage and bridge fees that are to be applied to this development and are in substantial conformance with the approved DBPS.

APPENDIX

VICINITY MAP

VICINITY MAP



LIST DRIVE

CENTENNIAL BLVD

SITE

GARDEN OF THE GODS ROAD

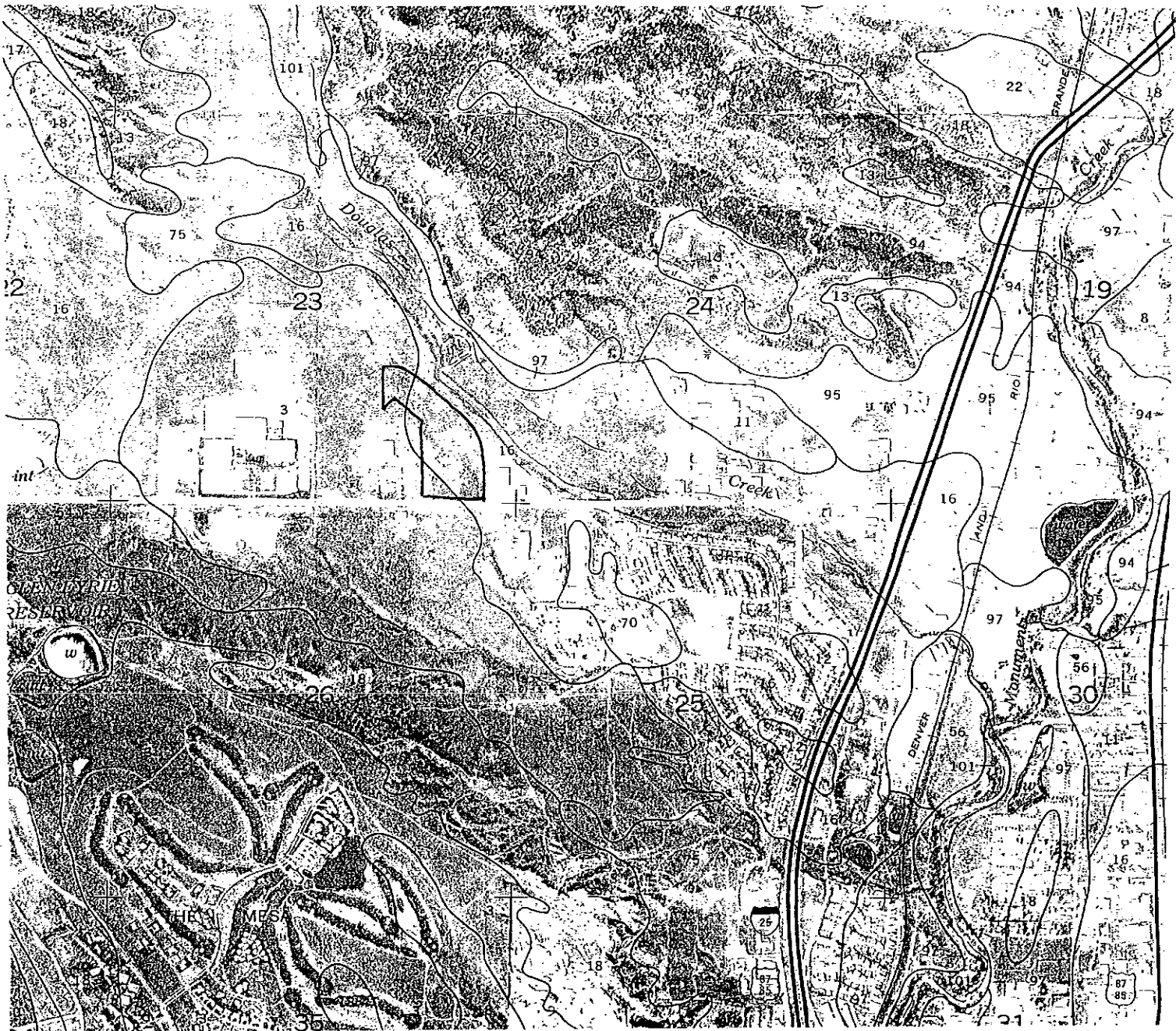
CENT. BLVD.

I-25

NEVADA AVENUE



SCS SOILS MAP



118.1
SHEET NO. 8
EL PASO COUNTY AREA, COLORADO
(PIKEVIEW QUADRANGLE)

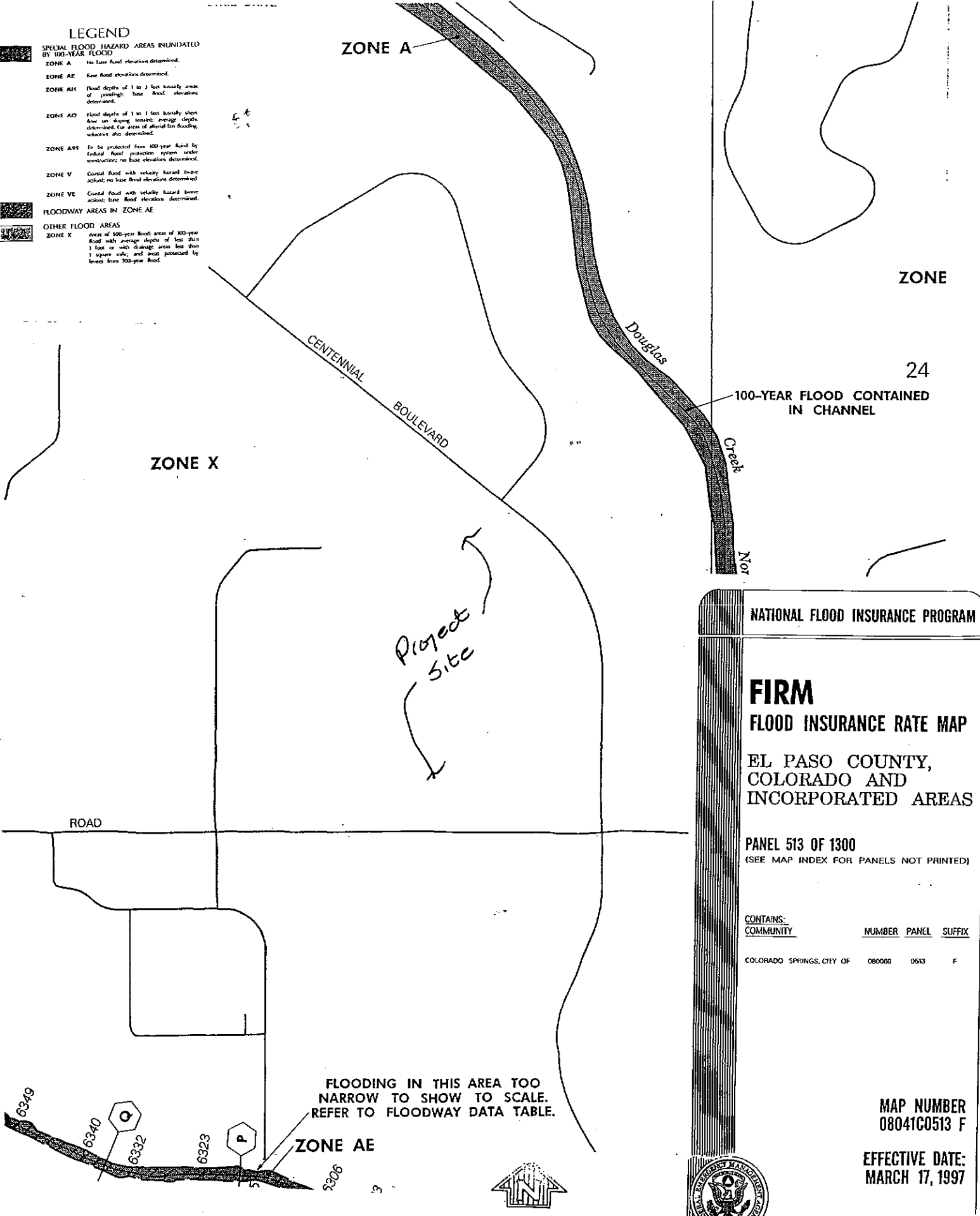
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

**FEMA FLOODPLAIN
EXHIBIT**

LEGEND

SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD

- ZONE A** Base flood elevation determined.
- ZONE AE** Base flood elevations determined.
- ZONE AH** Flood depths of 1 to 3 feet locally areas of ponding; base flood elevations determined.
- ZONE AO** Flood depths of 1 to 3 feet locally sheet flow on sloping terrain; average depths determined; for areas of ponding in flooding, velocities also determined.
- ZONE A99** To be protected from 100-year flood by federal flood protection system under construction; no base flood elevations determined.
- ZONE V** Coastal flood with velocity hazard (wave action); no base flood elevations determined.
- ZONE VE** Coastal flood with velocity hazard (wave action); base flood elevations determined.
- FLOODWAY AREAS IN ZONE AE**
- OTHER FLOOD AREAS**
- ZONE X** Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.



ZONE

24

100-YEAR FLOOD CONTAINED IN CHANNEL

ZONE X

CENTENNIAL BOULEVARD

Douglas

Creek
Not

Project Site

ROAD

FLOODING IN THIS AREA TOO NARROW TO SHOW TO SCALE. REFER TO FLOODWAY DATA TABLE.

ZONE AE

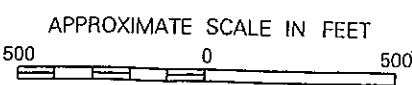
NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP
EL PASO COUNTY,
COLORADO AND
INCORPORATED AREAS

PANEL 513 OF 1300
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:	NUMBER	PANEL	SUFFIX
COMMUNITY			
COLORADO SPRINGS, CITY OF	080060	0513	F

MAP NUMBER
08041C0513 F
EFFECTIVE DATE:
MARCH 17, 1997



Federal Emergency Management Agency

**DRAINAGE BASIN
PLANNING STUDY
EXHIBITS**

**DOUGLAS CREEK
DRAINAGE BASIN**

COLORADO SPRINGS

OFFICE COPY

MARCH 1981

DATE

Submitted 11-3-81

LOCATION			EXISTING				MAXIMUM DESIGN FLOW (Q ₅)	REQUIRED				
SUB BASIN	NEAR POINT	STREET	PIPE	LENGTH	CATCH BASINS	OUTLET STRUCT.		FACILITY	LENGTH	CATCH BASINS	COMMENTS	ESTIMATED COST
F-2	-	Garden of Gods Side Kaman Sciences					40	18"@2.75% 36"@2% 42"@2% 48"@2%	400' 800' 350' 400'	2-4' 6-6'	Tie to Exist. 48" Stub. out of G. of G. ROW Cost incl. Asph. Repair	\$130,000
F-2	-	Kaman Sciences Interior	None in unplatted area. possible in improved portion.				121	W. 24"@2% 21"@1.5% 18"@1.0%	500' 500' 500'	6-6'	Reimbursable if located in public street	\$ 80,000
								E. 24"@1% 18"@2%	500' 500'	4-6'		
F-3	H-1F	Mostek Site	60"	2000'	4-8' 1-10'	Major Channel					Construction of the proposed private facilities within the site. No public facilities required.	-
F-4	H-1F	No name-Hill Prop. S. of Mostek	None	-	-	-	20	18" RCP @ 2%	200'	2-8'	No street Planned-No Master Plan Available	\$ 8,000
F-5	H-1F	Along Nat'l Drg. South of Above	None	-	-	-	17	18" RCP @ 2%	100'	2-6'	Flow can be handled in possible future road.	\$ 6,000
F-6	-	Centennial Blvd. & area West	None	-	-	-	50 121	24" RCP @ 2% 48" RCP @ 2%	500' 1100'	3-4' 2-6' 1-8' 1-12'	Outfalls into Prop. Conc. Chan. in F-13	\$135,000
F-6	-	Centennial Blvd. & Chan. Area East	None	-	-	-	210	Conc. Chan. B=D=2.75' @ 4%	500'	-		
								1 1/2:1 Sides ROW 20'				
F-7	H-2F	Centennial Blvd.	None	-	-	-	37			2-6'	Tie to major Chan. @ Bridge Structure in Master Plan	\$ 4,000
F-8	H-2F	Centennial Blvd.	54" to 24" System	1600'	4-4' 1-6' 1-10'	Major Chan. Future Imp.	50	24" RCP @ 6%	1000'	4-8'		\$ 35,000

SUMMARY OF HYDRAULICS (Facilities Inventory) - DOUGLAS CREEK DRAINAGE BASIN

EXHIBIT 7a. STORM SYSTEMS INVENTORY

NOTE: The Max. Design Flow is that Flow for which the Largest Portion of the Storm System was Sized.

SUB BASIN	AREA		Tc (Hr.)	Tpo (Hr.)	Tb (Hr.)	CURVE NUMBER (CN)	PEAK DISCHARGE (CSM/IN.)	RUNOFF (Inches)		PEAK FLOW (c.f.s.)	
	Acres	Sq.Miles						5 YR.	100 YR.	5 YR.	100 YR.
E 11	86	0.134	0.229	1.637	4.372	70	1020	0.28	1.01	38	138
12	44	0.069	0.133	1.580	4.219	84	1200	0.82	1.94	68	161
13	17	0.027	0.123	1.574	4.203	83	1220	0.765	1.86	25	61
14	74	0.116	0.197	1.618	4.288	90	1070	1.18	2.45	146	304
15	25	0.039	0.062	1.537	4.104	79	1260	0.58	1.57	29	77
16	30	0.047	0.112	1.567	4.184	90	1245	1.18	2.45	69	143
17	26	0.041	0.115	1.569	4.189	89	1240	1.115	2.36	57	120
18	19	0.030	0.112	1.567	4.184	88	1245	1.05	2.27	39	85
19	99	0.155	0.132	1.579	4.216	81	1200	0.665	1.71	124	318
(F) 1	96	0.150	0.284	1.670	4.340	88	940	1.05	2.27	148	320
* (2)	95	0.148	0.332	1.699	4.536	86	885	0.92	CRUM 2.10	150 121	263 275
3	74	0.116	0.324	1.694	4.523	88	890	1.05	2.27	108	234

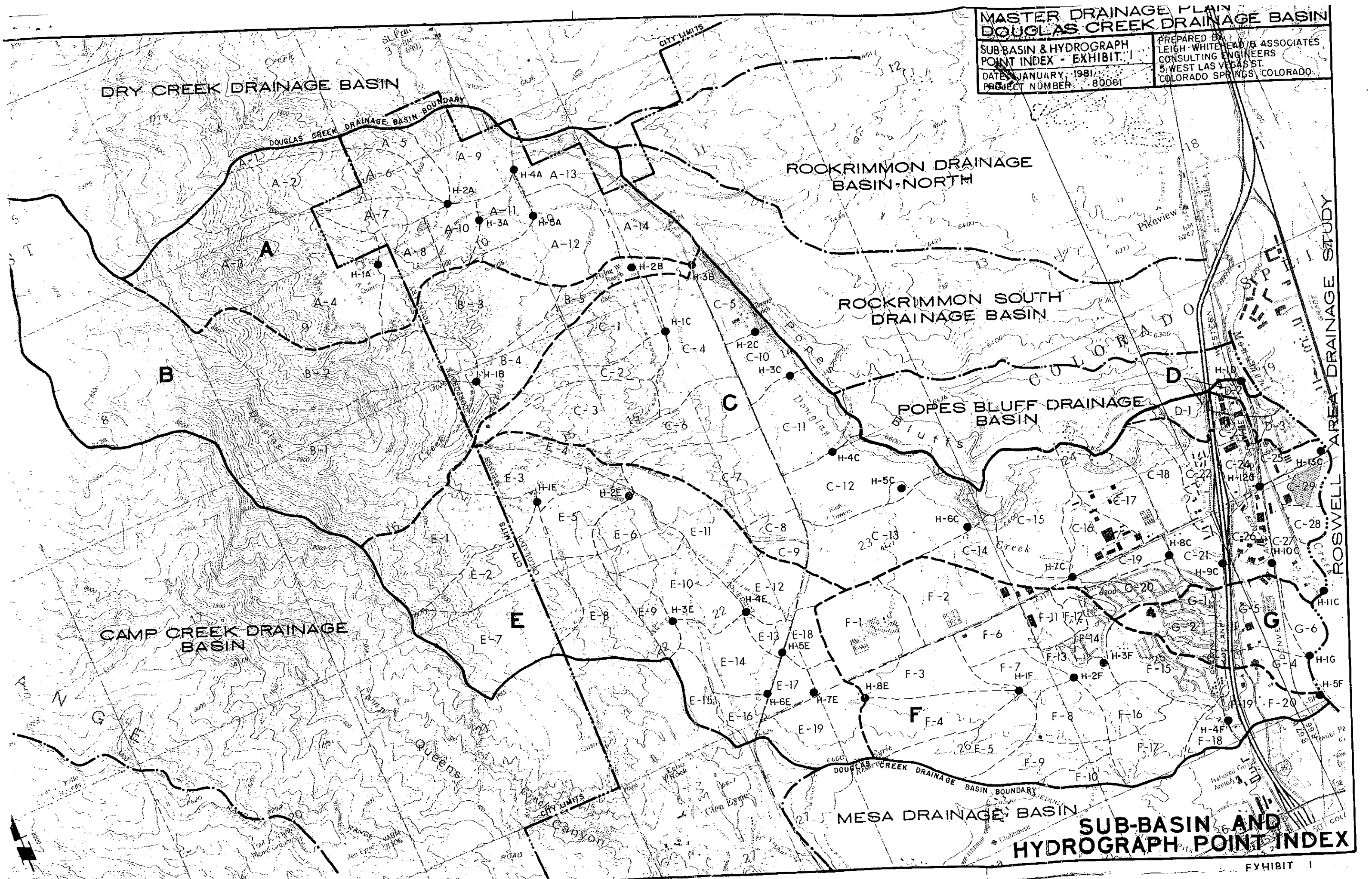
SUMMARY OF HYDROLOGIC COMPUTATIONS-DOUGLAS CREEK DRAINAGE BASIN
EXHIBIT 6a. SUB-BASIN RUNOFF

SHEET 6 OF 8



**MASTER DRAINAGE PLAN
DOUGLAS CREEK DRAINAGE BASIN**

SUB-BASIN & HYDROGRAPH POINT INDEX - EXHIBIT I	PREPARED BY LEIGH WHITEHEAD & ASSOCIATES CONSULTING ENGINEERS 5 WEST LAS VEGAS ST. COLORADO SPRINGS, COLORADO
DATE: JANUARY, 1981	
PROJECT NUMBER: 80061	



SCALE: 1" = 2000'
NAD 83 DATUM POINT

**SUB-BASIN AND
HYDROGRAPH POINT INDEX**

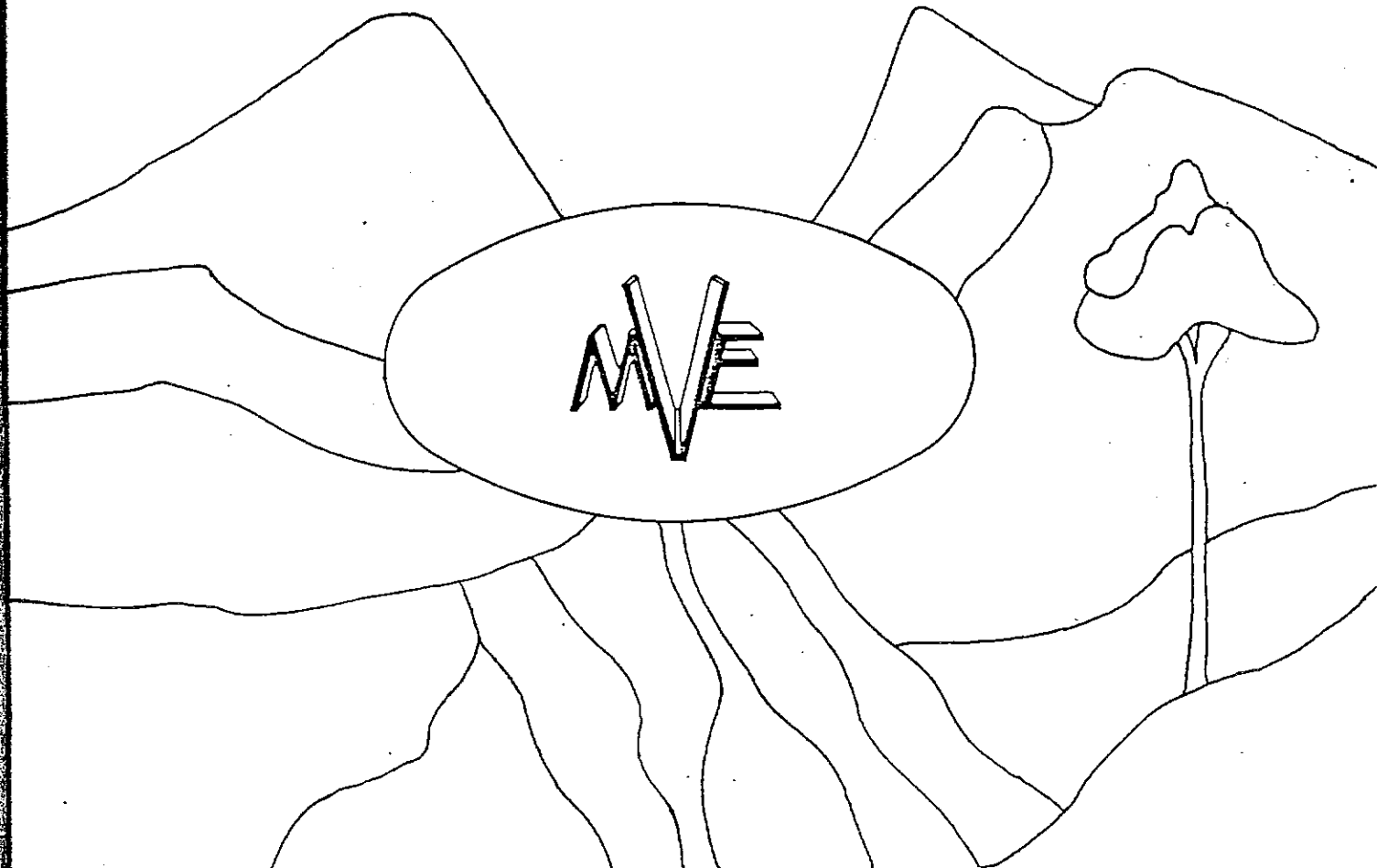
EXHIBIT I

**FINAL DRAINAGE
REPORT EXHIBITS**

Garden of the Gods Road
Corridor Improvements

Drainage Study and Report

Project No. 50624
May 18, 1990



M.V.E., Inc. has been contracted by the City of Colorado Springs Department of Public Works to prepare Engineering plans & specifications for Garden of the Gods Road Corridor Improvements. These improvements will be designed from Chestnut Street to Centennial Boulevard. A Vicinity Map (Exhibit I) and a Location Map (Exhibit II) have been included denoting the project area.

This drainage study and report has been prepared to evaluate the need and preliminary sizing of storm sewer collection systems within the project area. M.V.E., Inc. has prepared Drainage Basin Maps of the effected drainage area and proposed storm sewer collection facilities. These maps have been included within this report for your review.

The Rational Method was used as the method for computing the storm runoff in this study area. The three minor basins that effect the project area are all less than 100 acres. The Rational Method relates peak runoff to drainage area, rainfall intensity, and basin surface characteristics by the formula;

$$Q = C i A$$

Q = peak runoff rate, in cubic feet per second (cfs),

C = runoff coefficient representing a ratio of peak runoff rate to average rainfall intensity for a duration equal to the runoff time of concentration,

i = average rainfall intensity in inches per hour, and,

A = drainage area in acres.

The Rational Method is further described within the City of Colorado Springs & El Paso County Drainage Criteria Manual which has been utilized in preparing this report.

flows from minor sub-basins F-2-f, and F-2-e1 & e2. These storm water flows will be collected by the proposed curb inlets along the northern side of Garden of the Gods Road. Uncollected storm runoff flows will be collected by the existing sump catch basins on Elkton Drive in minor sub-basin E-15-a.

Future developed storm water flows into Centennial Boulevard from the F-2 basins will overload the existing storm sewer facilities in place at the intersection of Garden of the Gods Road and Centennial Boulevard. Therefore, curb inlets are proposed to intercept the storm water flows north of said intersection and convey the flows to Douglas Creek. Minor sub-basins F-2-g2, h, i2, & i3 storm water flows overland to Centennial Boulevard and via gutter flow to the proposed curb inlets. Collected flow would then be routed in a proposed storm sewer conduit to Douglas Creek.

Minor sub-basin F-2-c storm water runoff is carried via gutter along the southern side of Garden of the Gods Road and around the corner to the south on Centennial Boulevard. These flows are collected in existing curb inlets along said Centennial Boulevard.

Minor sub-basins F-2-d & p storm water runoff will flow along the southern side of Garden of the Gods Road and exit southerly at the two existing drives.

The remainder of the F-2 basin that effects storm runoff to Garden of the Gods Road is at least two-thirds undeveloped. Future development plans will set the site grading for these

areas including minor sub-basins F-2-j, k, l, m, n, o, q, r, s, & t. Presently the storm runoff ends up in a ponded sump condition at the northwest corner of Garden of the Gods Road and Centennial Boulevard. An additional storm water conduit is proposed under Garden of the Gods Road from said northwest corner and paralleling the existing 48" pipe. These facilities would then be available for future use when the remainder of F-2 basin is developed. These twin pipes would then connect to an existing 60" pipe. This 60" pipe must be checked for type and grade to establish its hydraulic capacity. Remainder of pipe under Centennial Boulevard going south is of sufficient grade to carry proposed collected flows. These facilities would then be available for future use when the remainder of F-2 basin is developed.

M.V.E., INC.

15
12
1911 Lelaray Street
COLORADO SPRINGS, COLORADO 80909
(303) 635-5736

JOB SUB-1 11 - 500 1' x 1' man 1' low fall

SHEET NO. _____ OF _____

CALCULATED BY A. Cum DATE _____

CHECKED BY _____ DATE _____

SCALE _____

PRESENT SPRING 90
SOLVE PEAK RUNOFF AT S.E. CORNER BASIN F-2-j (N.W. Cor GOC & CENT.)

WTD C - EXISTING 1990 - SPRING

BASIN	AREA (Ac.)	C ₁₀	C ₁₀ · A	C ₁₀₀	C ₁₀₀ · A
F-2-j	25.54	0.44	11.24	0.53	13.54
F-2-g	2.89	0.40	1.16	0.49	1.42
F-2-r	0.62	0.30	0.19	0.40	0.25
F-2-s	4.19	0.59	2.47	0.62	2.60
F-2-t	2.25	0.30	0.68	0.40	0.90
F-2-n	35.65	0.30	10.70	0.40	14.26
	Σ 71.14		Σ 26.44		Σ 32.97

Wtd C₁₀ = 0.37
Wtd C₁₀₀ = 0.46

OVERLAND 1000' @ 3%

C₁₀ = 0.30 T_{C10} = 32.9 min.
C₁₀₀ = 0.40 T_{C100} = 28.8 min.

Natural Channel Flow $V = \frac{1.49}{n} r^{2/3} S^{1/2}$

L = 1700' @ 2% n = 0.035 V Channel w/ 10:1 Side Slopes

Try 2' depth A = 20' P = 40.2' R = 0.5
 $V = \frac{1.49}{0.035} (0.5)^{2/3} (0.02)^{1/2} = 3.8 \text{ ft/sec} \cdot 20' = 76 \text{ cfs } \overset{T_0}{\text{BIG}}$

Try 1' depth A = 10' P = 20' R = 0.5
 $V = \frac{1.49}{0.035} (0.5)^{2/3} (0.02)^{1/2} = 3.8 \text{ ft/sec} \cdot 10 = 38 \text{ cfs } \text{OK}$

1700/38 = 447 sec 7.5 min.

Σ T_{C10} = 40.4 min. ∴ i = 2.3
Σ T_{C100} = 36.3 min. ∴ i = 3.7

Q₁₀ = (0.37) (2.3) (71.14) = 60.5 cfs
Q₁₀₀ = (0.46) (3.7) (71.14) = 121.1 cfs
PRESENT

FUTURE DEVELOPED

WTD C - Assumed FUTURE USE Same as BASIN F-2-K
C₁₀ = 0.64 C₁₀₀ = 0.71

OVERLAND - Landscaped 300' @ 4% C₁₀ = 0.25 T_{C10} = 17.4
C₁₀₀ = 0.35 T_{C100} = 15.4

M.V.E., INC.
1911 Lelaray Street
COLORADO SPRINGS, COLORADO 80909
(303) 635-5736

SHEET NO. _____ OF _____

CALCULATED BY CCU DATE _____

CHECKED BY _____ DATE _____

SCALE _____

PIPE FLOW - Assume 48" Dia @ 2800' @ 1% aug (REALISTIC)

Velocity See Fig 5 12 ft/sec.

$$2800/12 = 233 \text{ sec} = 3.9 \text{ min.}$$

$$\Sigma TC_{10} = 21.3 \quad \therefore C_{10} = 3.3$$

$$\Sigma TC_{100} = 19.3 \quad \therefore C_{100} = 5.2$$

$$Q_{10} = (0.64) (3.3) (71.14) = 150.3 \text{ cfs} \quad \text{FURNACE}$$

$$Q_{100} = (0.71) (5.2) (71.14) = 262.7 \text{ cfs}$$

PRELIMINARY AND FINAL
DRAINAGE PLAN AND REPORT
CENTENNIAL COMMONS SUBDIVISION

December 11, 1996

Revised
December 13, 1996

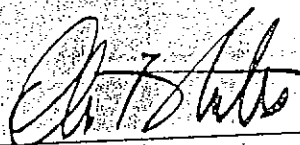
prepared for
CENTENNIAL COMMONS LLC

Oliver E. Watts
Consulting Engineer
Colorado Springs

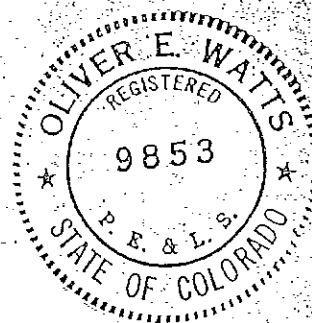
Drainage Report
Centennial Commons Subdivision

1. ENGINEER'S STATEMENT:

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the City for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.



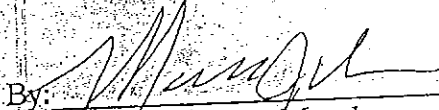
Oliver E. Watts Colo. PE-LS No. 9853



2. DEVELOPER'S STATEMENT:

The developer has read and will comply with all of the requirements specified in this drainage report.

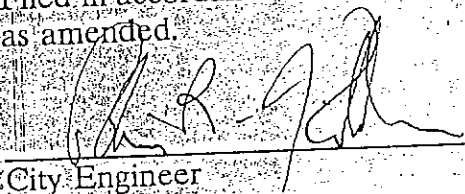
CENTENNIAL COMMONS L.L.C.



By: Michael J. Duitch, Member
1405 Big Valley Drive
Colorado Springs, CO 80919

3. CITY OF COLORADO SPRINGS:

Filed in accordance with Section 15-3-906 of the Code of the City of Colorado Springs, 1980, as amended.



City Engineer

date

12/16/96

Conditions:

Drainage Report
Centennial Commons Subdivision

4. LOCATION AND DESCRIPTION:

The Centennial Commons Subdivision is located on the easterly side of Centennial Boulevard just north of Garden of the Gods Road in part of Section 23, T.13S., R.67W. of the 6th P.M. in the City of Colorado Springs, as shown on the enclosed drainage plan, occupying 6.65 acres in the Douglas Creek Drainage basin. The basin study has been consulted and this plan is in conformance therewith. The proposed subdivision will be a commercial development with buildings as shown on the enclosed drainage plan.

5. FLOOD PLAIN STATEMENT:

This subdivision is partially within the limits of a flood plain or flood hazard area, according to FEMA map panel number 080060 0161 D, dated August 16, 1995, a copy of which is enclosed for reference. The flood plain is totally contained within an existing City owned and maintained drainage channel along the easterly property line, totally contained within an easement as shown on the enclosed drainage plan. The limits of the flood plain are shown on the enclosed drainage plan.

6. METHOD AND CRITERIA:

The method used for all computations is that specified in the City-County Drainage Criteria Manual, using the rational method for areas of the size of the subdivision, and the major basin involved. All computations are enclosed for reference and review.

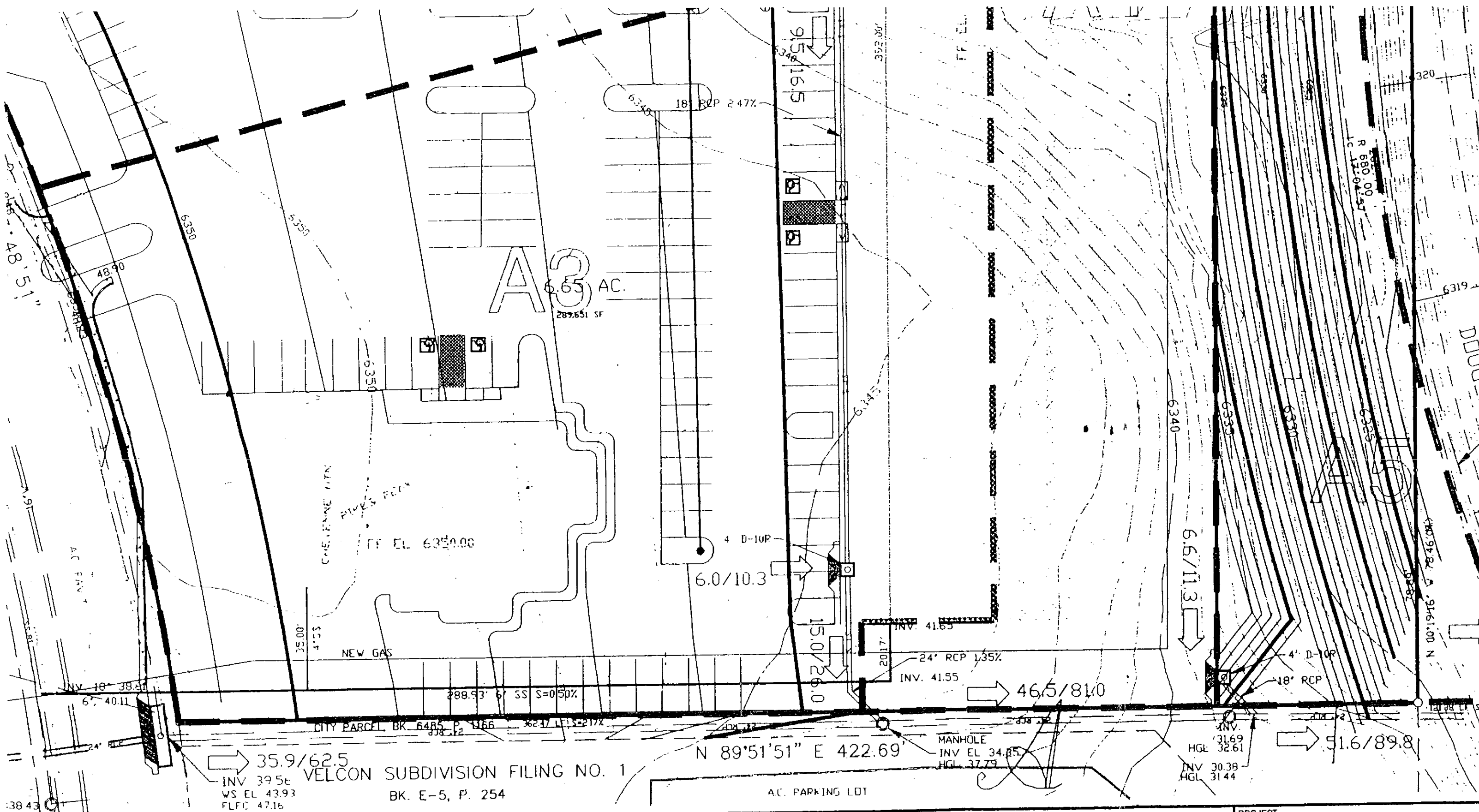
The soils in the subdivision have been mapped by the local USDA/SCS office, and a soils map and interpretation sheet are enclosed for reference. All soils in this area are of hydrologic group "A".

7. DESCRIPTION OF RUNOFF:

The runoff into the subdivision is from Centennial Boulevard, as shown on the enclosed area drainage map. The runoff at the south line of List Drive is 26.5 cfs / 45.7 cfs (5-year/100-year runoff), according to the drainage plan on file with the City for Centennial Industrial Park, filing no. 1, and as recomputed in accordance with current criteria as shown on the enclosed computations. This runoff will be increased as it progresses southerly by the runoff from the adjacent drainage basin O1 to 35.9 cfs / 62.5 cfs at the sump location of two 20' catch basins near the southwest corner of the subdivision, where a public 24" RCP storm sewer runs to the channel, exiting near the southeast corner of the subdivision.

No improvements are necessary or proposed in the existing concrete channel of Douglas Creek along the easterly line of the subdivision.

Interior runoff will be routed as shown on the drainage plan. Basins A1 through A3 will be intercepted by a private storm sewer system along the front of the larger building and routed to the existing public storm sewer described above. A manhole at the junction point is provided. Basin A4 will be routed to the southeast rear of the large building to a private catch basin, and then into the 24" RCP. Each of these catch basins and storm sewers are capable of intercepting the 100-year runoff as shown on the enclosed computations. Basin A5 will "sheet-flow" into the existing channel, being runoff from the existing reseeded



REVISIONS	12-13-96 CITY COMMENTS	DEW

OLIVER E. WATTS
CONSULTING ENGINEER
COLORADO SPRINGS

PROJECT
DANA CORP
PART SE1/4, SECTION 2
COLORAD

38.43

35.9/62.5
INV 39.5e
WS EL 43.93
FLFC 47.16

VELCON SUBDIVISION FILING NO. 1
BK. E-5, P. 254

N 89°51'51" E 422.69'

A.C. PARKING LOT

MANHOLE
INV EL 34.85
HGL 37.79

INV 31.69
HGL 32.61
INV 30.38
HGL 31.44

51.6/89.8

46.5/81.0

6.0/10.3

6.6/11.3

A3
6.63 AC.
289,651 SF

NEW GAS

COSTUME A/TN
PIPES PCOM

TF EL 6350.00

4 D-10R

2017
-24" RCP L35%
INV. 41.55

4" D-10R
18" RCP

R 680.00
LC 17.04.57

N 79°46'00" E 9161.00'

DOUGLAS

**CENTENNIAL
BOULEVARD STREET
ANALYSIS SUMMARY**

Station 1+00

A. Upstream Dev. Conditions: Exist Development

Total Flow	216 cfs
Storm Sewer Cap	125 cfs
48" @ 0.75%	"
Remaining Flow	91 cfs
Street Capacity (8" @ Curb)	92 cfs
Street Cap (12" @ Curb)	283 cfs

B. Upstream Dev. Conditions: Exist w/ Crestone

Total Flow	287 cfs
Storm Sewer Cap	125 cfs
Remaining Flow	162 cfs
Street Capacity (8" @ Curb)	92 cfs
Street Cap (12" @ Curb)	283 cfs

C. Upstream Dev. Conditions: Exist w/ Crestone & HP

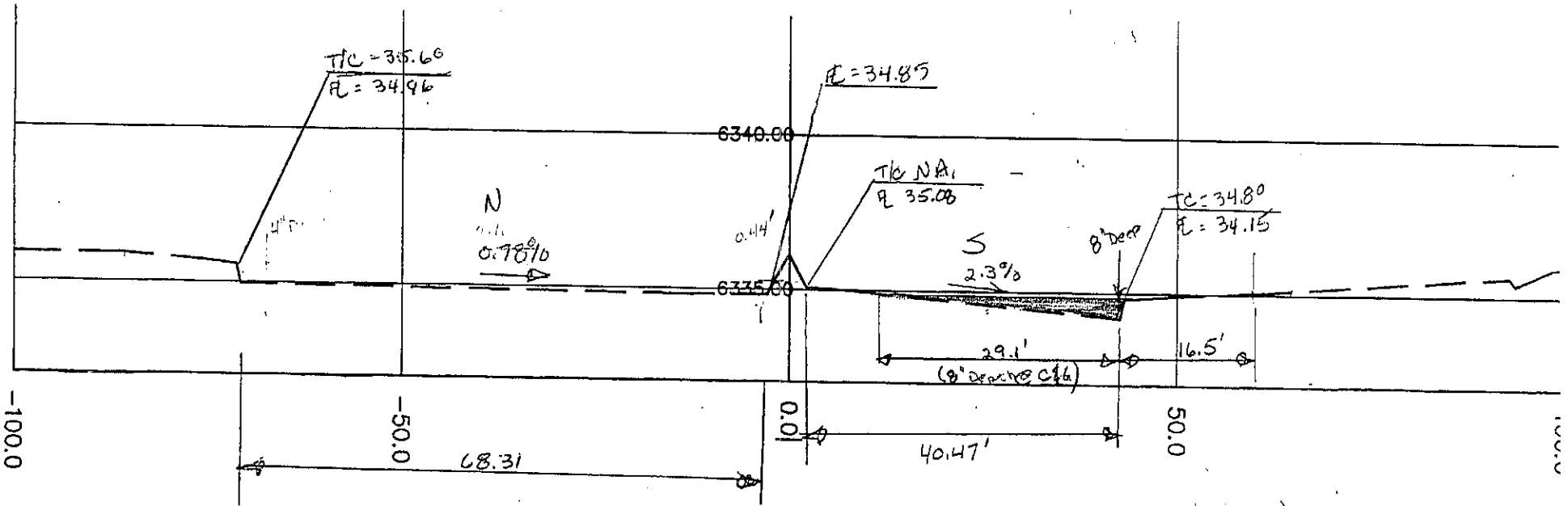
Total Flow	378 cfs
Storm Sewer Cap	125 cfs
Remaining Flow	253 cfs
Street Cap (8" @ Curb)	92 cfs
Street Cap (12" @ Curb)	283 cfs

This section is the critical section for surface flow.

The existing storm sewer can be moved out if additional inlets are placed inside street.

West E-E = 3.21%
 West Med E-E = 3.08%
 Ave = 3.15%

100.00



Street Q_{cap} = 92.4 cfs (8" Deep); 283 cfs, 12" Deep
 Storm Q_{cap} = 48" RCP (assumed) @ 0.75% = 125 cfs
 Total Cap = 217.4 cfs, 408 cfs

Obering, Wurth & Associates

Consulting Civil Engineers
Registered Land Surveyors

1015 Elkton Drive
Colorado Springs, Colorado 80907
(719) 531-6200

JOB _____

SHEET NO. 2 OF _____

CALCULATED BY _____ DATE _____

CHECKED BY _____ DATE _____

SCALE _____

Station 5+00

Problem Due to Flat longitudinal slope & Steep Cross Slope

A. Upstream Dev Conditions = Exist Dev

Total Flow =	216 cfs
Storm Sewer Cap 48" @ 1.0%	155 cfs
Remaining Flow	61 cfs
Street Cap (8" @ Curb)	24 cfs
Street Cap (12" @ Curb)	71.5 cfs

B. Upstream Dev. Condition = Exist w/ Crestone

Total Flow =	287 cfs
Storm Sewer Cap (48" @ 1.0%)	155 cfs
Remaining Flow	132 cfs
Street Cap (8" @ Curb)	24 cfs
Street Cap (12" @ Curb)	71.5 cfs

C. Upstream Dev Condition = Exist w/ Crestone & HP

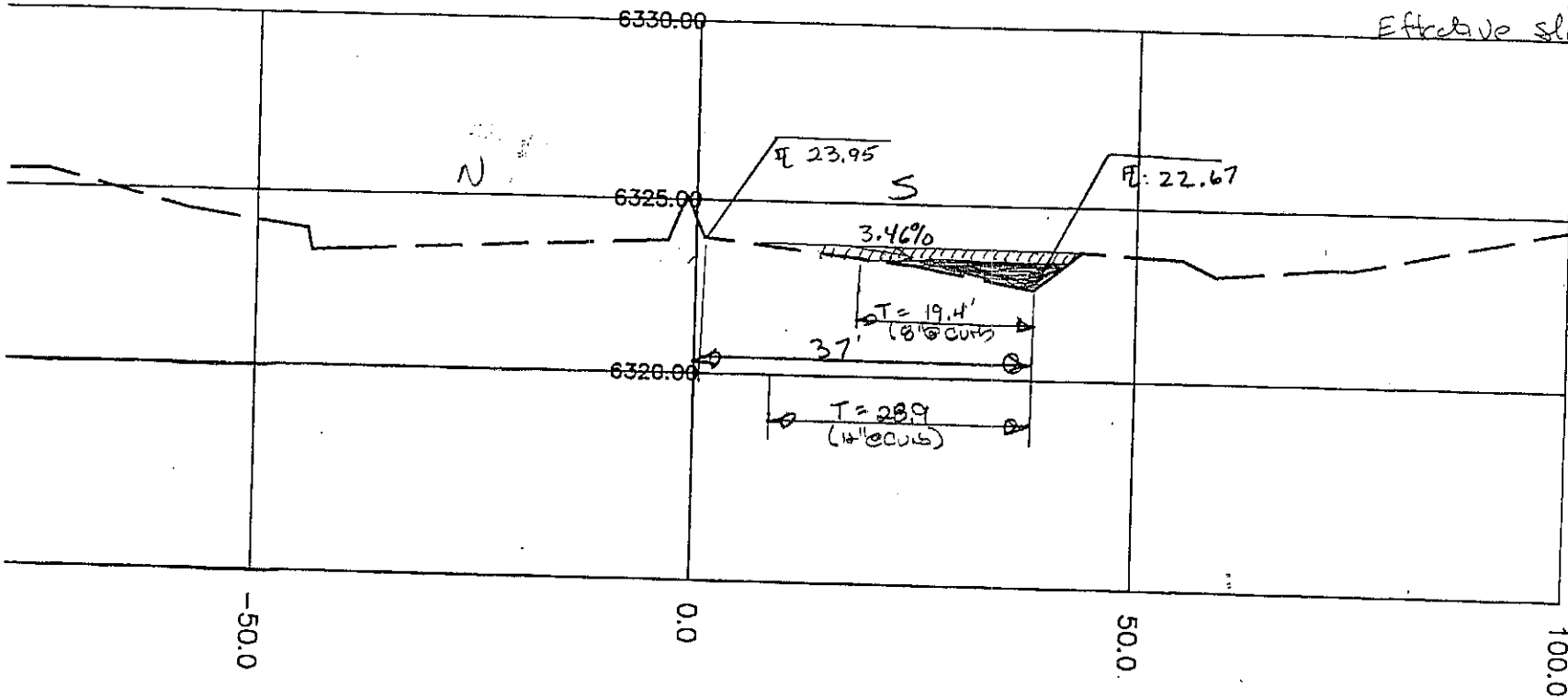
Total Flow =	378 cfs
Storm Sewer Cap (48" @ 1.0%)	155 cfs
Remaining Flow	233 cfs
Street Cap (8" @ Curb)	24 cfs
Street Cap (12" @ Curb)	71.5 cfs

500.00

West C&G = -0.09%
Med C&G = 1.05%
Ave = 0.5% ±

North Bound

South Bound



Effective slope between Section
reduces capacity

Criteria = 8" @ curbline (Problem w/ cross flow @ 6+00)
Street Cap = 23.7 cfs (8" @ curb), 71.5 cfs (12")
Storm Cap = 40" @ 1.0% = 155 cfs
Total Cap = 178.7 cfs (8"), 250.2 (12")

Additional Flow from UTM Property

A. Assumptions

Rational Method used for conservative reasons

B. Drainage Area (Assume Fully Developed)

	C _s	C ₁₀₀
Commercial	22.5	0.75
		0.85

(needs to be evaluated using HEC I model as well)

C. Time of Conc.

T_e @ #4 = 31 min

T_T Storm Sewer 1000ft @ 10fps = 1.7 min

Total T_c = 32.7 min

D. I₅ = 2.55

I₁₀₀ = 3.88

E. Q₅ = 0.75 * 2.55 * 22.5 = 43.0 cfs

Q₁₀₀ = 0.85 * 3.88 * 22.5 = 74.2 cfs

Station 10+00

(Super-elevated section - No capacity along West Side)

A Upstream Development Condition: Exist Developed

Total Flow	290.2	(includes runoff from UTM)
Storm Sewer Cap 48" @ 1.73%	206.0 cfs	
Remaining Flow	84.2 cfs	
Street Cap (8" @ Curb)	46.0 cfs	
Street Cap (12" @ Curb)	113.9 cfs	

B Upstream Development Condition: Exist + Crestone

Total Flow	361.2 cfs
Storm Sewer Cap 48" @ 1.73%	206.0 cfs
Remaining Flow	155.2 cfs
Street Cap (8" @ Curb)	46.0 cfs
Street Cap (12" @ Curb)	113.9 cfs

C Upstream Development Condition: Exist + Crestone + HP

Total Flow	452.2 cfs
Storm Sewer Cap 48" @ 1.73%	206.0 cfs
Remaining Flow	246.2 cfs
Street Cap (8" @ Curb)	46.0 cfs
Street Cap (12" @ Curb)	113.9 cfs

Station 16+00
(Typical Cross Section)

A. Upstream Development Condition - First Development

Total Flow	290.2
Storm Sewer Cap 48' @ 3.4%	275 cfs
Remaining Flow	15.2 cfs
Street Cap (8" @ Curb)	106.3 cfs (West Side)

B. Upstream Development Condition = Exist + Crestone

Total Flow	361.2 cfs
Storm Sewer Cap 48' @ 3.4%	275.0 cfs
Remaining Flow	86.2 cfs
Street Cap	106.3 cfs (West Side)

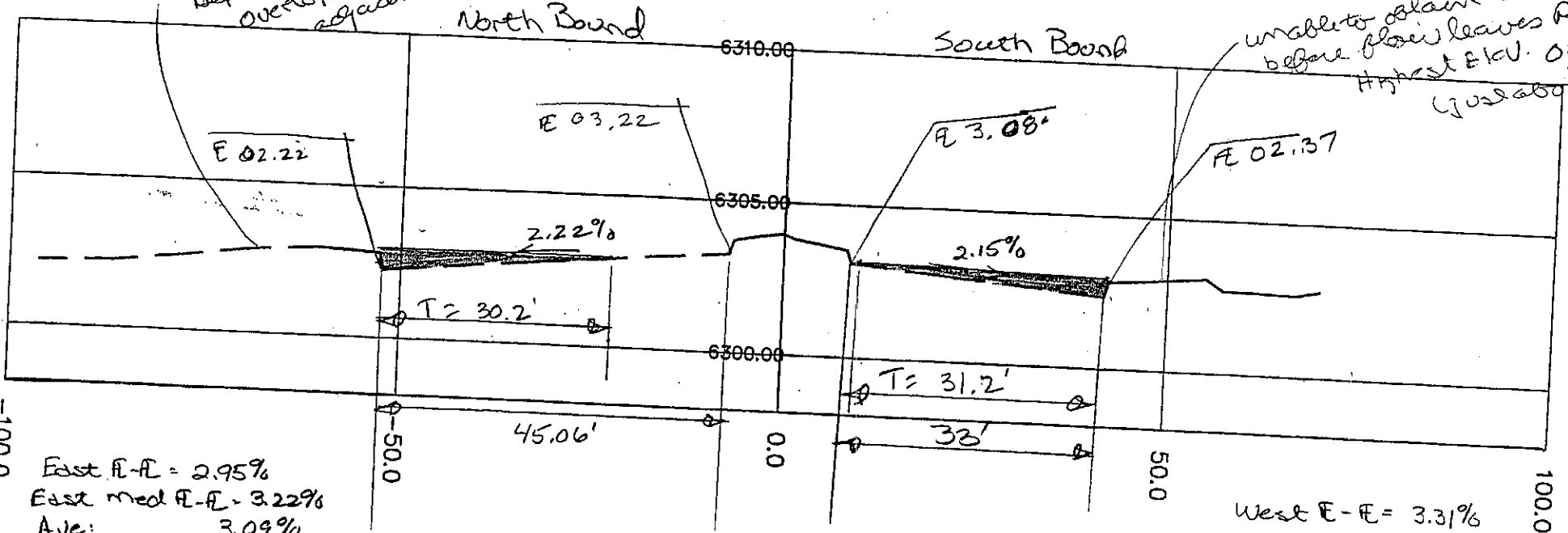
C. Upstream Development Conditions: Exist + Crestone + HD

Total Flow	452.2 cfs
Storm Sewer Cap 48' @ 3.4%	275.0 cfs
Remaining Flow	177.2 cfs
Street Cap	106.3 cfs

1600.00

unable to obtain 12" depth @ curb line overlaps adjacent property

unable to obtain 12" depth before flow leaves P.O.W. Highest Elev. 03.07 (just above 8)



Street Cap = 95.3' (8" Deep)
Street Cap = (12" Deep)

Street Cap = 106.3' (8" Deep)
Street Cap = (12" Deep)

Storm Sewer Cap
48" @ 3.4% ≈ 275'

**HYDROLOGIC
SUMMARY EXHIBITS**

HYDROLOGIC SUMMARY TABLE**CRESTONE DEVELOPMENT MDDP**

Development Conditions	Drain Area (acres)	Ave CN/C	Tc (min)	Peak Flow (cfs)	Outfall Capacity (cfs)	Bypass (cfs)	Comments
Sum Pnt #1: HP Outfall							
DC #1	135.4	80.1	27.1	283	220	63	Bypass flows to pnt #4
DC#2	Same as development condition #1						
DC#3	Same as development condition #1						
DC#4	Same as development condition #1						
Sum Pnt #2: West side of Crestone Development							
DC #1	165	83.6	29	386	220	166	Bypass flows to pnt #4
DC#2	Same as development condition #1						
DC#3	192	84.2	29	459	220	239	Bypass flow value used to size storm sewer along south side of Crestone Dev
DC#4	Same as development condition #3						
Sum Pnt #3: Pinon Valley Outfall							
DC #1	58.9	C100=0.74	26.4	194	120	74	Bypass flows to pnts 4A and 4
DC#2	Same as development condition #1						
DC#3	Same as development condition #1						
DC#4	Same as development condition #1						
Sum Pnt #4: Centennial Blvd Outfall							
DC #1	288.6	78.4	30.1	556	340	216	used to evaluate Cent outfall system under exist conditions
DC#2	288.6	81.5	30.1	627	340	287	used to evaluate both street cap and storm sewer system in Cent Blvd
DC#3	288.6	85.3	30.1	718	340	378	
DC#4	288.6	80.4	30.1	554	340	214	maintains existing conditions flow
Sum Pnt #4A							
DC #1	not evaluated						
DC#2	not evaluated						
DC#3	not evaluated						
DC#4	23	C100=0.9	15.4	122.1	NA	NA	used to size, on a prelim basis, outfall Velcon outfall facilities See Table on Onsite Facilities Drainage Plan.

Development Conditions

#1: Existing development of the entire contributing drainage area

#2: Existing development of areas west of #1 and North of #3 and full development of the 30 acre Crestone property

#3: Existing Development of areas West of #1 and North of #3 and full development of all areas East of Point #1

#4: Same as #3 except with a change in outfall point for 23 acres of the Crestone Development

Outfall Capacities

HP Outfall: 220 cfs

Pinon Valley Outfall: 120 cfs

Total Outfall = 340 cfs

RUNOFF CURVE DETERMINATION FOR EXISTING DEVELOPMENT**(DEVELOPMENT CONDITION #1)****MASTER DRAINAGE PLANNING STUDY****CRESTONE DEVELOPMENT @ GARDEN OF THE GODS AND CENTENNIAL BLVD****Date: July, 1997****Project No. 97003**

Summary Pnt	Drainage Subbasin	Area ID	Existing Land Use	Area	Curve Number	CN*A	Total Subbasin Area	Total Area @ Summ Pnt	Average CN	Comments
1	GG1	Hotsy S/D	Paved/Buildings	2.6	98	254.8				
		Hotsy S/D	Vacant/Platted	7.4	65	481.0				
		PV Indus Prk #8	Vacant/Platted	6.8	65	442.0				
		Mtn Rsrch Bus Prk #1	Industrial	2.8	94	263.2				
		Unplatted Area	Vacant	11.6	65	754.0	31.2			
GG2	Hewlett Packard	Paved/Buildings	54.8	96	5260.8					
		Vacant Platted	43.9	65	2853.5	98.7				
GG5	Garden of the Gods Road	Roadway	5.5	98	539.0	5.5				
TOTALS								135.4	80.1	
2	GG3	Unplatted	Vacant	15.2	65	988.0	15.2			
	GG4	Kaman Sciences	Industrial	12.3	88	1082.4	12.3			
	GG6	Roadway	Roadway	2.2	98	215.6	2.2			
TOTALS								29.7	77.0	
3	CE1	Mtn Shadows #28	Residential	23.0	75	1725.0	23.0			
	CE2	Corp Club Plaza	Office/Comm	5.8	92	533.6				
		30th Street	Roadway	1.5	98	147.0	7.3			
	CE3	CW Bus Prk #1	Industrial	2.4	94	225.6				
		Unplatted	Vacant	4.7	65	305.5				
		PV Indus Prk #11	Industrial	5.0	94	470.0				
		PV Indus Prk #1	Industrial	10.3	92	947.6				
		PV Indus Prk #3	Industrial	4.4	94	413.6				
	PV Indus Prk #1	Industrial	1.8	94	169.2	28.6				
TOTALS								58.9	83.8	
4	CE4	Hewlett Packard	Vacant	11.2	65	728.0	11.2			
	CE5	Kaman	Industrial	4.1	94	385.4				

TABLE4A.XLS

Summary Pnt	Drainage Subbasin	Area ID	Existing Land Use	Area	Curve Number	CN*A	Total Subbasin Area	Total Area @ Summ Pnt	Average CN	Comments
			Vacant	11.7	65	760.5	15.8			
	CE6	Crestone	Vacant	23.0	65	1495.0	23.0			
	CE6A	Crestone	Vacant	7.0	65	455.0	7.0			
	CE7	Centennial Blvd	Roadway	6.8	98	666.4	6.8			
	GG7	Garden oof the Gods	Roadway	0.8	98	78.4	0.8			
TOTALS								64.6	70.7	
		GRAND TOTALS				0.0		288.6	78.4	

RUNOFF CURVE DETERMINATION FOR EXISTING DEVELOPMENT AND CRESTONE DEVELOPMENT**(DEVELOPMENT CONDITION #2)****MASTER DRAINAGE PLANNING STUDY****CRESTONE DEVELOPMENT @ GARDEN OF THE GODS AND CENTENNIAL BLVD****Date: July, 1997****Project No. 97003**

Summary Pnt	Drainage Subbasin	Area ID	Existing Land Use	Area	Curve Number	CN*A	Total Subbasin Area	Total Area @ Summ Pnt	Average CN	Comments
1	GG1	Hotsy S/D	Paved/Buildings	2.6	98	254.8				
		Hotsy S/D	Vacant/Platted	7.4	65	481.0				
		PV Indus Prk #8	Vacant/Platted	6.8	65	442.0				
		Mtn Rsrch Bus Prk #1	Industrial	2.8	94	263.2				
		Unplatted Area	Vacant	11.6	65	754.0	31.2			
GG2	Hewlett Packard	Paved/Buildings	54.8	96	5260.8					
		Vacant Platted	43.9	65	2853.5	98.7				
GG5	Garden of the Gods Road	Roadway	5.5	98	539.0	5.5				
TOTALS								135.4	80.1	
2	GG3	Unplatted	Vacant	15.2	65	988.0	15.2			
	GG4	Kaman Sciences	Industrial	12.3	88	1082.4	12.3			
	GG6	Roadway	Roadway	2.2	98	215.6	2.2			
TOTALS								29.7	77.0	
3	CE1	Mtn Shadows #28	Residential	23.0	75	1725.0	23.0			
	CE2	Corp Club Plaza	Office/Comm	5.8	92	533.6				
		30th Street	Roadway	1.5	98	147.0	7.3			
	CE3	CW Bus Prk #1	Industrial	2.4	94	225.6				
		Unplatted	Vacant	4.7	65	305.5				
		PV Indus Prk #11	Industrial	5.0	94	470.0				
		PV Indus Prk #1	Industrial	10.3	92	947.6				
		PV Indus Prk #3	Industrial	4.4	94	413.6				
	PV Indus Prk #1	Industrial	1.8	94	169.2	28.6				
TOTALS								58.9	83.8	
4	CE4	Hewlett Packard	Vacant	11.2	65	728.0	11.2			
	CE5	Kaman	Industrial	4.1	94	385.4				

TABLE4B.XLS

Summary Pnt	Drainage Subbasin	Area ID	Existing Land Use	Area	Curve Number	CN*A	Total Subbasin Area	Total Area @ Summ Pnt	Average CN	Comments
			Vacant	11.7	65	760.5	15.8			
	CE6	Crestone	Industrial	23.0	94	2162.0	23.0			
	CE6A	Crestone	Industrial	7.0	94	658.0	7.0			
	CE7	Centennial Blvd	Roadway	6.8	98	666.4	6.8			
	GG7	Garden of the Gods	Roadway	0.8	98	78.4	0.8			
TOTALS								64.6	84.2	
		GRAND TOTALS				0.0		288.6	81.5	
								0.4509	Sq Mi	

RUNOFF CURVE DETERMINATION FOR PROPOSED DEVELOPMENT OF AREAS EAST OF HP SITE**(DEVELOPMNET CONDITION #3)****MASTER DRAINAGE PLANNING STUDY****CRESTONE DEVELOPMENT @ GARDEN OF THE GODS AND CENTENNIAL BLVD****Date: July, 1997****Project No. 97003**

Summary Pnt	Drainage Subbasin	Area ID	Existing Land Use	Area	Curve Number	CN*A	Total Subbasin Area	Total Area @ Summ Pnt	Average CN	Comments
1	GG1	Hotsy S/D	Paved/Buildings	2.6	98	254.8				
		Hotsy S/D	Vacant/Platted	7.4	65	481.0				
		PV Indus Prk #8	Vacant/Platted	6.8	65	442.0				
		Mtn Rsrch Bus Prk #1	Industrial	2.8	94	263.2				
		Unplatted Area	Vacant	11.6	65	754.0	31.2			
GG2	Hewlett Packard	Paved/Buildings	54.8	96	5260.8					
		Vacant Platted	43.9	65	2853.5	98.7				
GG5	Garden of the Gods Road	Roadway	5.5	98	539.0	5.5				
TOTALS								135.4	80.1	
2	GG3	Industrial	Industrial	15.2	94	1428.8	15.2			
	GG4	Kaman Sciences	Industrial	12.3	88	1082.4	12.3			
	GG6	Roadway	Roadway	2.2	98	215.6	2.2			
TOTALS								29.7	91.8	
3	CE1	Mtn Shadows #28	Residential	23.0	75	1725.0	23.0			
	CE2	Corp Club Plaza	Office/Comm	5.8	92	533.6				
		30th Street	Roadway	1.5	98	147.0	7.3			
	CE3	CW Bus Prk #1	Industrial	2.4	94	225.6				
		Unplatted	Vacant	4.7	65	305.5				
		PV Indus Prk #11	Industrial	5.0	94	470.0				
		PV Indus Prk #1	Industrial	10.3	92	947.6				
		PV Indus Prk #3	Industrial	4.4	94	413.6				
	PV Indus Prk #1	Industrial	1.8	94	169.2	28.6				
TOTALS								58.9	83.8	
4	CE4	Hewlett Packard	Industrial	11.2	94	1052.8	11.2			
	CE5	Kaman	Industrial	4.1	94	385.4				

TABLE4C.XLS

Summary Pnt	Drainage Subbasin	Area ID	Existing Land Use	Area	Curve Number	CN*A	Total Subbasin Area	Total Area @ Summ Pnt	Average CN	Comments
			Industrial	11.7	94	1099.8	15.8			
	CE6	Crestone	Industrial	23.0	94	2162.0	23.0			
	CE6A	Crestone	Industrial	7.0	94	658.0	7.0			
	CE7	Centennial Blvd	Roadway	6.8	98	666.4	6.8			
	GG7	Garden of the Gods	Roadway	0.8	98	78.4	0.8			
TOTALS								64.6	94.5	
		GRAND TOTALS				0.0		288.6	85.3	

RUNOFF CURVE DETERMINATION FOR EXISTING DEVELOPMENT & CRESTONE AREA CE6A ONLY**(DEVELOPMENT CONDITION #4)****MASTER DRAINAGE PLANNING STUDY****CRESTONE DEVELOPMENT @ GARDEN OF THE GODS AND CENTENNIAL BLVD****Date: July, 1997****Project No. 97003**

Summary Pnt	Drainage Subbasin	Area ID	Existing Land Use	Area	Curve Number	CN*A	Total Subbasin Area	Total Area @ Summ Pnt	Average CN	Comments
1	GG1	Hotsy S/D	Paved/Buildings	2.6	98	254.8				
		Hotsy S/D	Vacant/Platted	7.4	65	481.0				
		PV Indus Prk #8	Vacant/Platted	6.8	65	442.0				
		Mtn Rsrch Bus Prk #1	Industrial	2.8	94	263.2				
		Unplatted Area	Vacant	11.6	65	754.0	31.2			
	GG2	Hewlett Packard	Paved/Buildings	54.8	96	5260.8				
			Vacant Platted	43.9	65	2853.5	98.7			
	GG5	Garden of the Gods Road	Roadway	5.5	98	539.0	5.5			
TOTALS								135.4	80.1	
2	GG3	Unplatted	Vacant	15.2	65	988.0	15.2			
	GG4	Kaman Sciences	Industrial	12.3	88	1082.4	12.3			
	GG6	Roadway	Roadway	2.2	98	215.6	2.2			
TOTALS								29.7	77.0	
3	CE1	Mtn Shadows #28	Residential	23.0	75	1725.0	23.0			
	CE2	Corp Club Plaza	Office/Comm	5.8	92	533.6				
		30th Street	Roadway	1.5	98	147.0	7.3			
	CE3	CW Bus Prk #1	Industrial	2.4	94	225.6				
		Unplatted	Vacant	4.7	65	305.5				
		PV Indus Prk #11	Industrial	5.0	94	470.0				
		PV Indus Prk #1	Industrial	10.3	92	947.6				
		PV Indus Prk #3	Industrial	4.4	94	413.6				
	PV Indus Prk #1	Industrial	1.8	94	169.2	28.6				
TOTALS								58.9	83.8	
4	CE4	Hewlett Packard	Vacant	11.2	65	728.0	11.2			
	CE5	Kaman	Industrial	4.1	94	385.4				
			Vacant	11.7	65	760.5	15.8			

TABLE4D.XLS

Summary Pnt	Drainage Subbasin	Area ID	Existing Land Use	Area	Curve Number	CN*A	Total Subbasin Area	Total Area @ Summ Pnt	Average CN	Comments
	CE6	Crestone	Vacant	0.0	65	0.0	0.0			Area to drain to Velcon Outfall
	CE6A	Crestone	Industrial	7.0	94	658.0	7.0			
	CE7	Centennial Blvd	Roadway	6.8	98	666.4	6.8			
	GG7	Garden of the Gods	Roadway	0.8	98	78.4	0.8			
TOTALS								41.6	78.8	
		GRAND TOTALS						265.6	80.4	
								0.4150	sq mi	

Time of Concentration Calculations

Crestone Development

Date: July, 1997

Project #: 97003

Summ Pnt	Overland Travel Time				Channel Travel Time				C & G Travel Time				Strm Swr Travel Time				Cum Tc
	Length	C	Slope	Tt	Length	H1 - H2	Ave. Vel (fps)	Tt	Length	Slope	Vel	Tt	Length	Diam	Appr Vel	Tt	
1	300	0.3	3.3	18	800	28	2.7	4.9	750		10	1.3	2100	24-36	12	2.9	27.1
3	500	0.3	7	15	neg	neg	neg	neg	2000	3	5	6.7	2800	Strm & Chan	10	4.7	26.4
2													1600		12	2.2	29.3
													600		12	0.8	30.1


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*****
*
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*   MAY 1991 *
*   VERSION 4.0.1E *
*
* RUN DATE **/**/1997 TIME 00:00:** *
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*****
*
* U.S. ARMY CORPS OF ENGINEERS *
* HYDROLOGIC ENGINEERING CENTER *
*   609 SECOND STREET *
*   DAVIS, CALIFORNIA 95616 *
*   (916) 756-1104 *
*
*****
```

Runoff Determination @ Hewlett Packard Outfall
 Existing Conditions
 100 yr/ 24 hour Storm=4.6" (EX100HP.HC1)

5 IO

OUTPUT CONTROL VARIABLES

IPRNT 5 PRINT CONTROL
 IPLOT 0 PLOT CONTROL
 QSCAL 0. HYDROGRAPH PLOT SCALE

IT

HYDROGRAPH TIME DATA

NMIN 15 MINUTES IN COMPUTATION INTERVAL
 IDATE 13JUN97 STARTING DATE
 ITIME 1000 STARTING TIME
 NQ 300 NUMBER OF HYDROGRAPH ORDINATES
 NDDATE 16JUN97 ENDING DATE
 NDTIME 1245 ENDING TIME
 ICENT 19 CENTURY MARK

COMPUTATION INTERVAL 0.25 HOURS
 TOTAL TIME BASE 74.75 HOURS

ENGLISH UNITS

DRAINAGE AREA SQUARE MILES
 PRECIPITATION DEPTH INCHES
 LENGTH, ELEVATION FEET
 FLOW CUBIC FEET PER SECOND
 STORAGE VOLUME ACRE-FEET
 SURFACE AREA ACRES
 TEMPERATURE DEGREES FAHRENHEIT

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
				6-HOUR	24-HOUR	72-HOUR			
HYDROGRAPH AT	GG	283.	5.75	47.	15.	5.	0.21		

*** NORMAL END OF HEC-1 ***

LINE	ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10
1	ID Runoff Determination @ West Side of Crestone Property
2	ID Existing Conditions
3	ID 100 yr/ 24 hour Storm=4.6" (EX100CR.HC1)
4	IT 15 13JUN97 1000 300
5	IO 5 0 0
6	KK GGArea West of Crestone Property and North of Garden of the Gods
7	KM Basin Runoff from GG1,2,3,4,5,6
8	BA 0.258
9	PB 4.6
10	IN 15
11	PC .0005 .0015 .0030 .0045 .0060 .0080 .0100 .0120 .0143 .0165
12	PC .0188 .0210 .0233 .0255 .0278 .0320 .0390 .0460 .0530 .060
13	PC .0750 .1 .4 .7000 .7250 .7500 .7650 .7800 .7900 .8000
14	PC .8100 .8200 .8250 .8300 .8350 .8400 .8430 .8500 .8550 .8600
15	PC .8638 .8675 .8713 .8750 .8788 .8825 .8863 .8900 .8938 .8975
16	PC .9013 .9050 .9083 .9115 .9148 .9180 .9210 .9240 .9270 .9300
17	PC .9325 .9350 .9375 .9400 .9425 .9450 .9475 .9500 .9525 .9550
18	PC .9275 .9600 .9625 .9650 .9675 .9700 .9725 .9750 .9775 .9800
19	PC .9813 .9825 .9838 .9850 .9863 .9875 .9888 .9900 .9913 .9925
20	PC .9938 .9950 .9963 .9975 .9988 1.000
21	LS 83.6
22	UD 0.2930
23	ZZ

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*
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*   MAY 1991 *
*   VERSION 4.0.1E *
*
* RUN DATE **/**/1997 TIME 00:00:** *
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* U.S. ARMY CORPS OF ENGINEERS *
*   HYDROLOGIC ENGINEERING CENTER *
*   609 SECOND STREET *
*   DAVIS, CALIFORNIA 95616 *
*   (916) 756-1104 *
*
*****
    
```

Runoff Determination @ West Side of Crestone Property
 Existing Conditions
 100 yr/ 24 hour Storm=4.6" (EX100CR.HC1)

5 IO

OUTPUT CONTROL VARIABLES

```

IPRNT      5 PRINT CONTROL
IPLOT      0 PLOT CONTROL
QSCAL      0. HYDROGRAPH PLOT SCALE
    
```

IT

HYDROGRAPH TIME DATA

```

NMIN      15 MINUTES IN COMPUTATION INTERVAL
IDATE     13JUN97 STARTING DATE
ITIME     1000 STARTING TIME
NQ        300 NUMBER OF HYDROGRAPH ORDINATES
NDDATE    16JUN97 ENDING DATE
NDTIME    1245 ENDING TIME
ICENT     19 CENTURY MARK
    
```

```

COMPUTATION INTERVAL  0.25 HOURS
TOTAL TIME BASE      74.75 HOURS
    
```

ENGLISH UNITS

```

DRAINAGE AREA      SQUARE MILES
PRECIPITATION DEPTH  INCHES
LENGTH, ELEVATION  FEET
FLOW               CUBIC FEET PER SECOND
STORAGE VOLUME     ACRE-FEET
SURFACE AREA       ACRES
TEMPERATURE        DEGREES FAHRENHEIT
    
```


RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
				6-HOUR	24-HOUR	72-HOUR			
HYDROGRAPH AT	GG	386.	6.00	66.	21.	7.	0.26		

*** NORMAL END OF HEC-1 ***

LINE	ID	1	2	3	4	5	6	7	8	9	10
1	ID	Runoff Determination @ West Side of Crestone Property									
2	ID	Developed Conditions of Properties East of HP Outfall and West of Pnt 2									
3	ID	100 yr/ 24 hour Storm=4.6" (F100YR.HC1									
4	IT	15	13JUN97	1000	300						
5	ID	5	0	0							
6	KK	GGArea West of Crestone Property and North of Garden of the Gods									
7	KM	Basin Runoff from GG1,2,3,4,5,6,CE5									
8	BA	0.3002									
9	PB	4.6									
10	IN	15									
11	PC	.0005	.0015	.0030	.0045	.0060	.0080	.0100	.0120	.0143	.0165
12	PC	.0188	.0210	.0233	.0255	.0278	.0320	.0390	.0460	.0530	.060
13	PC	.0750	.1	.4	.7000	.7250	.7500	.7650	.7800	.7900	.8000
14	PC	.8100	.8200	.8250	.8300	.8350	.8400	.8430	.8500	.8550	.8600
15	PC	.8638	.8675	.8713	.8750	.8788	.8825	.8863	.8900	.8938	.8975
16	PC	.9013	.9050	.9083	.9115	.9148	.9180	.9210	.9240	.9270	.9300
17	PC	.9325	.9350	.9375	.9400	.9425	.9450	.9475	.9500	.9525	.9550
18	PC	.9275	.9600	.9625	.9650	.9675	.9700	.9725	.9750	.9775	.9800
19	PC	.9813	.9825	.9838	.9850	.9863	.9875	.9888	.9900	.9913	.9925
20	PC	.9938	.9950	.9963	.9975	.9988	1.000				
21	LS		84.2								
22	UD	0.2930									
23	ZZ										

Total Flow @ Pnt #2 L

Capacity of HP outfall

Remaining

459 cfs

220 cfs - assuming that change to outfall pipe to allow more water into the pipe

239 cfs

Size Pipe 54" @ 1% to accommodate 100% of flow

The size can be reduce by the street capacity

Minimal Street Capacity w/ @ a 1% cross slope & 2 lanes open

Minimal Street Capacity w/ @ 1% cross slope & 1 lane open

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* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*   MAY 1991 *
*   VERSION 4.0.1E *
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* RUN DATE **/**/1997 TIME 00:00:** *
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* DAVIS, CALIFORNIA 95616 *
* (916) 756-1104 *
*
*****
```

Runoff Determination @ West Side of Crestone Property
 Developed Conditions of Properties East of HP Outfall and West of Pnt 2
 100 yr/ 24 hour Storm=4.6" (F100YR.HC1)

5 IO

OUTPUT CONTROL VARIABLES

```
IPRNT      5 PRINT CONTROL
IPLOT      0 PLOT CONTROL
QSCAL      0. HYDROGRAPH PLOT SCALE
```

IT

HYDROGRAPH TIME DATA

```
NMIN      15 MINUTES IN COMPUTATION INTERVAL
IDATE     13JUN97 STARTING DATE
ITIME     1000 STARTING TIME
NQ        300 NUMBER OF HYDROGRAPH ORDINATES
NDDATE    16JUN97 ENDING DATE
NDTIME    1245 ENDING TIME
ICENT     19 CENTURY MARK
```

```
COMPUTATION INTERVAL  0.25 HOURS
TOTAL TIME BASE       74.75 HOURS
```

ENGLISH UNITS

```
DRAINAGE AREA      SQUARE MILES
PRECIPITATION DEPTH INCHES
LENGTH, ELEVATION  FEET
FLOW               CUBIC FEET PER SECOND
STORAGE VOLUME     ACRE-FEET
SURFACE AREA       ACRES
TEMPERATURE        DEGREES FAHRENHEIT
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
				6-HOUR	24-HOUR	72-HOUR			
HYDROGRAPH AT	GG	459.	6.00	78.	25.	8.	0.30		

*** NORMAL END OF HEC-1 ***

LINE	ID	1	2	3	4	5	6	7	8	9	10
1	ID	Runoff Determination @ SE Corner of Crestone Property									
2	ID	Existing Conditions									
3	ID	100 yr/ 24 hour Storm=4.6" (EX100tot.hc1)									
4	IT	15	13JUN97	1000	300						
5	IO	5	0	0							
6	KK	Entire Basin North and West of SE Corner of Crestone Property									
7	KM	Basin Runoff from Entire Basin									
8	BA	0.4509									
9	PB	4.6									
10	IN	15									
11	PC	.0005	.0015	.0030	.0045	.0060	.0080	.0100	.0120	.0143	.0165
12	PC	.0188	.0210	.0233	.0255	.0278	.0320	.0390	.0460	.0530	.060
13	PC	.0750	.1	.4	.7000	.7250	.7500	.7650	.7800	.7900	.8000
14	PC	.8100	.8200	.8250	.8300	.8350	.8400	.8430	.8500	.8550	.8600
15	PC	.8638	.8675	.8713	.8750	.8788	.8825	.8863	.8900	.8938	.8975
16	PC	.9013	.9050	.9083	.9115	.9148	.9180	.9210	.9240	.9270	.9300
17	PC	.9325	.9350	.9375	.9400	.9425	.9450	.9475	.9500	.9525	.9550
18	PC	.9275	.9600	.9625	.9650	.9675	.9700	.9725	.9750	.9775	.9800
19	PC	.9813	.9825	.9838	.9850	.9863	.9875	.9888	.9900	.9913	.9925
20	PC	.9938	.9950	.9963	.9975	.9988	1.000				
21	LS		78.4								
22	UD	0.3010									
23	ZZ										

Ped2 Flow 556 - Represents Exist Flow w/o outfalls
 HP outfall - 220
 PU outfall - 120

 216 cfs
 Represents

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*
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
* MAY 1991 *
* VERSION 4.0.1E *
*
* RUN DATE **/**/1997 TIME 00:00:** *
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* DAVIS, CALIFORNIA 95616 *
* (916) 756-1104 *
*
*****

```

Runoff Determination @ SE Corner of Crestone Property
Existing Conditions
100 yr/ 24 hour Storm=4.6" (EX100tot.hc1)

5 IO OUTPUT CONTROL VARIABLES

```

IPRNT      5 PRINT CONTROL
IPLOT      0 PLOT CONTROL
QSCAL      0. HYDROGRAPH PLOT SCALE

```

IT HYDROGRAPH TIME DATA

```

NMIN      15 MINUTES IN COMPUTATION INTERVAL
IDATE     13JUN97 STARTING DATE
ITIME     1000 STARTING TIME
NQ        300 NUMBER OF HYDROGRAPH ORDINATES
NDDATE    16JUN97 ENDING DATE
NDTIME    1245 ENDING TIME
ICENT     19 CENTURY MARK

```

```

COMPUTATION INTERVAL  0.25 HOURS
TOTAL TIME BASE       74.75 HOURS

```

ENGLISH UNITS

```

DRAINAGE AREA      SQUARE MILES
PRECIPITATION DEPTH  INCHES
LENGTH, ELEVATION  FEET
FLOW                CUBIC FEET PER SECOND
STORAGE VOLUME     ACRE-FEET
SURFACE AREA       ACRES
TEMPERATURE        DEGREES FAHRENHEIT

```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
				6-HOUR	24-HOUR	72-HOUR			
HYDROGRAPH AT		556	6.00	94.	31.	10.	0.45		

*** NORMAL END OF HEC-1 ***

LINE	ID	1	2	3	4	5	6	7	8	9	10
1	ID	Runoff Determination @ SE Corner of Crestone Property									
2	ID	Crestone Development Conditions									
3	ID	100 yr/ 24 hour Storm=4.6" (E100yr.hc1)									
4	IT	15	13JUN97	1000	300						
5	IO	5	0	0							
6	KK	Entire Basin North and West of SE Corner of Crestone Property									
7	KM	Basin Runoff from Entire Basin									
8	BA	0.4509									
9	PB	4.6									
10	IN	15									
11	PC	.0005	.0015	.0030	.0045	.0060	.0080	.0100	.0120	.0143	.0165
12	PC	.0188	.0210	.0233	.0255	.0278	.0320	.0390	.0460	.0530	.060
13	PC	.0750	.1	.4	.7000	.7250	.7500	.7650	.7800	.7900	.8000
14	PC	.8100	.8200	.8250	.8300	.8350	.8400	.8430	.8500	.8550	.8600
15	PC	.8638	.8675	.8713	.8750	.8788	.8825	.8863	.8900	.8938	.8975
16	PC	.9013	.9050	.9083	.9115	.9148	.9180	.9210	.9240	.9270	.9300
17	PC	.9325	.9350	.9375	.9400	.9425	.9450	.9475	.9500	.9525	.9550
18	PC	.9275	.9600	.9625	.9650	.9675	.9700	.9725	.9750	.9775	.9800
19	PC	.9813	.9825	.9838	.9850	.9863	.9875	.9888	.9900	.9913	.9925
20	PC	.9938	.9950	.9963	.9975	.9988	1.000				
21	LS	81.5									
22	UD	0.3010									
23	ZZ										

Peak Flow w/o HP outfall & PV outfall = 627 cfs
 HP outfall (open channel, water level control) = - 220 cfs (if the pipe w/ accept
 PV outfall = - 120 cfs (maybe increased to 200 cfs
 Remaining @ SE corner = 287 cfs depending on hydraulics

Capacity of ~~54" P~~ 4' x 7' CBC
 Hw/D = 1.0 = 157.5 cfs
 Hw/D = 1.5 = 259.0 cfs
 Capacity inside the CBC = 287 cfs


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*
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*   MAY 1991 *
*   VERSION 4.0.1E *
*
* RUN DATE **/**/1997 TIME 00:00:** *
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*
* U.S. ARMY CORPS OF ENGINEERS *
* HYDROLOGIC ENGINEERING CENTER *
*   609 SECOND STREET *
*   DAVIS, CALIFORNIA 95616 *
*   (916) 756-1104 *
*
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```

Runoff Determination @ SE Corner of Crestone Property
 Crestone Development Conditions
 100 yr/ 24 hour Storm=4.6" (E100yr.hc1)

5 IO OUTPUT CONTROL VARIABLES

IPRNT	5	PRINT CONTROL
IPLT	0	PLOT CONTROL
QSCAL	0.	HYDROGRAPH PLOT SCALE

IT HYDROGRAPH TIME DATA

NMIN	15	MINUTES IN COMPUTATION INTERVAL
IDATE	13JUN97	STARTING DATE
ITIME	1000	STARTING TIME
NQ	300	NUMBER OF HYDROGRAPH ORDINATES
NDDATE	16JUN97	ENDING DATE
NDTIME	1245	ENDING TIME
ICENT	19	CENTURY MARK

COMPUTATION INTERVAL 0.25 HOURS
 TOTAL TIME BASE 74.75 HOURS

ENGLISH UNITS

DRAINAGE AREA	SQUARE MILES
PRECIPITATION DEPTH	INCHES
LENGTH, ELEVATION	FEET
FLOW	CUBIC FEET PER SECOND
STORAGE VOLUME	ACRE-FEET
SURFACE AREA	ACRES
TEMPERATURE	DEGREES FAHRENHEIT

RUNOFF SUMMARY
 FLOW IN CUBIC FEET PER SECOND
 TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
				6-HOUR	24-HOUR	72-HOUR			
HYDROGRAPH AT		627.	6.00	106.	34.	11.	0.45		

*** NORMAL END OF HEC-1 ***

LINE	ID	1	2	3	4	5	6	7	8	9	10
1	ID	Runoff Determination @ SE Corner of Crestone Property									
2	ID	Developed Conditions for GG3, CE4, CE5, CE6									
3	ID	100 yr/ 24 hour Storm=4.6" (G100YR.HC1)									
4	IT	15	13JUN97	1000	300						
5	IO	5	0	0							
6	KK	Entire Basin North and West of SE Corner of Crestone Property									
7	KM	Basin Runoff from Entire Basin									
8	BA	0.4509									
9	PB	4.6									
10	IN	15									
11	PC	.0005	.0015	.0030	.0045	.0060	.0080	.0100	.0120	.0143	.0165
12	PC	.0188	.0210	.0233	.0255	.0278	.0320	.0390	.0460	.0530	.060
13	PC	.0750	.1	.4	.7000	.7250	.7500	.7650	.7800	.7900	.8000
14	PC	.8100	.8200	.8250	.8300	.8350	.8400	.8430	.8500	.8550	.8600
15	PC	.8638	.8675	.8713	.8750	.8788	.8825	.8863	.8900	.8938	.8975
16	PC	.9013	.9050	.9083	.9115	.9148	.9180	.9210	.9240	.9270	.9300
17	PC	.9325	.9350	.9375	.9400	.9425	.9450	.9475	.9500	.9525	.9550
18	PC	.9275	.9600	.9625	.9650	.9675	.9700	.9725	.9750	.9775	.9800
19	PC	.9813	.9825	.9838	.9850	.9863	.9875	.9888	.9900	.9913	.9925
20	PC	.9938	.9950	.9963	.9975	.9988	1.000				
21	LS	85.3									
22	UD	0.3010 Tot 30.1 min									
23	ZZ										

Total Flow @ Pnt #4 718 cfs
 Capacity @ H Poutfall - 220 cfs
 Capacity @ P Voutfall - 120 cfs
 Remaining 378 cfs

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*****
*
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*   MAY 1991 *
*   VERSION 4.0.1E *
*
* RUN DATE **/**/1997 TIME 00:00:** *
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* U.S. ARMY CORPS OF ENGINEERS *
* HYDROLOGIC ENGINEERING CENTER *
*   609 SECOND STREET *
*   DAVIS, CALIFORNIA 95616 *
*   (916) 756-1104 *
*
*****

```

Runoff Determination @ SE Corner of Crestone Property
 Developed Conditions for GG3, CE4, CE5, CE6
 100 yr/ 24 hour Storm=4.6" (G100YR.HC1)

5 IO OUTPUT CONTROL VARIABLES

IPRNT	5	PRINT CONTROL
IPLOT	0	PLOT CONTROL
QSCAL	0.	HYDROGRAPH PLOT SCALE

IT HYDROGRAPH TIME DATA

NMIN	15	MINUTES IN COMPUTATION INTERVAL
IDATE	13JUN97	STARTING DATE
ITIME	1000	STARTING TIME
NQ	300	NUMBER OF HYDROGRAPH ORDINATES
NDDATE	16JUN97	ENDING DATE
NDTIME	1245	ENDING TIME
ICENT	19	CENTURY MARK

COMPUTATION INTERVAL	0.25 HOURS
TOTAL TIME BASE	74.75 HOURS

ENGLISH UNITS

DRAINAGE AREA	SQUARE MILES
PRECIPITATION DEPTH	INCHES
LENGTH, ELEVATION	FEET
FLOW	CUBIC FEET PER SECOND
STORAGE VOLUME	ACRE-FEET
SURFACE AREA	ACRES
TEMPERATURE	DEGREES FAHRENHEIT

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
				6-HOUR	24-HOUR	72-HOUR			
HYDROGRAPH AT		718.	6.00	122.	38.	13.	0.45		

*** NORMAL END OF HEC-1 ***

LINE	ID	1	2	3	4	5	6	7	8	9	10
1	ID	Runoff Determination @ SE Corner of Crestone Property Utilizing Velcon Outfall									
2	ID	Developed Conditions (see table)									
3	ID	100 yr/ 24 hour Storm=4.6" (H100YR.HC1)									
4	IT	15	17JUN97	1000	300						
5	IO	5	0	0							
6	KK	Entire Basin North and West of SE Corner of Crestone Property w/o CE6									
7	KM	Basin Runoff from Entire Basin w/o CE6									
8	BA	0.4150									
9	PB	4.6									
10	IN	15									
11	PC	.0005	.0015	.0030	.0045	.0060	.0080	.0100	.0120	.0143	.0165
12	PC	.0188	.0210	.0233	.0255	.0278	.0320	.0390	.0460	.0530	.060
13	PC	.0750	.1	.4	.7000	.7250	.7500	.7650	.7800	.7900	.8000
14	PC	.8100	.8200	.8250	.8300	.8350	.8400	.8430	.8500	.8550	.8600
15	PC	.8638	.8675	.8713	.8750	.8788	.8825	.8863	.8900	.8938	.8975
16	PC	.9013	.9050	.9083	.9115	.9148	.9180	.9210	.9240	.9270	.9300
17	PC	.9325	.9350	.9375	.9400	.9425	.9450	.9475	.9500	.9525	.9550
18	PC	.9275	.9600	.9625	.9650	.9675	.9700	.9725	.9750	.9775	.9800
19	PC	.9813	.9825	.9838	.9850	.9863	.9875	.9888	.9900	.9913	.9925
20	PC	.9938	.9950	.9963	.9975	.9988	1.000				
21	LS		80.4								
22	UD	0.3010									
23	ZZ										

Peak Flow 554
 HP outfall - 220
 PU outfall - 120

Remaining @ SE corner 214 cfs

Assumptions

- Existing development & development of Crestone Property
- 23 acres of runoff redirected to Velcon outfall storm sewer
- Only 7 acres drains to corner

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*****
*
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*   MAY 1991 *
*   VERSION 4.0.1E *
*
* RUN DATE **/**/1997 TIME 00:00:** *
*
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*****
*
* U.S. ARMY CORPS OF ENGINEERS *
* HYDROLOGIC ENGINEERING CENTER *
*   609 SECOND STREET *
*   DAVIS, CALIFORNIA 95616 *
*   (916) 756-1104 *
*
*****
```

Runoff Determination @ SE Corner of Crestone Property Utilizing Velcon Outfall
 Developed Conditions (see table)
 100 yr/ 24 hour Storm=4.6" (H100YR.HC1)

5 IO

OUTPUT CONTROL VARIABLES

IPRNT 5 PRINT CONTROL
 IPLOT 0 PLOT CONTROL
 QSCAL 0. HYDROGRAPH PLOT SCALE

IT

HYDROGRAPH TIME DATA

NMIN 15 MINUTES IN COMPUTATION INTERVAL
 IDATE 17JUN97 STARTING DATE
 ITIME 1000 STARTING TIME
 NQ 300 NUMBER OF HYDROGRAPH ORDINATES
 NDDATE 20JUN97 ENDING DATE
 NDTIME 1245 ENDING TIME
 ICENT 19 CENTURY MARK

COMPUTATION INTERVAL 0.25 HOURS
 TOTAL TIME BASE 74.75 HOURS

ENGLISH UNITS

DRAINAGE AREA SQUARE MILES
 PRECIPITATION DEPTH INCHES
 LENGTH, ELEVATION FEET
 FLOW CUBIC FEET PER SECOND
 STORAGE VOLUME ACRE-FEET
 SURFACE AREA ACRES
 TEMPERATURE DEGREES FAHRENHEIT

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
				6-HOUR	24-HOUR	72-HOUR			
HYDROGRAPH AT		554.	6.00	94.	30.	10.	0.41		

*** NORMAL END OF HEC-1 ***

Time of Concentration for Onsite Facility Drainage Plan

Crestone Development

Date: August 15, 1997

Project #: 97003

Summ Pnt	Overland Travel Time				Curb And Gutter Travel Time				Strm Swr Travel Time				Cummul Tc	
	Length	C	Slope	Tt	Length	Slope	Vel	Tt	Length	Diam	Approx Vel	Tt		
Velcon Outfall														
1	200	0.8	2	5										5.0
2	300	0.8	2	6	150	2	4	0.6						6.6
3									150	24	8	0.3		6.9
4	Use minimum Tc to size inlet and lateral													5.0
5									200	30	8	0.4		7.3
6									140	30	8	0.3		7.6
7	Use minimum Tc to size inlet and lateral													5.0
8									220	30	8	0.5		8.1
9									160	30	10	0.3		8.4
10									380	30	12	0.5		8.9
11									380	36	9	0.7		9.6
12	Use minimum Tc to size inlet and lateral													5.0
13	Use minimum Tc to size inlet and lateral													5.0
14									100	36	10	0.2		9.8
15	Use minimum Tc to size inlet and lateral													5.0
16									140	36	10	0.2		10.0

Summ Pnt	Overland Travel Time				Curb And Gutter Travel Time				Strm Swr Travel Time				Cummul Tc
	Length	C	Slope	Tt	Length	Slope	Vel	Tt	Length	Diam	Approx Vel	Tt	
17									130	36	10	0.2	10.2
	Determination of Tc for Surface Flow only												
17	200	0.8	2	5	1500	2	4	6.2					11.2
	Use consevative Tc of 10.2 minutes												
Garden of The Gods Road Outfall													
22	150	0.8	2	5	150	1	4	0.6					5.6
23	Same as Point #22												5.6
24									180	18	6	0.5	6.1
25	Use minimum Tc to size inlet and lateral												5.0
26									170	18	8	0.4	6.5
27	Use minimum Tc to size inlet and lateral												5.0
28	Use minimum Tc to size inlet and lateral												5.0
30	200	0.8	2	5	500	2	5	1.7					6.6
	Total Runoff at Point #30												
30									360	24-42"	10	0.6	7.1

Design Flows for Onsite Facilities Drainage Plan

Crestone Development

Date: August 15, 1997

Project #: 97003

Summ Pnt	Drainage Area		Runoff Coefficients		Tc (min)	Rainfall Intensity				Cumulative	
	ID	Area (acres)	C5	C100		I5	I100	Q5	Q100	Q5	Q100
Velcon Outfall											
1	CB1	2.5	0.80	0.90	5.0	5.2	9.0	10.4	20.3		
2	CB2	5.6	0.80	0.90	6.6	4.7	8.2	21.1	41.3		
3	CB1-2	8.1	0.80	0.90	6.9	4.6	8.0			29.8	58.3
4	CB3	2.7	0.80	0.90	5.0	5.2	9.0	11.2	21.9		
5	CB1-3	10.8	0.80	0.90	7.3	4.4	7.9			38.0	76.8
6	CB4	0.5	0.80	0.90	7.6	4.4	7.8	1.8	3.5		
6	CB1-4	11.3	0.80	0.90	7.6	4.4	7.8			39.8	79.3
7	CB6	0.4	0.80	0.90	5.0	5.2	9.0	1.7	3.2		
8	CB5	0.8	0.80	0.90	8.1	4.2	7.3	2.7	5.3		
8	CB1-6	12.5	0.80	0.90	8.1	4.2	7.3			42.0	82.1
9	CB7	1.8	0.80	0.90	8.4	4.1	7.2	5.9	11.7		
9	CB1-7	14.3	0.80	0.90	8.4	4.1	7.2			46.9	92.7
10	CB8	1.5	0.80	0.90	8.9	4.1	7.1	4.9	9.6		
10	CB1-8	15.8	0.80	0.90	8.9	4.1	7.1			51.8	101.0
11	CB9	2.1	0.80	0.90	9.6	4.0	7.0	6.7	13.2		
11	CB1-9	17.9	0.80	0.90	9.6	4.0	7.0			57.3	112.8
12	CB10	0.9	0.80	0.90	5.0	5.2	9.0	3.7	7.3		
13	CB11	0.6	0.80	0.90	5.0	5.2	9.0	2.5	4.9		
14	CB1-11	19.4	0.80	0.90	9.8	4.0	7.0			62.3	122.2
15	CB12	1.2	0.80	0.90	5.0	5.2	9.0	5.0	9.7		

Summ Pnt	Drainage Area		Runoff Coefficients		Tc (min)	Rainfall Intensity			Cummulative		
	ID	Area (acres)	C5	C100		I5	I100	Q5	Q100	Q5	Q100
16	CB1-12	20.6	0.80	0.90	10.0	4.0	7.0			65.9	129.8
17	CB13	1.9	0.80	0.90	10.2	3.9	6.9	5.9	11.8		
17	CB1-13	22.5	0.80	0.90	10.2	3.9	6.9			70.2	139.7
Centennial Blvd Outfall											
22	GG1	0.8	0.80	0.90	5.6	5.0	8.5	3.2	6.1		
23	GG2	1.2	0.80	0.90	5.6	5.0	8.5	4.8	9.2		
24	GG1-2	2.0	0.80	0.90	6.1	4.8	8.2			7.7	14.8
25	GG3	0.7	0.80	0.90	5.0	5.2	9.0	2.9	5.7		
26	GG1-3	2.7	0.80	0.90	6.5	4.7	8.0			10.2	19.4
27	GG4	0.3	0.80	0.90	5.0	5.2	9.0	1.2	2.4		
28	GG5	0.8	0.80	0.90	5.0	5.2	9.0	3.3	6.5		
30	GG6	3.4	0.80	0.90	6.6	4.7	8.0	12.8	24.5		
Total Flow @ Point #30											
30	GG1-6	7.2	0.80	0.90	7.1	4.5	8.0	25.9	51.8		

**HYDRAULIC
SUMMARY EXHIBITS**

CENTENNIAL BLVD. STREET CROSS SECTION ANALYSIS**Development Condition: Existing Development**

Station	Comments
1+00	The storm sewer and the street section have just enough capacity to accommodate the 100 yr. flow
5+00	The street section does not have the capacity to accommodate the surface flow that is not inside the storm sewer. However, the street will accommodate the total flow with 12" of depth at the curb line
10+00	The street does not have the capacity to accommodate the excess flow under current criteria. However, the excess flow can be accommodated in the street section with 12" of depth at the curb line
16+00	The street section as able to accommodate the excess flow under current criteria. The street section will not accommodate 12" of depth at the curb line. The water will exit the ROW into adjacent properties

NOTES See Appendix for detail calculations and roadway cross sections

CENTENNIAL BLVD. STREET CROSS SECTION ANALYSIS

Development Condition: Existing Development w/ Crestone Tract Developed

Station	Comments
1+00	The street does not have the capacity to accommodate excess surface flow that is not handled by the storm sewer under current criteria. The street will accommodate excess flow in the street for 12' depth
5+00	The street will not accommodate excess flow under either the current criteria or the 12" depth criteria
10+00	Same as Station 5+00
16+00	The street has the capacity to accommodate excess flow under current criteria. 12" of depth cannot be obtained at this cross section w/o flowing outside the ROW
NOTES	See Appendix for detail calculations and roadway cross sections

CENTENNIAL BLVD. STREET CROSS SECTION ANALYSIS

Development Condition:

**Existing Development w/ Crestone and areas East of the HP
Outfall Developed**

Station	Comments
1+00	Street section will not accommodate excess flow under current criteria. Street section will accommodate excess flow under a 12" depth criteria
5+00	Street section will not accommodate excess flow under both the 8" & 12" depth criteria
10+00	Same as Station 5+00
16+00	Same as Station 5+00. 12" of depth cannot be obtained w/o stormwater leaving the ROW and entering adjacent properties

NOTES See Appendix for detail calculations and roadway cross sections

Hydraulic Summary Table**Crestone Development MDDP**

Date: July, 1997

Project #: 97003

Exist	Prop	Facility Description	Slope (ft/ft)	HW/D	Approx Capacity (cfs)	Hydraulic Sizing Criteria	Comments
-------	------	----------------------	---------------	------	-----------------------	---------------------------	----------

HP Outfall System

x		2-34" by 53" Horiz Ellip Pipe	1.00		220		Controlling section of outfall system
x		2-34" by 53" Horiz Ellip Pipe		1.0	50		
x		60" Reinforced Concrete Pipe	3.00		490	Open Channel Flow	
x		60" Reinforced Concrete Pipe	2.00		400	Open Channel Flow	
x		60" Reinforced Concrete Pipe	1.50		330	Open Channel Flow	
x		60" Reinforced Concrete Pipe	3.80		530	Open Channel Flow	
x		60" Reinforced Concrete Pipe	3.60		520	Open Channel Flow	

Centennial Blvd Outfall System

x		4' by 7' Reinforced Concrete Box	1.00		>400	Open Channel Flow	
x		4' by 7' Reinforced Concrete Box	NA	1.0	161	Inlet Control	
x		48" Reinforced Concrete Pipe	0.75		135	Open Channel Flow	Controlling section of outfall system
x		48" Reinforced Concrete Pipe	1.00		150	Open Channel Flow	
x		48" Reinforced Concrete Pipe	1.75		200	Open Channel Flow	
x		48" Reinforced Concrete Pipe	3.40		280	Open Channel Flow	
x		48" Reinforced Concrete Pipe	4.00		300	Open Channel Flow	

Velcon Outfall System

x		24" Reinforced Concrete Pipe	2.17		35	Open Channel Flow	
	x	42" Reinforced Concrete Pipe	2.50		230	Open Channel Flow	

Pinon Valley Outfall System

x		54" Reinforced Concrete Pipe	1.54		275	Open Channel Flow	
x		54" Reinforced Concrete Pipe		1.2	120	Inlet Control	Controlling section of outfall system
x		48" Reinforced Concrete Pipe	1.80		290	Open Channel Flow	
x		60" Reinforced Concrete Pipe	0.70		220	Open Channel Flow	

BOX CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

May 22, 1997

Rating of 4 x 7 CBC at SE Corner of Site
Crestone Development @ Centennial and Garden of the Gods

Date: May 22, 1997

PROGRAM INPUT DATA:

DESCRIPTION	VALUE
Culvert Span (Width of Opening) (feet).....	7.00
Culvert Rise (Height of Opening) (feet).....	4.00
FHWA Chart Number (8,9,10,11,12 or 13).....	8
Scale Number on Chart (Type of Culvert Entrance).....	1
Manning's Roughness Coefficient (n-value).....	0.0130
Entrance Loss Coefficient of Culvert Opening.....	0.50
Culvert Length (feet).....	160.0
Culvert Slope (feet per foot).....	0.0100

PROGRAM RESULTS:

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater Inlet Control (ft)	Headwater Outlet Control (ft)	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.0	0.50	0.13	0.44	0.07	0.09	0.50	0.29
100.0	0.50	2.96	1.74	1.30	1.85	1.30	11.02
125.0	0.50	3.45	2.11	1.51	2.15	1.51	11.84
150.0	1.00	3.92	2.53	1.71	2.42	1.71	12.54
175.0	1.00	4.36	3.00	1.90	2.69	1.90	13.14
200.0	1.00	4.90	3.51	2.09	2.94	2.09	13.67
225.0	1.00	5.73	4.06	2.27	3.18	2.27	14.15
250.0	1.00	6.31	4.67	2.45	3.41	2.45	14.58
275.0	1.00	6.95	5.31	2.62	3.63	2.62	14.97
300.0	1.00	7.66	6.01	2.79	3.85	2.79	15.33
350.0	1.00	9.26	7.42	3.13	4.00	3.13	15.97
400.0	1.00	11.10	8.96	3.46	4.00	3.46	16.53

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**Storm Sewer/ Drainage Facilities for
Onsite Facilities Drainage Plan**

Crestone Development

Date: August 15, 1997

Project #: 97003

		Proposed Drainage Facilities			
Summ Pnt	Design Q	Diameter/Size	Slope	Capacity	Vel.
Velcon Outfall System					
1-3	10.4	18	1	12	7
2-3	21.1	24	1	25	8
3-5	29.8	30	0.7	35	8
4-5	11.2	18	1	12	7
5-6	38	30	1	41	8
6-8	39.8	30	1	41	8
7-8	1.7	18	0.7	9	5
8-9	42	30	1.2	45	10
9-10	46.9	30	1.5	50	12
10-11	51.8	36	0.7	56	8
11-14	57.3	36	1	70	10
12-14	3.7	18	0.7	9	5
13-14	2.5	18	0.7	9	5
14-16	62.3	36	1	70	10
15-16	5	18	0.7	9	5
16-17	65.9	36	1	70	10
17-20	70.2	36	1.2	75	11

36" RCP ok for 5 yr storm, however the system across Cent needs too be sized for 100yr

11-14	87.3	36	1.6		
14-16	92.3	42	0.8	100	
16-17	95.9	42	0.8	100	
17-20	139.7	42	1.5	145	
sized to accomodate to 100yr storm					

		Proposed Drainage Facilities			
Summ Pnt	Design Q	Diameter/Size	Slope	Capacity	Vel.
20-21	175.6	48	1.5	185	14
21-22	201.6	48	2	210	15
Centennial Outfall System					
22-24	3.2	18	0.8	10	6
23-24	4.8	18	1	12	7
24-26	7.7	18	1	12	7
25-26	2.9	18	0.8	10	6
26-27	10.2	24	0.7	10	6
27-48"	1.2	18	0.8	10	6
28-48"	3.3	18	0.8	10	6
30-48"	24.5	24	1.5	30	9

**Sizing for Inlets in Sump Conditions for
Onsite Drainage Facilities Drainage Plan
Crestone Development**

Date: August 15, 1997

Project #: 97003

Point	Design Q 5yr	Proposed Inlet Length	Intercept Capacity	Comments
Velcon Outfall System				
1	10.4	5	14.7	
2	21.1	8	23.6	
4	11.2	5	14.7	
6	1.8	5	14.7	
8	2.7	5	14.7	
9	5.9	5	14.7	
10	4.9	5	14.7	
11	36.7	12	36	Design Q based on additional 30 cfs
13	2.5	5	14.7	
15	5	5	14.7	
17	45.9	15	45	Design Q based on additional 40 cfs
Centennial Boulevard Outfall System				
22	3.2	5	14.7	
23	4.8	5	14.7	
25	2.9	5	14.7	
27	1.2	5	14.7	
28	3.3	5	14.7	
30	38.7	15	45	Designed to intercept 100% of surface flow

Inlet Interception Rates

Length	Rate (cfs)
5	14.7
6	17.7
7	20.6
8	23.6
9	26.5
10	29.5
15	45

Formula $Q=C*h*L*(2*g*d)^{0.5}$

Where: c= 0.67
 h=ht. of inlet throat=8"
 L=length of inlet opening
 g= 32.2 fps
 d=depth of water less 1/2 throat

Obering, Wurth & Associates

Consulting Civil Engineers
Registered Land Surveyors

1015 Elkton Drive
Colorado Springs, Colorado 80907
(719) 531-6200

JOB _____

SHEET NO. _____

OF _____

CALCULATED BY _____

DATE _____

CHECKED BY _____

DATE _____

SCALE _____

Garden of the Gods Storm Sewer Sizing

Design Flow Determination

Development Conditions

Exist Development West of HP outfall Pnt #1

Developed between Pnt #1 and Pnt #2

Total Flow =

459 cfs

HP outfall Capacity

220 cfs

Remaining

239 cfs

Street Capacity

61 cfs (see below)

Design Flow

178 cfs

Street Capacity Determination

$$Q = \frac{0.56}{n} S_x^{1.67} S^{0.5} T^{2.67}$$

where $n = 0.016$

$S_x = 1.5\%$

$S = 1.5\%$

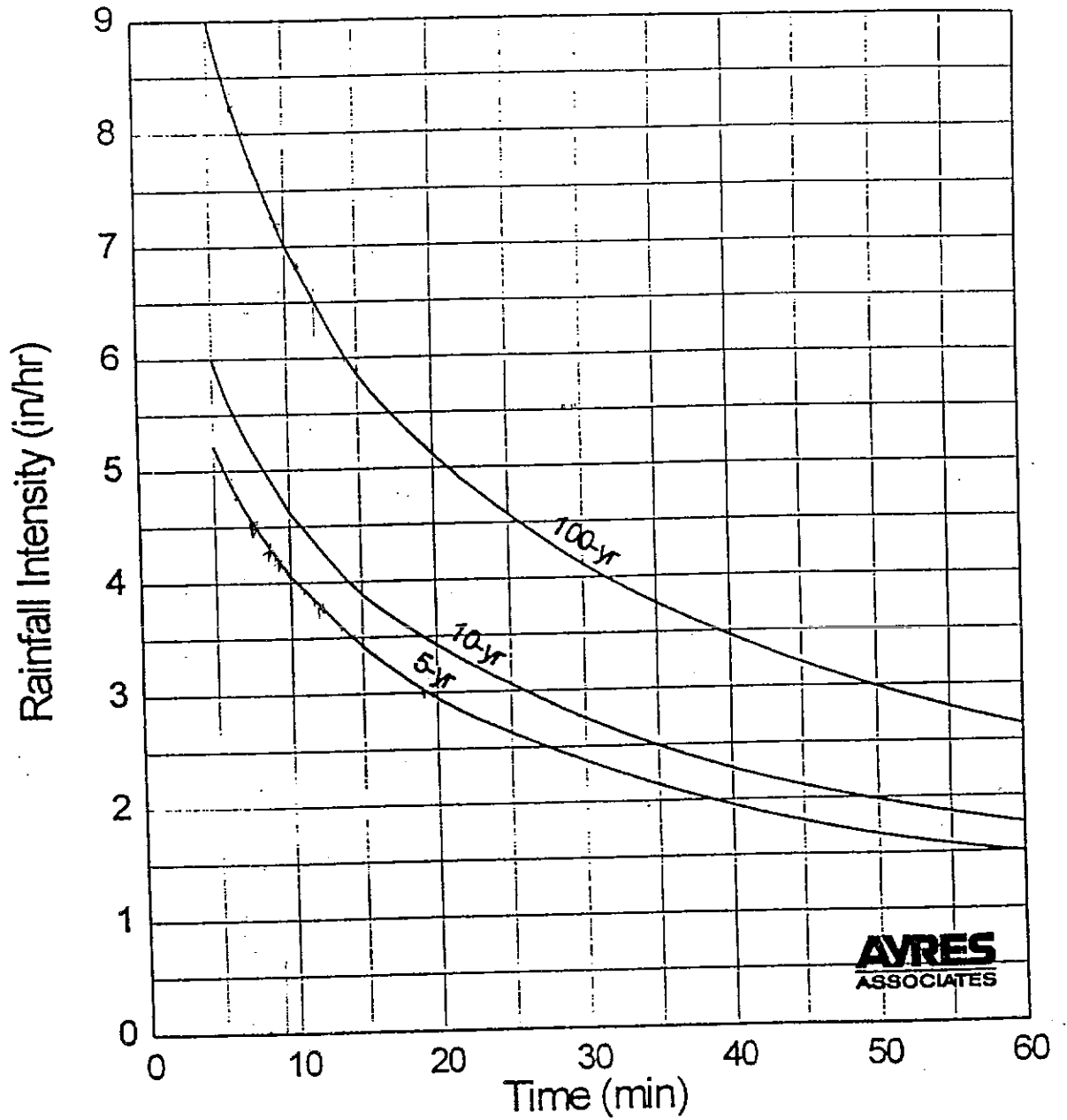
$T = 36'$ (3 lanes wide)

$$Q = 55 \text{ cfs}$$

Adjust for Depressed Gutter

$$Q = 55 / 0.90 = 61 \text{ cfs}$$

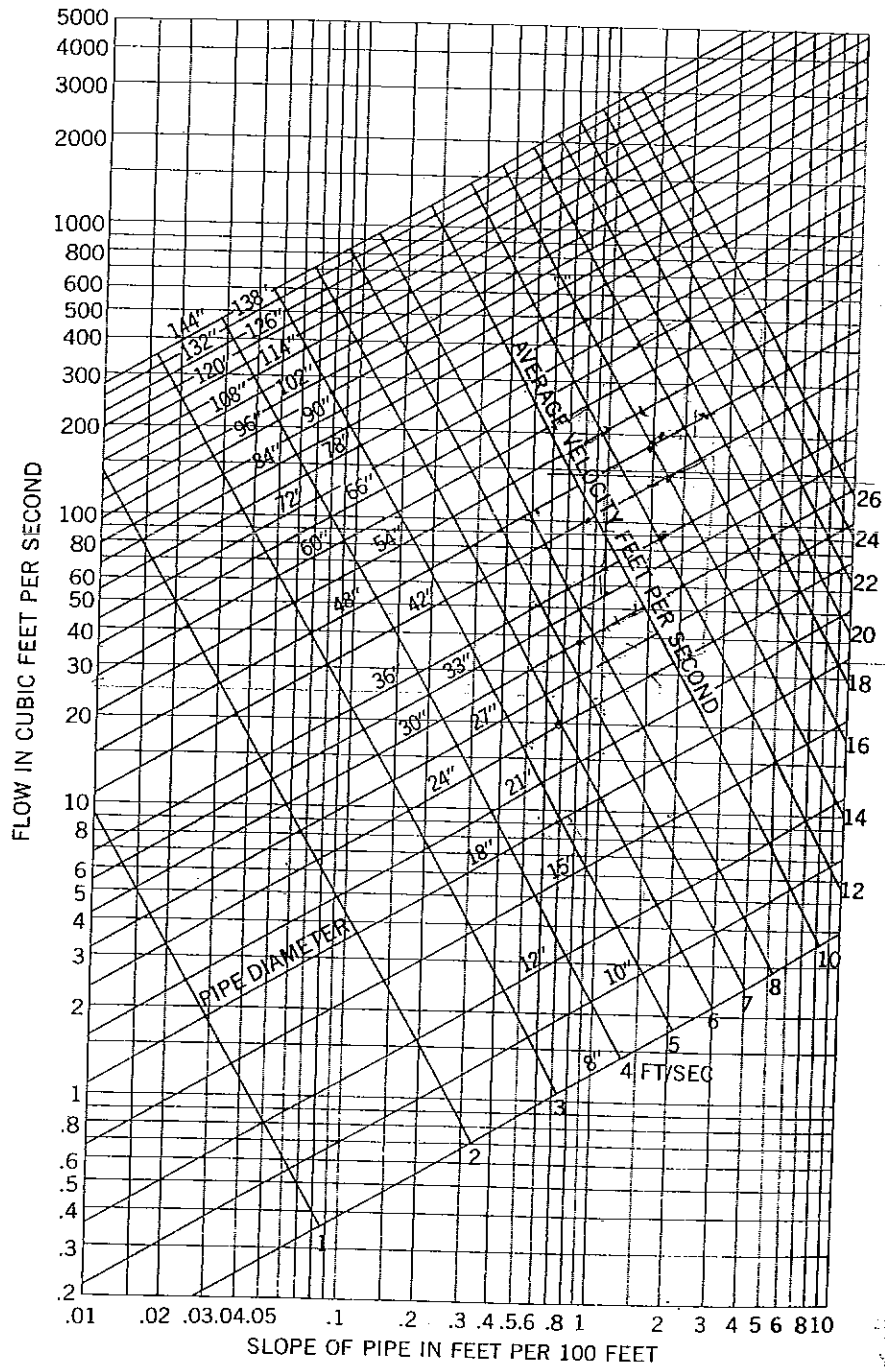
MISCELLANEOUS

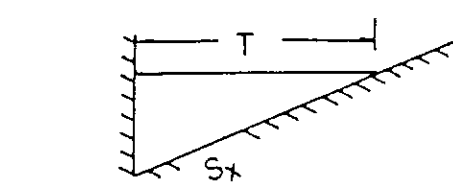


Interim Release October 12, 1994 , Rainfall Intensity Curves
 City Of Colorado Springs Drainage Criteria Manual

FIGURE 5

FLOW FOR CIRCULAR PIPE FLOWING FULL
BASED ON MANNING'S EQUATION $n=0.013$

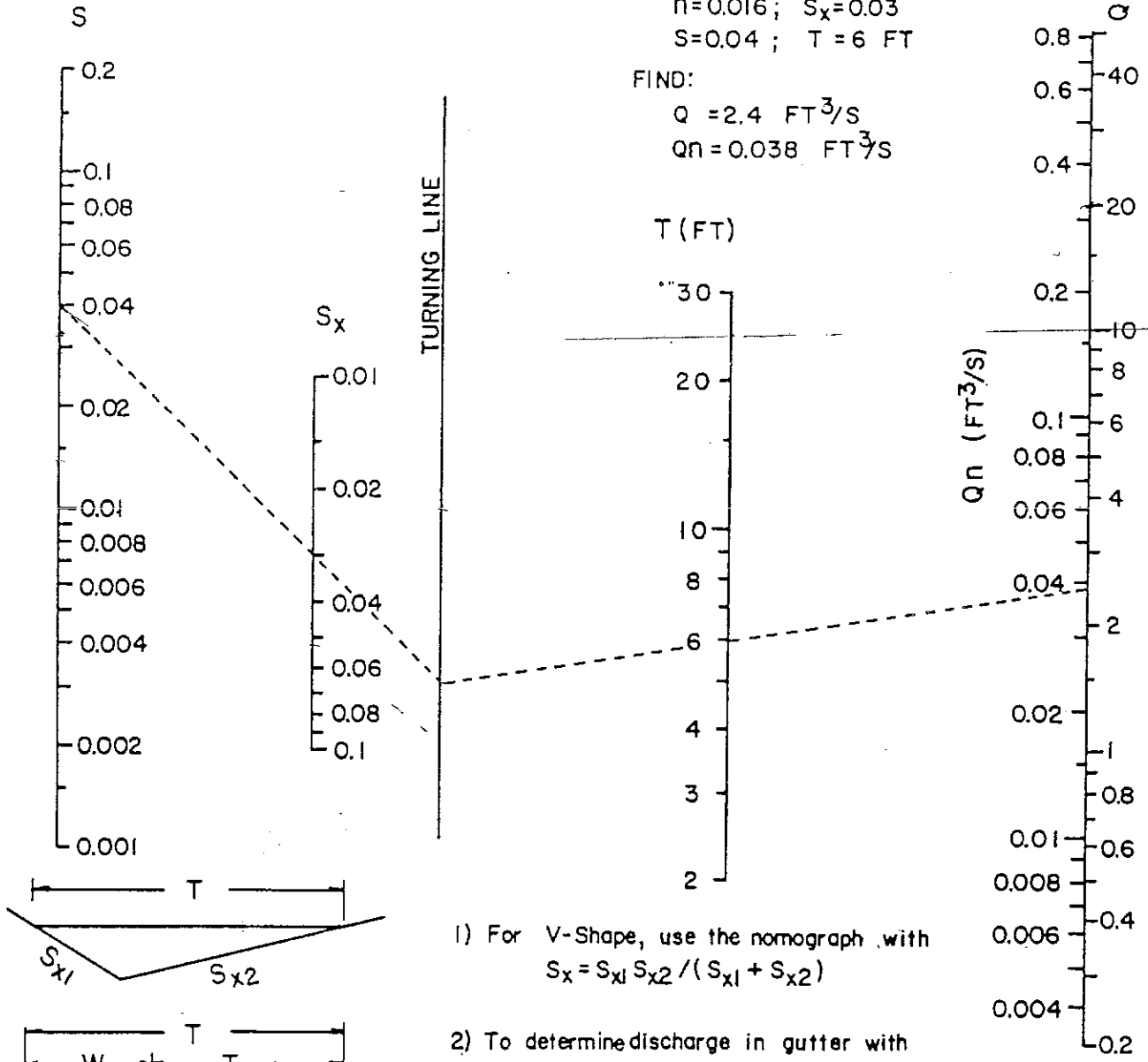




$$Q = \frac{0.56}{n} S_x^{1.67} S^{0.5} T^{2.67}$$

EXAMPLE: GIVEN:
 $n = 0.016$; $S_x = 0.03$
 $S = 0.04$; $T = 6$ FT

FIND:
 $Q = 2.4$ FT³/S
 $Qn = 0.038$ FT³/S

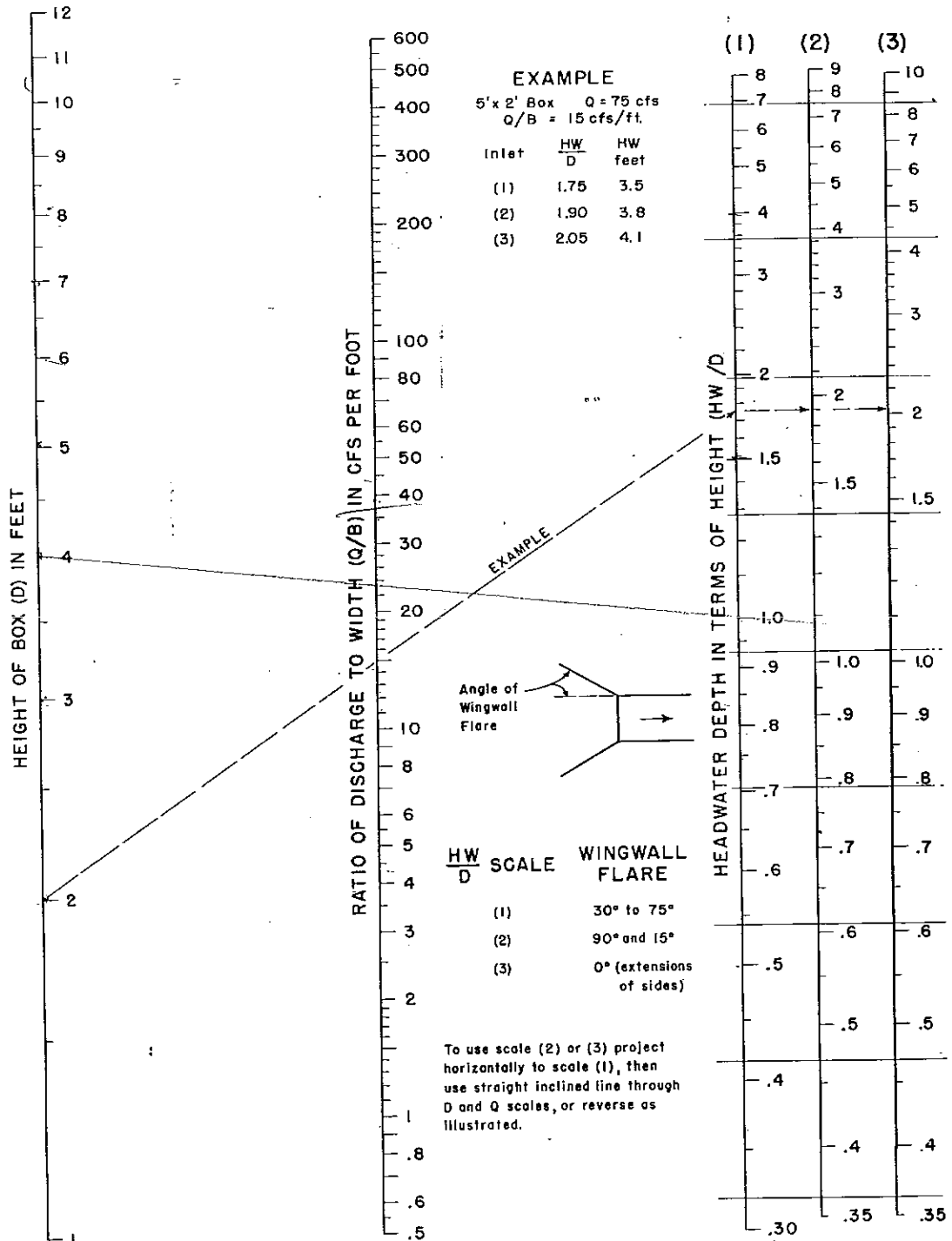


- 1) For V-Shape, use the nomograph with $S_x = S_{x1} S_{x2} / (S_{x1} + S_{x2})$
- 2) To determine discharge in gutter with composite cross slopes, find Q_s using T_s and S_x . Then, use CHART 4 to find E_o . The total discharge is $Q = Q_s / (1 - E_o)$, and $Q_w = Q - Q_s$.

CHART 3. Flow in triangular gutter sections.



CHART 8



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

COMPARISON OF EXISTING AND PROPOSED CRITERIA

INITIAL STORM:

STREET TYPE	OLD	NEW
Hillside Residential ramp curb	flow spread to crown, maximum 25 cfs. per side, whichever is more restrictive	flow spread to crown max. 15 cfs. per side
Hillside Residential vertical curb	flow spread to crown, maximum 25 cfs. per side, whichever is more restrictive	6" allowable depth @ flowline max. 25 cfs. per side
Residential Street ramp curb	flow spread to crown	flow spread to crown max. 20 cfs. per side
Residential Street vertical curb	flow spread to crown	6" allowable depth @ flowline max. 34 cfs. per side
Collector Street	20 foot flow spread	6" allowable depth @ flowline, max. 34 cfs. per side, no overtopping the crown
Arterial Street	flow may encroach onto one outside lane	6" allowable depth @ flowline, max. 34 cfs. per side, one ten foot lane free of water in each direction

MAJOR STORM:

STREET TYPE	OLD	NEW
Hillside Residential Residential Streets Collector Streets	12" max. depth @ flowline no adjacent flooding	NO CHANGE
Arterial Streets	8" max. depth @ flowline (no curb overtopping)	NO CHANGE

CROSS FLOWS: No changes to any street types for the initial storm.
 Only change for Major Storm is the Arterial street will now allow 12" max. depth @ flowline and 4" max.