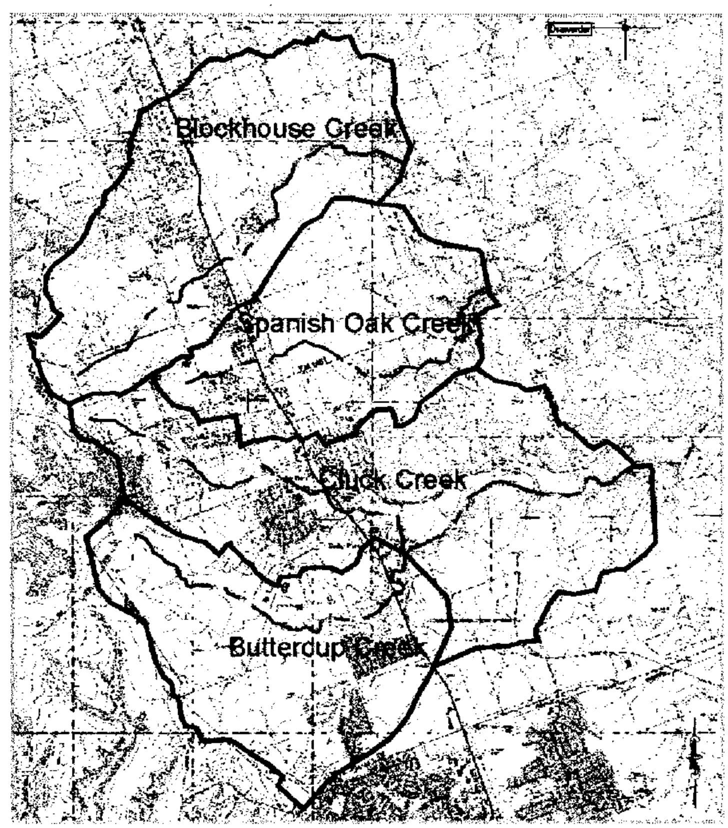
CEDAR PARK MASTER DRAINAGE PLAN
South Brushy Creek Cluck Creek, Spanish Oak Creek, and Blockhouse Creek



City of Cedar Park

DRAFT June 2002

Project No. 2000-43

CEDAR PARK MASTER DRAINAGE PLAN

South Brushy Creek (including Buttercup Creek), Cluck Creek, Spanish Oak Creek, and Blockhouse Creek

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1.0 INTRODUCTION

Cedar Park lies in Williamson County, Texas, northwest of Austin along U.S. Highway 183 (Exhibit 1) in the headwaters of Brushy Creek. Four primary drainage ways extend through Cedar Park: South Brushy Creek (including Buttercup Creek), Cluck Creek, Spanish Oak Creek, and Blockhouse Creek. Four Natural Resource Conservation Service (NRCS, formerly the Soil Conservation Service) in-line reservoirs lie in this area: NRCS No. 3, NRCS No. 4, NRCS No. 6, and NRCS No. 7. All of these systems ultimately discharge easterly into Brushy Creek (Exhibit 2).

1.1 PURPOSE OF THIS REPORT

The purpose of this master plan report is to identify, and quantify current flood conditions along primary waterways, and evaluate measures to reduce flooding. This report includes hydrologic analyses to estimate flow rates, hydraulic analyses to determine water surface elevations, a cursory environmental survey of the area, preliminary construction cost estimates, and implementation plan. This report does not extensively include an evaluation of flooding in localized areas due to site grading problems, poor lateral collection systems, etc. This report does not include any detailed analyses or evaluations of the existing NRCS structures. The regional watershed-based approach to this study is important in evaluating drainage and flooding problems on a comprehensive level.

1.2 SPONSORS

Project sponsors include the City of Cedar Park and Texas Water Development Board. These sponsors have contributed both financial and technical resources for development of this drainage plan.

1.3 HISTORICAL FLOODING

Growth and development of the city and surrounding area have occurred at an accelerated pace during the past ten years, compounding flooding problems. Cedar Park is one of the fastest growing cities in the nation for a city of its size. From a population of 5,161 in 1990, Cedar Park now includes an urbanized center of over 18,000 residents. It has been difficult for the city to keep up with the planning necessary to fully address existing drainage problem areas, as well as potential problem areas caused by new development. The current information available in Williamson County's Flood Insurance Study (FIS) reflects the development conditions of the 1980's. For the City to employ effective floodplain management in light of significant development since the 1980's, a comprehensive regional analysis of the watershed is necessary.

Not only has new development resulted in changes in flood conditions, but prior to the city's current development code, existing developments were built in areas that were, or are, in the flood prone areas. Although the City of Cedar Park does not currently allow construction in the 100-year floodplain, there are many existing homes at risk of damage by high waters because of their low elevations. Also, due to the fact that many low water crossings, culverts, and bridges were built more than 20 years ago, these structures cannot adequately convey floodwaters to current standards for an acceptable level of service.

Routine complaints from residents throughout the City after storm events are typically in the older parts of town, and can be primarily attributed the absence of local collection and conveyance systems (e. g. storm sewers, roadside ditches, etc.) Areas along South Cougar Avenue and upstream of Cedar Park Drive are indicative of these problems. Given the upland topography in many of these areas, drainage patterns typically include sheet flow across residential lots, with some conveyance provided in streets. Out of bank flooding also occurs in the older parts of town adjacent to residences due to undersized natural drainage ways, which are sometimes ill-defined, poorly maintained, clogged, etc., as are the outfall systems located along Spanish Oak Creek and Cluck Creek. Another area that routinely experiences flooding problems includes the subdivision located upstream from the southern tributary of the existing NRCS No. 6 reservoir. The existing reservoir outfall structure produces a flood stage that backs up through the subdivision resulting in problems for low-lying properties.

1.4 SUMMARY AND CONCLUSIONS

The need to develop a drainage master plan arose through resident concern and the City's commitment to provide equitable and efficient levels of service. A watershed-based approach enables the City and its residents to see known problem areas as part of a dynamic system, and fundamentally recognizes the interdependencies of reaches within the watershed. This context is critical in evaluating alternatives for flood hazard reduction.

New development is generally kept safe from flooding through the City's adopted drainage criteria and floodplain management ordinance, which also serve to protect upstream and downstream properties from adverse impacts. However, in older, developed areas, reducing the risk of flooding is often more difficult, given the constraints of land available for public improvements and the relative expense of retrofitting drainage improvements. Other factors, such as environmental sensitivity, also play a role in selecting the best option.

For each problem area identified in the study, several options (structural and non-structural) were evaluated within the context of the watershed, and in each case, the ensuing recommendation reflects the best allocation of resources to derive the highest public benefit.

For problem areas along Upper Spanish Oak Creek (refer to Section 4.1), channelization (open and enclosed) is recommended as a solution. The estimated cost for these improvements would range between $700,000 and $1,100,000 and would provide immediate 100-year level protection.

Along Lower Spanish Oak Creek (refer to Section 4.2), an initial creek maintenance project and the implementation of a maintenance program is recommended to provide flood protection to approximately 10 structures, at an estimated cost of $150,000 to $200,000. Buyout of repetitive-loss structures is also recommended for consideration and further study.

The problem areas along Upper Cluck Creek (refer to Section 4.3) are primarily the result of wastewater crossings which reduce conveyance. Relocating these lines will both increase conveyance in the channel and present opportunities for sanitary sewer line upgrades. The cost for these improvements is estimated between $120,000 and $170,000.

In the area near Cedar Park Drive (refer to Section 4.4), the recommended solution is to improve the localized drainage system, and could be expected to cost between $30,000 and $50,000. This solution offers some transferability in concept to other areas of the city.

Similarly, the area around South Cougar Avenue would benefit most from localized drainage improvements and some minor culvert upgrades. The cost of these improvements ranges in estimate between $40,000 and $70,000.

Finally, to address backwater flooding at NRCS Reservoir No. 6, floodproofing is recommended for each residential structure. The estimated cost for these measures would likely range from $5,000 to $10,000 per structure. However, in some instances, acquisition may be a more cost-effective solution, and further study is recommended to determine the site-specific feasibility, accounting for repetitive-loss history.

2.0 HYDROLOGIC ANALYSIS

2.1 METHOD OF ANALYSIS

The HEC-1 computer program developed by the Hydrologic Engineering Center of the U. S. Army Corps of Engineers (USACE) is used in this analysis to estimate peak flow rates for the 10-year, 25-year, 50-year, and 100-year frequency storm events. This section describes the input parameters used in this study and summarizes the results of the hydrologic analysis. HEC-1 model output is included in Appendix B.

2.2 PRECIPITATION

The design storms used in this analysis include a balanced rainfall distribution with a 3-hour duration as specified by the City's drainage criteria. A 24-hour duration design storm was considered; however, the 3-hour design storm typically produced the same or higher peak flow rates. Therefore, the 3-hour design storm is used to produce more conservative design peak flow rates, and to provide consistency with adopted local drainage criteria. The precipitation depths for each design storm presented in Table 1 are taken from The City of Austin Drainage Criteria Manual, Chapter 2 Table 2-10.

Table 1 Precipitation Depths

Storm	Recurrance Interval			
Duration	10-Year	25-Year	50-Year	100-Year
5-min	0.034	0.044	0.052	0.061
15-min	0.038	0.050	0.058	0.068
60-min	0.092	0.117	0.135	0.154
2-hrs	0.100	0.127	0.146	0.167
3-hrs	0.033	0.043	0.051	0.059

2.2.1 Drainage Area

The watersheds included in this study are delineated using LIDAR topographic information provided by the City of Cedar Park. Each watershed is subdivided into sub-areas as defined by critical points of interest along the waterways. Exhibit 2 illustrates watershed delineations and subareas.

2.2.2 Infiltration Losses

The U.S. Department of Agriculture Natural Resource Conservation Service (NRCS, formerly the Soil Conservation Service) has developed a rainfall runoff index, the runoff curve number (CN), which takes into account such factors as soil characteristics, land use/land condition, and antecedent soil moisture to derive a generalized rainfall runoff relationship for a given area. A description of these components and the equation for calculating runoff depth from rainfall are provided below.

The NRCS classifies soils into four hydrologic soil groups: A, B, C and D. These soil groups indicate the runoff potential of a soil, ranging from a low runoff potential (group A) to a high runoff potential (group D). Using ESRI's ArcVIEW software and the Soil Survey Geographic (SSURGO) database, a composite curve number was calculated for each sub-area in the watersheds.

The NRCS provides runoff curve numbers for three Antecedent Moisture Conditions (AMC): I, II and III. AMC I represents dry soil conditions and AMC III represents saturated soil conditions. AMC II, which represents average soil moisture conditions, is assumed for this analysis. Runoff curve numbers vary from 0 to 100, with the smaller values representing lower runoff potential and the larger values representing higher runoff potential. CN values between 76 and 81 were calculated for the soil types within the study area. Impervious cover values are entered separately from CN values into HEC-1 model. It is assumed that 100% runoff is generated from impervious areas, while runoff from pervious areas is estimated using the selected CN value and the following equations:

$$Q = (P - 0.2\times S)^2 / (P + 0.8\times S) \qquad \text{Equation 1}$$

and

$$CN = 1000 / (10 + S) \qquad \text{Equation 2}$$

where:

Q = depth of runoff (in),
P = depth of precipitation (in),
S = potential maximum retention after runoff begins, and
CN = runoff curve number.

Land use conditions for existing conditions were determined using aerial photographs, and future land use conditions are based on zoning maps provided by the City of Cedar Park. Impervious cover values assigned to each land use are shown below in Table 2.

Table 2: Land Use Categories and Impervious Cover Values

Category	Impervious Cover %
Residential	40
Multifamily	65
Comercial, General Office	80
Transportation	95

2.2.3 Unit Hydrograph Method

A rainfall/runoff transformation is required to convert rainfall excess (total rainfall minus infiltration losses) into runoff from a particular subarea. The NRCS unit hydrograph option in HEC-1 is used in this analysis to generate runoff hydrographs for each defined subarea within the watersheds.

The dimensionless unit hydrograph developed by the NRCS (Figure 4) was developed by Victor Mockus and presented in National Engineering Handbook, Section 4, Hydrology, published by the U. S. Natural Resource Conservation Service. The dimensionless unit hydrograph has its ordinate values expressed in a dimensionless ratio q/qp and its abscissa values as t/Tp. This unit hydrograph has a point of inflection approximately 1.7 times the time to peak (Tp), and the time-to-peak 0.2 of the time-of-base (Tb) (NRCS, 1985).

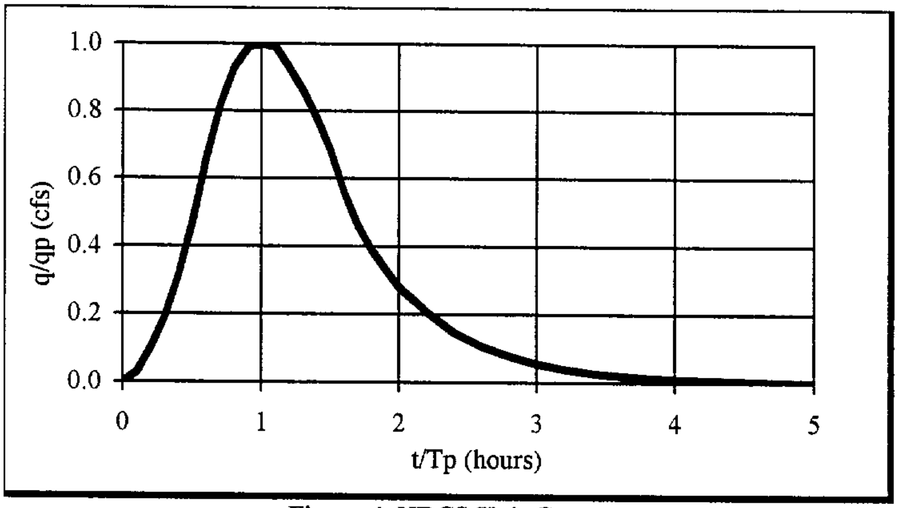


Figure 4 NRCS Unit Graph

Input data for this method consists of a single parameter, T_{LAG}, which is equal to the time (hours) between the center of mass of rainfall excess and the peak of the unit hydrograph. (NRCS, 1985) The time to peak of the hydrograph is computed using the following equation:

$$T_{PEAK} = \Delta t/2 + T_{LAG}$$ Equation 3

where:

T_{PEAK} = time to peak of the unitgraph (hrs)
Δt = computation interval / duration of unit excess (hrs)

T_{LAG} = watershed lag (hrs)

The peak flow rate of the unitgraph is computed using the following equation:

$$qp = 484A/T_{PEAK}$$ Equation 4

where:

qp = peak flow rate of the unitgraph (cfs/in)
A = watershed area (sq mi)

2.2.4 Time of Concentration and Lag Time Computation

The NRCS method assumes that the lag time of a watershed is 60% of the watershed's time of concentration. The time of concentration is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed (NRCS, 1985). It may be estimated by calculating and summing the travel time for each sub-reach defined by the flow type: sheet flow, shallow concentrated flow, roadway, storm sewers and channelized flow. The methods prescribed in the NRCS' Technical Release 55 (TR55) are used to determine the time of concentrations for each flow segment in this analysis. The watershed parameter worksheet used to calculate time of concentration and lag time for each subarea is presented in Appendix B. A detailed discussion of the methods used to estimate travel times for each typical flow segment is presented below.

- **Sheet Flow (< 300 feet)**

Sheet flow is flow over plane surfaces, and usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact, drag over the plane surface, obstacles such as litter, crop ridges, and rocks, and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. For undeveloped areas, sheet flow lengths may be as long as 300 feet; however, for ultimate development conditions assumptions, the sheet flow distance is reduced by approximately half in order to represent a more efficient drainage system, commonly associated with new development. For sheet flow less than 300 feet, travel time is computed as follows:

$$Tt = (0.007 \times (n \times L)^{0.8}) \ / \ (P_2^{0.5} \times s^{0.4}) \qquad \text{Equation 5}$$

where

Tt	=	travel time (hr),
n	=	Manning's roughness coefficient,
L	=	flow length (ft),
P_2	=	2-year, 24-hour rainfall (in), and
s	=	slope of hydraulic grade line (land slope, ft/ft).

- **Shallow Concentrated Flow**

After a maximum of 300 feet, it is assumed that sheet flow becomes "shallow concentrated flow." The average velocity for this flow can be determined from the following figure (Figure 5) in which average velocity is a function of watercourse slope and type of channel.

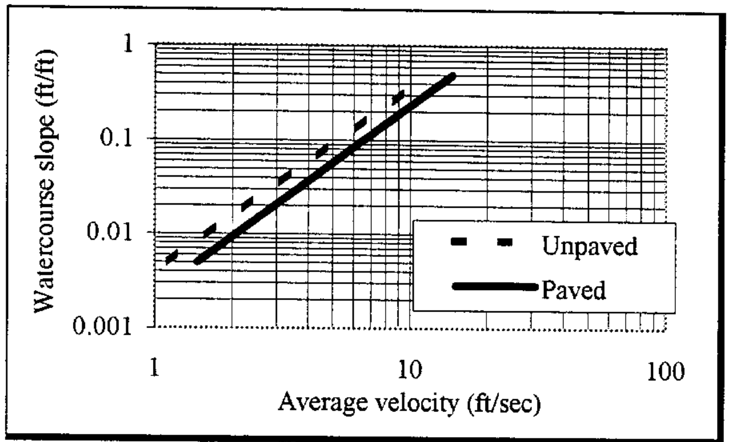


Figure 5 Average Velocities for Estimating Travel Time in Shallow Concentrated Flow Segments

After determining the average velocity, the following equation is used to compute travel time:

$$Tt = L / (3600 \times V) \qquad \text{Equation 6}$$

Where;

Tt = travel time (hr),
L = flow length (ft),
V = average velocity (ft/s), and
3600 = conversion factor from seconds to hours.

- **Open Channel Flow**

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation. Both open channel and closed conduit systems can be included.

Manning's equation is

$$V = 1.49 \times r^{2/3} \times s^{0.5} / n \qquad \text{Equation 7}$$

where

V = average velocity (ft/sec),
r = hydraulic radius (ft) and is equal to a/p_w,
a = cross sectional flow area (ft^2),
p_w = wetted perimeter (ft),
s = slope of the hydraulic grade line (channel slope, ft/ft), and
n = Manning's roughness coefficient for open channel flow.

After determining the average velocity, equation 6 is used to compute travel time.

2.3 HYDROGRAPH ROUTING

The Muskingum-Cunge method of stream flow routing is used in this analysis to modify hydrographs to reflect the effects of translation and attenuation within a channel reach. The required input for this method includes: channel length, channel slope, Manning's roughness coefficient, channel bottom width, and a representative channel side slope. Pond and reservoir routing is performed using the modified Puls method.

Relatively small detention ponds specifically constructed for development projects are not included in the hydrologic model. The effects of these detention ponds on the timing of the peak is accounted for in the lag time computation.

2.4 COMPUTED PEAK FLOW RATES

The following sections include a summary of computed peak flow rates for each system. Complete rainfall (depth and distribution) and peak flow rate information was not available for calibration in this study. USGS regional regression equations were used to evaluate the HEC-1 models. Computed flows are within the confidence limits calculated from the regression equations.

2.4.1 South Brushy Creek (Including Cluck Creek and Buttercup Creek)

Tables 2 and 3 include a summary of computed peak flow rates for South Brushy Creek (including Cluck Creek and Buttercup Creek) for existing and ultimate development conditions, respectively.

Table 3 South Brushy Creek Computed Peak flow Rates (Existing Conditions)

HEC-1 Node	Drainage Area (sq mi)	Computed Peak Flow Rates (cfs) 10-Year	25-Year	50-Year	100-Year	Flow Location
CLUCK CREEK						
C1	0.860	1,027	1,335	1,566	1,801	Cedar Park Drive
T1 CON	2.210	2,379	3,112	3,661	4,219	U/S of Confl. w Trib No. 1
Cluck Creek Tributary No. 1						
C3	0.700	1,206	1,555	1,814	2,075	Cluck Creek Road
CC CON	1.050	1,102	1,458	1,733	2,012	U/S of Confl. w Cluck Creek
US 183	3.260	3,368	4,433	5,232	6,053	Total Flow U/S of US 183
S BRSH	4.120	3,823	5,073	6,024	6,993	U/S of Confl. w South Brushy
BUTTERCUP CREEK						
BC1	1.550	1,937	2,551	3,011	3,477	U/S of Confl w Unnamed Trib.
CCRD	2.120	2,670	3,521	4,159	4,807	Cluck Creek Road
NRCS 6	4.380	4,853	6,359	7,482	8,621	
NRCS 6	5.960	6,665	8,721	10,249	11,802	Total Flow U/S of NRCS 6
NRCS 6	5.960	64	67	68	70	Total Flow D/S of NRCS 6
SOUTH BRUSHY CREEK						
CC CON	6.550	635	832	974	1,118	U/S of Confl w Cluck Creek
SBRSH	10.670	4,435	5,880	6,972	8,095	D/S of Confl w/ Cluck Creek
BC Rd	12.600	5,462	7,403	8,895	10,435	near U/S from Brushy Crk Rd
NRCS 7	16.180	7,493	10,146	12,186	14,268	Total Flow U/S of NRCS 6
NRCS 7	16.180	21	35	48	67	Total Flow D/S of NRCS 6

NOTE: Computed peak flow rates are based on theoretical design storms and do not necessarily represent the results of a statistically based storm frequency analysis.

Table 4 South Brushy Creek Computed Peak flow Rates (Ultimate Conditions)

HEC-1 Node	Drainage Area (sq mi)	Computed Peak Flow Rates (cfs)				
		10-Year	25-Year	50-Year	100-Year	Flow Location
CLUCK CREEK						
C1	0.860	1,132	1,442	1,672	1,905	Cedar Park Drive
T1 CON	2.210	2,537	3,275	3,820	4,374	U/S of Confl. w Trib No. 1
Cluck Creek Tributary No. 1						
C3	0.700	1,248	1,596	1,853	2,113	Cluck Creek Road
CC CON	1.050	1,181	1,537	1,812	2,092	U/S of Confl. w Cluck Creek
US 183	3.260	3,592	4,661	5,465	6,283	Total Flow U/S of US 183
S BRSH	4.120	3,986	5,212	6,134	7,077	U/S of Confl. w South Brushy
BUTTERCUP CREEK						
BC1	1.550	2,177	2,795	3,251	3,715	U/S of Confl w Unnamed Trib.
CCRD	2.120	2,944	3,797	4,429	5,072	Cluck Creek Road
NRCS 6	4.380	5,467	6,975	8,100	9,239	
NRCS 6	5.960	7,439	9,498	11,028	12,581	Total Flow U/S of NRCS 6
NRCS 6	5.960	65	68	69	157	Total Flow D/S of NRCS 6
SOUTH BRUSHY CREEK						
CC CON	6.550	825	1,060	1,234	1,406	U/S of Confl w Cluck Creek
SBRSH	10.670	4,619	6,049	7,124	8,229	D/S of Confl w/ Cluck Creek
BC Rd	12.600	6,059	7,881	9,307	10,792	near U/S from Brushy Crk Rd
NRCS 7	16.180	8,965	11,749	13,884	16,061	Total Flow U/S of NRCS 6
NRCS 7	16.180	28	46	65	88	Total Flow D/S of NRCS 6

NOTE: Computed peak flow rates are based on theoretical design storms and do not necessarily represent the results of a statistically based storm frequency analysis.

2.4.2 Spanish Oak Creek

Tables 4 and 5 includes a summary of computed peak flow rates for Spanish Oak Creek for existing and ultimate development conditions, respectively.

Table 5 Spanish Oak Creek Computed Peak flow Rates (Existing Conditions)

HEC-1 Node	Drainage Area (sq mi)	Computed Peak Flow Rates (cfs)				
		10-Year	25-Year	50-Year	100-Year	Flow Location
SPANISH OAK CREEK						
SP1	0.150	152	210	254	299	Carriage Hills Pond Outflow
CENTRD	0.540	756	993	1,174	1,358	Century Road
US 183	0.540	616	812	1,001	1,182	Total Flow U/S of US 183
RR	0.790	957	1,218	1,426	1,699	Total Flow U/S of Railroad
FM 1431	1.270	1,856	2,338	2,706	3,079	Total Flow U/S of FM 1431
FM 1431	1.380	2,040	2,569	2,971	3,380	Total Flow D/S of FM1431
SOCRK	1.460	2,166	2,727	3,156	3,594	U/S of Confl on Spaonish Oak
SOCRK	2.580	3,563	4,707	5,534	6,334	Total Flow at Confl Spanish Oak
NRCS 4	3.570	4,597	6,038	7,091	8,114	
NRCS 4	5.610	6,799	9,004	10,641	12,283	Total Flow U/S of NRCS 4
NRCS 4	5.610	13	20	28	37	Total flow D/S of NRCS 4

NOTE: Computed peak flow rates are based on theoretical design storms and do not necessarily represent the results of a statistically based storm frequency analysis.

Table 6 Spanish Oak Creek Computed Peak flow Rates (Ultimate Conditions)

HEC-1 Node	Drainage Area (sq mi)	Computed Peak Flow Rates (cfs) 10-Year	25-Year	50-Year	100-Year	Flow Location
SPANISH OAK CREEK						
SP1	0.150	154	212	257	302	Carriage Hills Pond Outflow
CENTRD	0.540	824	1,062	1,242	1,424	Century Road
US 183	0.540	674	871	1,079	1,245	Total Flow U/S of US 183
RR	0.790	1,040	1,302	1,515	1,800	Total Flow U/S of Railroad
FM 1431	1.270	2,005	2,501	2,884	3,266	Total Flow U/S of FM 1431
FM 1431	1.380	2,229	2,774	3,192	3,610	Total Flow D/S of FM1431
SOCRK	1.460	2,366	2,960	3,405	3,853	U/S of Confl on Spaonish Oak
SOCRK	2.580	3,648	4,814	5,691	6,526	Total Flow at Confl Spanish Oak
NRCS 4	3.570	4,962	6,451	7,593	8,715	
NRCS 4	5.610	7,486	9,652	11,354	13,103	Total Flow U/S of NRCS 4
NRCS 4	5.610	15	23	33	42	Total flow D/S of NRCS 4

NOTE: Computed peak flow rates are based on theoretical design storms and do not necessarily represent the results of a statistically based storm frequency analysis.

2.4.3 Blockhouse Creek

Tables 6 and 7 includes a summary of computed peak flow rates for Blockhouse Creek for existing and ultimate development conditions, respectively.

Table 7 Blockhouse Creek Computed Peak flow Rates (Existing Conditions)

HEC-1 Node	Drainage Area (sq mi)	Computed Peak Flow Rates (cfs) 10-Year	25-Year	50-Year	100-Year	Flow Location
BLOCKHOUSE CREEK						
BH1	0.465	764	986	1,153	1,318	West New Hope Road
US 183	2.712	3,643	4,736	5,552	6,382	Total Flow at US 183
CONFLY	4.158	5,322	6,945	8,145	9,360	Total flow at confluence 1
CONFL	6.205	7,704	10,046	11,784	13,563	Total flow at confluence 2
SCS 3	7.809	9,326	12,238	14,411	16,632	U/S of SCS 3

NOTE: Computed peak flow rates are based on theoretical design storms and do not necessarily represent the results of a statistically based storm frequency analysis.

Table 8 Blockhouse Creek Computed Peak flow Rates (Ultimate Conditions)

HEC-1 Node	Drainage Area (sq mi)	Computed Peak Flow Rates (cfs) 10-Year	25-Year	50-Year	100-Year	Flow Location
BLOCKHOUSE CREEK						
BH1	0.465	829	1,050	1,213	1,379	West New Hope Road
US 183	2.712	3,964	5,067	5,874	6,695	Total Flow at US 183
CONFLY	4.158	5,866	7,496	8,703	9,934	Total flow at confluence 1
CONFL	6.205	8,576	10,986	12,754	14,567	Total flow at confluence 2
SCS 3	7.809	10,257	13,219	15,417	17,660	U/S of SCS 3

NOTE: Computed peak flow rates are based on theoretical design storms and do not necessarily represent the results of a statistically based storm frequency analysis.

3.0 HYDRAULIC ANALYSIS

3.1 METHOD OF ANALYSIS

Version 3.0 of the HEC-RAS computer program developed by the Hydrologic Engineering Center (HEC) of the US Army Corps of Engineers is used in this analysis to compute water surface elevations along the existing channel reach. Water surface elevations are computed for the 10-year, 25year, 50-year, and 100-year frequency storm events. HEC-RAS model output is included in Appendix C. The following sections describe the primary model input parameters and the results of the analysis.

3.1.1 Starting Condition

The starting conditions (downstream boundary condition) are based on the rating curves of the NRCS reservoirs for South Brushy Creek (including Buttercup Creek), Spanish Oak Creek and Blockhouse Creek. The starting condition for Cluck Creek is normal depth.

3.1.2 Peak Flow Rates

The computed peak flow rates presented in the previous section are used in this analysis to compute the 10-year, 25-year, 50-year and 100-year water surface elevations along the creek.

3.1.3 Channel Geometry

Channel cross-section data used in the hydraulic model is taken from light detection and ranging (LIDAR) survey information collected by Sanborn Colorado, L.L.C. in 2001. The survey network is referenced to the NAD 83 (1993) horizontal datum, and NAVD88 vertical datum. Accuracy of the LIDAR data meets American Society for Photogrammetry & Remote Sensing (ASPRS) Class 1 standards for large scale maps which includes a 2' contour interval.

3.1.4 Mannings Roughness Coefficients

For open channel flow, the HEC-RAS computer program computes water surface elevations for each cross-section based on the energy equation and the standard step method. Typically, Manning's equation is used by the program to estimate head losses from one cross-section to the next, and is dependent on a roughness coefficient input. Channel roughness coefficients typically range from approximately 0.035 to 0.040 for grass lined channels, may increase to about 0.06 to 0.10 for poorly maintained channels with high weeds, brush and trees.

3.2 COMPUTED WATER SURFACE ELEVATIONS

Computed water surface elevations for the 10-year, 25-year, 50-year and 100-year frequency storm events are included in the HEC-RAS output included in Appendix C along with water surface profiles. The resulting 100-year floodplain is included in Exhibits 3a through 3e presented in Appendix A. For comparison, Exhibits 3a through 3e also include published FEMA base flood (100-year frequency) elevations taken from the effective Flood Insurance Rate Maps (FIRM) and mapped using the 2001 LIDAR survey data.

The model results indicated the following conveyance system deficiencies:
Along Spanish Oak Creek from Skyview Drive to Bagdad Road; and Cluck Creek from upstream of Cedar Park Drive to Post Oak Circle. Spanish Oak Creek is general characterized by an ill-defined channel cross-section that does not contain flood flows. Furthermore, significant head losses are computed through culvert and bridge structures at FM 1431, the Southern Pacific Railroad and US Highway 183. Concrete obstructions containing sanitary sewer crossings in Cluck Creek between Cedar Park Drive and Post Oak Circle result in a significant reduction in the channel's conveyance capacity.

4.0 PROPOSED IMPROVEMENTS

Since 1992, the City of Cedar Park has maintained very effective land development regulations, which includes a comprehensive floodplain management policy that has effectively managed new development and floodplains within the city limits since 1992. However, many developments constructed prior to 1992 were situated in flood-prone areas. Most of the flooding problems identified in this study are associated with older developments.

Specific recommendations to address the problems in six (6) flood prone areas have been identified as a result of this study, based on input from City of Cedar Park staff and local knowledge from residents. The proposed improvements include four (4) primary strategies: 1) Channel clearing and maintenance; 2) Channel improvements; 3) Storm sewer improvements; and, 4) Culvert upgrades.

The following sections describe these recommendations by area, and Exhibit 4 illustrates the limits of the proposed improvements. The acquisition of right of way and easements for the construction of these improvements will be required in most of these areas. Furthermore, these estimates are intended to provide an order of magnitude of the associated construction cost for planning purposes only. Detailed field survey and detail design of each solution will be required to more specifically identify the limits of improvements, estimate quantities and better estimate actual construction cost.

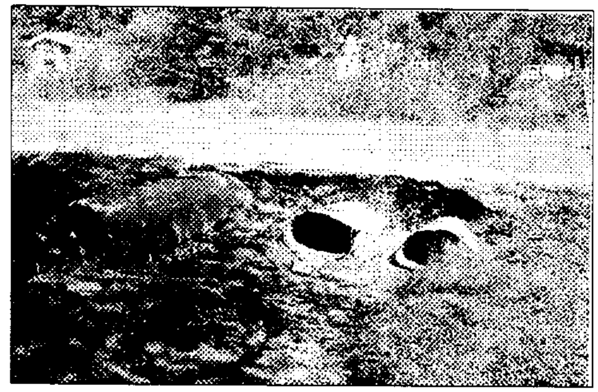
While the results of the analysis indicate that significant floodplain, culvert and bridge restrictions exist between FM 1431 and US Highway 183 along Spanish Oak Creek, this area, which includes Cedar Park's proposed Downtown District, is being developed under the City's current development drainage criteria. The criteria requires the effective management of this floodplain and flood prone area to ensure no adverse hydrologic or hydraulic impact to upstream or downstream property owners, and ensure that development in the area is outside the limits of the 100-year floodplain. Therefore, no recommendations for this area included in this master plan.

4.1 UPPER SPANISH OAK CREEK

Upper Spanish Oak Creek is almost 100% urbanized, and includes small single family lots and a poorly defined conveyance way. These 2 photographs show the existing channel looking downstream at Century Lane.


Spanish Oak Creek: Looking Downstream From Century Lane

Development in this area existed prior to the implementation of effective regulations, which has resulted in the placement of homes and structures directly in the path of stormwater runoff. Necessary structural improvements to this area will be extremely difficult due to confined space and very limited right-of-way or easements. Alternative solutions for this area are limited to improvements of conveyance systems



Spanish Oak Creek: Looking Downstream at Century Lane

to provide an adequate outfall to adjacent collection systems. A detention solution for regulating stormwater runoff was considered; however, because of the associated outfall system requirements and effectiveness of that solution, it was not selected. The only large, undeveloped tract in this area is located to the north of Spanish Oak Creek in drainage area SP2 (shown in Exhibit 2). However, given its location in the headwaters, any detention that could be obtained would prove inconsequential, considering the small size of the contributing area. Furthermore, a proposed pond with adequate storage depth (> 6.0 feet) would still require the construction of an outfall system downstream. In order to effectively and efficiently reduce flooding in this area, and provide an outfall drainage system from adjacent properties, an channelized (open and enclosed) system is recommended.

Proposed upper Spanish Oak Creek improvements extend an approximate total of 2,000 linear feet from Bagdad Road to the upstream end of the Walmart detention pond (currently under construction), located just downstream from Century Lane. The proposed improvements begin downstream from Bagdad Road, and includes an open channel design (6 bottom width, 3:1 side slopes, flow depth of approximately 4.5 feet) which extends approximately 800 feet along rear property lines to just upstream of Doris Lane. At that point the system is conveyed approximately 450 linear feet in an enclosed 10' X 7' (width by height) reinforced concrete box culvert (RCB) adjacent to the residential lots that front Doris Lane. From that point it is again conveyed in an open channel system (see previous description) along the back of residential lots and an existing vacant lot located to the back of the residential lots that front Century Lane. The length is approximately 350 linear feet. The downstream end of the improvement includes another enclosed system (10' X 7' RCB) that extends from the back of the residential lots that front Century Lane on the west to the headwaters of the Walmart detention pond. The estimated construction cost of these improvements, including easement acquisition, ranges from $700,000 to $1,100,000, and provide a 100-year level of protection to adjacent properties.

4.2 LOWER SPANISH OAK CREEK

Spanish Oak Creek: Skyview Drive Looking Upstream

Spanish Oak Estates lies downstream of FM 1431 along Spanish Oak Creek. This low-lying area includes large single family lots (ranchettes) and regularly experiences overbank flooding. Proposed improvements to lower Spanish Oak Creek extend approximately 5,000 linear feet downstream of FM 1431 through the Spanish Oak Estates subdivision to downstream of Skyview Drive.

Due to the sensitivity of this area to environmental constraints and regulations, and a low benefit to cost ratio for structural alternatives, the recommended improvements to this area include the clearing of heavy brushy and debris, and the implementation of a maintenance program in order to improve conveyance of flood waters. These photographs show the heavy undergrowth at Skyview Drive, typical through this reach. Buyouts of insurable structures that experience repeated flooding should also be considered. The estimated cost for initial clearing assuming a width of 50 to 100 feet along the creek centerline, including easement acquisition, is $150,000 to $200,000. This improvement would reduce the 100-year floodplain elevations by approximately 1 to 1.5 feet. Thirty structures currently lie within the limits of the computed 100-year floodplain (ultimate), and the proposed improvements would remove 10 of these structures.

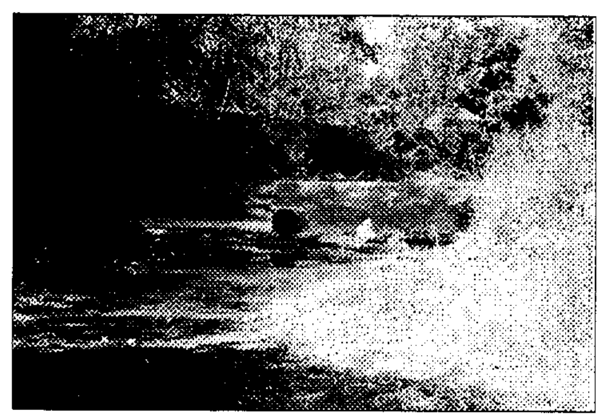
An alternative solution that was considered, but is not recommended, includes the construction of an open channel through this reach. However, due to environmental value of this riparian stream reach, the destruction would require a significant environmental mitigation effort. Furthermore, only a limited number of property owners (approximately 15), many of whom currently lie outside the city limits, would benefit from this very costly construction project.

Spanish Oak Creek: Skyview Drive Looking Downstream

An upstream detention alternative is not feasible because of the limited amount of area available for such a facility. Most of the watershed is developed, and the large undeveloped tracts located upstream from FM 1431 and downstream of the railroad are currently being developed as part of the City's new downtown project and are not available for this alternative.

4.3 UPPER CLUCK CREEK

Conveyance in upper Cluck Creek is significantly restricted by the existence of dam crossing structures located within the creek that encase wastewater lines. These wastewater lines appear to connect dual 6-inch lines extending the length of the creek. The purpose of the connections is unknown, but is presumably necessary to provide overflow relief of the wastewater system from one side to the other. The removal of these structures is the most logical first step in relieving existing flood problems and providing an improved level of protection. A diversion of flood waters in either open or closed conduits is not feasible because of urban conflicts and the linear dimension of the water course. A detention solution for regulating stormwater runoff was not considered because it could not be strategically located upstream from the site to sufficiently regulate flow rates through this reach.



Cluck Creek: Looking Upstream from Prize Oak Drive at Watewater Crossing

Necessary improvements in upper Cluck Creek extend from downstream of Post Oak Circle through Prize Oak Drive to Cedar Park Drive. Improvements to this channel reach include the demolition of the 5 existing 6-inch wastewater crossings encased in concrete, and the placement of a new wastewater line in the bank of the creek to provide necessary capacity. A hydraulic analysis of the wastewater system will be required in order to develop a specific design solution for the realignment/re-routing of these systems. This recommendation will provide a 10 to 25 year level of protection to adjacent residents. Preliminary construction cost estimates of the realignment/re-routing of the system in this area range from $120,000 to $170,000. It is assumed the majority of this work will occur with in the existing channel and established R.O.W.

4.4 CEDAR PARK DRIVE (UNNAMED TRIBUTARY TO CLUCK CREEK)

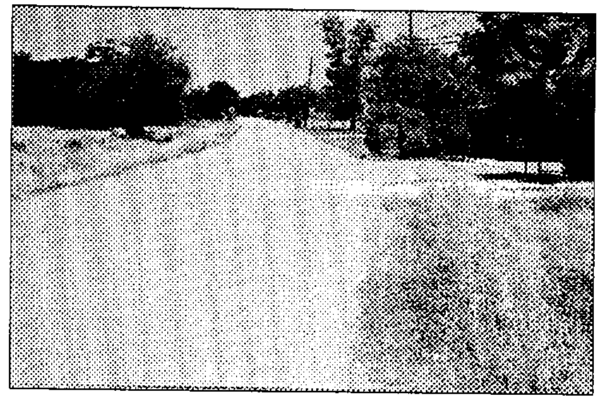

Cedar Park Drive Low-Water Crossing Looking West (Flow is From Right to Left)

This general area has long been a problem for the residents of Cedar Park who routinely experience nuisance flooding. Older development areas, such as this, were constructed prior to current development requirements with essentially no provisions for drainage infrastructure (e. g. storm sewer, roadside ditches, bypass outfall channels or easement provisions for future upstream developments, detention ponds, etc.). These developments are normally located in the headwaters of watersheds and don't necessarily experience flood damages typically associated with primary drainage ways. As a result, these structures are not subject to significant damage, posing health and safety risks. However, flood events in this area regularly produce inundation of driveways, lawns and streets that pose an inconvenience to home owners. Inconveniences include erosion, post storm debris deposits, temporary access restrictions, etc.

Improvements in these areas are intended to provide relief from nuisance flooding and bring the neighborhood's drainage infrastructure up to an acceptable level of services. They are not intended to protect properties from significant flood events (i.e. 5-year and greater). The recommended improvements include the construction of roadside collector ditches (v-shape with depths ranging from 1 foot to 2 feet) along the up-slope side (north) of Hall Street and Wooten Street that will collect and convey stormwater runoff to a central location that will then convey runoff in an open v-shape channel (approximately 2 feet to 4 feet) extending toward the south to near upstream of Cedar Park Drive. The improvement will also include culvert crossings at Hall Street and Wooten Street. The total estimated construction cost ranges from $30,000 to $50,000. The results of this project would benefit the City by providing an infrastructure template to be used in other parts of the City, and address citizen input.

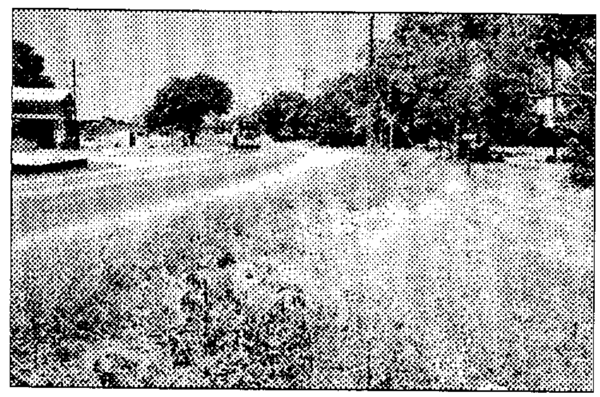
4.5 SOUTH COUGAR AVENUE (UNNAMED TRIBUTARY TO SOUTH BRUSHY)

Sheet flow collects in very shallow inadequate roadside ditches that extend along Cougar Avenue and Brushy Creek. Existing culverts in Cougar Avenue and Brushy Creek include a 24-inch and 30-inch diameter pipe, respectively. Both structures provide very poor conveyance due to the collection of silt and debris.



Looking Northerly Along Cougar Avenue (Upstream)

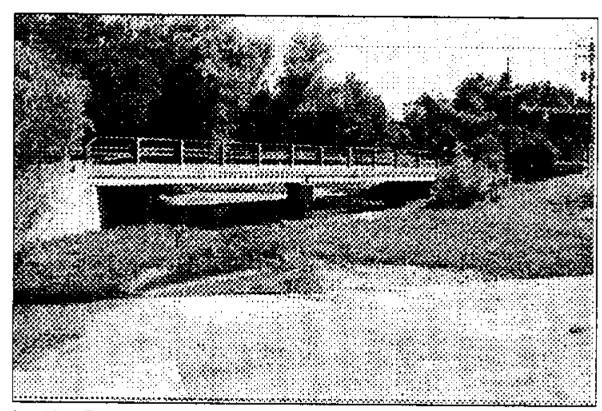
Similarly, improvements in these areas are intended to provide relief from nuisance flooding and bring the neighborhood's drainage infrastructure up to an acceptable level of service. They are not intended to protect properties from significant flood events (i.e. 5-year and greater). Recommended local drainage improvements to this area include improvements to the roadside ditches extending along Cougar Avenue and South Brushy Creek Road. The improvements include a v-shaped ditch ranging in depth from 2 feet to 4 feet and culvert crossings of Cougar Avenue (2 - 36" reinforced concrete pipe (RCP)) and South Brushy Creek Road (2 - 36" RCP). The improvements will also include the replacement of 8 to 10 driveway culverts. The total estimated construction cost ranges from $40,000 to $70,000.



Looking Westerly Along Brushy Creek Road (Upstream)

4.6 RIVIERA AT NRCS RESERVOIR NO. 6

Flood proofing of residences or buyouts of insurable structures that experience repeated flooding should be the primary consideration in this area. Structures located in low-lying areas will continue to be subject to flooding due to the backwater effects of NRCS reservoir No. 6. Currently 9 properties lie within this 100-year backwater floodplain. Flood proofing measures for residential structures can vary from $5,000 to 10,000 in cost whereas buyout cost could average $100,000 per home.



Looking Downstream at Riviera Drive Toward NRCS No. 6

Due to the fact that this is a backwater condition from NRCS reservoir No. 6, channel improvements would not be effective. Also, the City of Cedar Park does not control the NRCS Dam No. 6, and improvements to such a large structure would not be allowed.

5.0 IMPLEMENTATION PLAN

5.1 REGULATORY COMPLIANCE

Prior to commencement of construction, it will be necessary to submit the project and appropriate permit applications to regulatory agencies. A detailed review and acquisition of the necessary permits for the construction of these project(s) exceeds the scope of this contract. However, a partial list and brief discussion of permits is included in the following subsections. This following list of agencies and corresponding permit activities is intended to be general in nature, and is not intended to represent a definitive list of required permit acquisitions and agency coordination.

5.1.1 Federal Emergency Management Agency (FEMA)

The National Flood Insurance Act of 1968 was enacted by Title XIII of the Housing and Urban Development Act of 1968 (Public Law 90-448, August 1, 1968) to provide previously unavailable flood insurance protection to property owners in flood prone areas. The Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program (NFIP), however, if a local community elects to participate in the NFIP, the local government is primarily responsible for enforcement. Participating communities are typically covered by flood insurance studies (FIS) which define water surface profiles and floodplain boundaries through their communities.

All streams included in this hydraulic analysis are studied streams in the current Williamson County FIS dated July 1990, revised January 3, 1997. The effective Flood Insurance Rate Maps (FIRM) is dated September 27, 1991. Although various letters of map revision (LOMR) have been issued by FEMA throughout Cedar Park, floodplain elevations on original maps have not been revised.

The recommended drainage improvement projects summarized in this report are intended to reduce floodplain limits. However, if changes to the current effective FEMA floodplain elevations are desirable based on the results of this study, or from the proposed improvements, a request for a LOMR from FEMA will be required.

5.1.2 U. S. Army Corps of Engineers (USACOE)

Pursuant to Section 404 of the Clean Water Act and the Rules and Regulations promulgated thereunder by the United States Environmental Protection Agency (EPA) and the United States Army Corps of Engineers (USACE), the filling or excavation of waters of the United States, including wetlands, with dredged or fill material, requires the issuance of a permit from the USACE (33 CFR Parts 320-330). For purposes of administering the Section 404 permit program, the USACE defines wetlands as follows:

> *Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs*

and similar areas. (33 CFR 328.3)

The Corps of Engineers Wetlands Delineation Manual (Technical Report Y-87-1), issued by the USACE, in 1987, states that wetlands must possess three essential characteristics. These characteristics include, under normal circumstances: 1) the presence of hydrophytic (water-loving) vegetation, 2) hydric soils, and 3) wetland hydrology. If all three of these criteria are present on a particular property in areas larger than one-third acre in size, then a permit (general permit or nationwide permit) must be issued by the USACE in order to fill all or a portion of those areas.

Section 404 (b)(1) guidelines (40 CFR Part 230), established by the U. S. Environmental Protection Agency, constitute the substantive environmental criteria used in the evaluating activities regulated under Section 404 of the Clear Water Act. The purpose of these guidelines is to restore and maintain the chemical physical and biological integrity of waters of the United states through the control of discharge of dredged or fill material.

All property owners within the United States and its territories must adhere to the provisions of the Clean Water Act. If any contemplated activity might impact waters of the United States, including adjacent or isolated wetlands a permit application must be made. If jurisdictional wetlands are found to exist, then any activity which would involve filling, excavating, or dredging these wetlands would require the issuance of a permit.

5.1.3 U. S. Environmental Protection Agency (EPA)

The Federal Clean Water Act of 1972 established several programs designed to protect and enhance the quality of the Nation's surface water. One of these programs, the National Pollutant Discharge Elimination Systems (NPDES) regulates construction activities disturbing more than five (5) acres of land. Any proposed project that involves clearing, grading, or excavating will be covered under the NPDES Storm Water Permit for Construction Activities as long as the project complies with the Storm Water Pollution Prevention Plan (SWPPP) and all other conditions associated with the NPDES storm water construction permit.

In addition, a Notice of Intent (NOI) must be filed with the U. S. Environmental Protection Agency at least 48 hours in advance of construction activities. Changes to the timing of the notification should be tracked to ensure that construction delays do not result from inadequate advance notification.

5.1.4 U. S. Fish and Wildlife Service (USFWS)

The U. S. Fish and Wildlife Service (USFWS), in the Department of the Interior, and the National Marine Fisheries Service (NMFS), in the Department of Commerce, share responsibility for administration of the Endangered Species Act (ESA). Generally the USFWS is responsible for terrestrial and freshwater species and migratory birds, while the NMFS deals with those species occurring in marine environments and anadromous fish.

Section 9 of the ESA prohibits take of federally listed endangered or threatened species without appropriate authorization. Take is defined in the ESA, in part as "killing, harming, or harassment" of a federally listed species, while incidental take is take that is "incidental to, and not the purpose of, otherwise lawful activities".

Section 10 of the ESA provides a means for non-Federal projects resulting in take of listed species to be permitted subject to carefully prescribed conditions. Application for an incidental take permit is subject to a number of requirements, including preparation of a Habitat Conservation Plan by the applicant. In processing an incidental take permit application, the USFWS must comply with appropriate environmental laws, including the National Environmental Policy Act. Review of the application under Section 7 of the ESA is also required to ensure that permit issuance is not likely to jeopardize listed species. Section 10 issuance criteria require the USFWS to issue and incidental take permit if, after opportunity for public comment, it finds that:

1. the taking will be incidental;
2. the applicant will, to the maximum extent practicable, minimizing and mitigate the impacts of the taking;
3. the applicant will ensure that adequate funding and means to deal with unforeseen circumstances will be provided;
4. the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and
5. the applicant will ensure that other measures that the USFWS may require as being necessary or appropriate will be provided.

The U. S. Fish and Wildlife Service should be contacted to determine the potential occurrence of and consequent impacts to any federal threatened and endangered species. In addition, the Corps of Engineers will require USFWS review of the project to ensure the project is in compliance with the Endangered Species Act prior to the issuance of a Section 404 permit.

5.1.5 Texas Commission on Environmental Quality (TCEQ)

The Texas Commission on Environmental Quality (TCEQ) has regulatory authority over: dam safety, the Edwards Aquifer, water rights, Texas Pollutant Discharge Elimination System and Section 404(b)(1) guidelines for specification of disposal sites for dredged or fill material. The following sections briefly describe these regulations.

- Edwards Aquifer Rules

The Edwards Rules (30 TAC Chapter 213) regulate activities having the potential for polluting the Edwards Aquifer and associated surface waters. The goals of the rules are the protection of existing and potential uses of groundwater and the maintenance of Texas Surface Water Quality Standards. The activities addressed are those that pose a threat to water quality in the recharge and transition zones. The rules apply in the Edwards Aquifer recharge, transition, and contributing zones. The limits of this project(s) lie within the Edwards Aquifer contributing zone, and will require compliance with the Edwards Rules published June 1, 1999.

Construction of any regulated activity will require the submission of an application to, and the approval of the TNRCC. Each application is required to include the following:

1. Name of the development;
2. A narrative description of the location of the project;
3. A technical report (includes information prepared for NPDES SWPPP, description of permanent BMP's, measured to control stream bank erosion, method of wastewater disposal from the site, measures that will be used to contain any spill of static hydrocarbons or hazardous substances such as on a roadway or from a pipeline or temporary aboveground storage tank and indicate placement of permanent aboveground storage tank facilities (§213.24)); and
4. Any additional information needed by the executive director for plan approval.

- Texas Pollutant Discharge Elimination System (TPDES)

On September 14, 1998, the U.S. Environmental Protection Agency (EPA) authorized Texas to implement its Texas Pollutant Discharge Elimination System (TPDES) program. TPDES is the state program to carry out the National Pollutant Discharge Elimination System (NPDES), a federal regulatory program to control discharges of pollutants to surface waters of the United States. The Texas Natural Resource Conservation Commission (TNRCC) will regulate the program. However, under terms of NPDES authorization, the EPA will retain administration of all EPA-issued storm water general permits until the existing permits expire. The expiration date for existing construction permits is July 7, 2003.

- Section 401 Water Quality Certification

Any activity requiring authorization under Section 404 of the Clean Water Act will also require a Section 401 water quality certification from the TNRCC. In Texas, these regulations are administered by the TNRCC.

- Texas Historical Commission

The Division of Antiquities Protection of the Texas Historical Commission coordinates the program by identifying and protecting important archeological and historic sites that may be threatened by public construction projects. This department coordinates the nomination of numerous sites as State Archeological Landmarks or for listing in the National Register of Historic Places. Designation is often sought by interested parties as the most effective way to protect archeological sites threatened by new development or vandalism. Applicable rules are found in the Texas Administrative Code, Title 13-Cultural Resources, Part II-Texas Historical Commission, Chapters 24-28.

The Corps of Engineers will require that the State Historical Preservation Officer (SHPO) review the project to ensure the project is in compliance with the National Historic Act prior to issuance of a Section 404 permit.

5.2 ENVIRONMENTAL INVENTORY

The environmental issues of this report have been developed by reference to existing information in published reports, maps, aerial photography, unpublished documents and communications from government agencies, individuals, and private organizations. These issues have been summarized to provide a general review level area studied. Generally, this discussion presents a cursory, screening level perspective on the environmental issues that may affect the study area.

Important species may be considered the local dominant (most abundant) species, species having some economic or recreational importance, those exhibiting disproportionate habitat impacts (habitat formers) as well as species listed, or proposed for listing, by either the State of Texas or the federal government (protected species) or Texas Organization for Endangered Species (TOES). There are numerous unlisted species which are still of concern (due to their rarity, restricted distribution direct exploitation, or habitat vulnerability), yet have not been included in the following discussions. Typically, the level of detail required to obtain the distribution and life history of these species, so as to produce a substantive evaluation, would be beyond the scope of this screening level survey.

5.2.1 Wetlands Inventory

Based on the information provided on the U. S. Fish and Wildlife Service (USFWS) Inventory Maps dated 1992 (based on 7 ½ minute USGS Quadrangle, Lake Travis, Texas), the study area includes all four creeks studied. The following table provides a breakdown of the wetland designations presented on the inventory map.

Table 9 Wetlands Inventory

Identified Feature	Symbol	System	Subsystem	Class	Subclass	Water Regime	Special Modifiers
Spanish Oak Creek	POWHh	Palustrine	n/a	Open Water/ Unknown Bottom	n/a	Permanently Flooded	diked/impounded
	PFO1A	Palustrine	n/a	Forested	Broad-Leaved Deciduous	Temporarily Flooded	n/a
	PFO1Ah	Palustrine	n/a	Forested	Broad-Leaved Deciduous	Temporarily Flooded	diked/impounded
	L1OWHh	Lacustrine	Limnetic	Open Water/ Unknown Bottom	n/a	Permanently Flooded	diked/impounded
Blockhouse Creek	PFO1A	Palustrine	n/a	Forested	Broad-Leaved Deciduous	Temporarily Flooded	n/a
	PFO1Ah	Palustrine	n/a	Forested	Broad-Leaved Deciduous	Temporarily Flooded	diked/impounded
	L1OWHh	Lacustrine	Limnetic	Open Water/ Unknown Bottom	n/a	Permanently Flooded	diked/impounded
	POWHh	Palustrine	n/a	Open Water/ Unknown Bottom	n/a	Permanently Flooded	diked/impounded
Cluck Creek	POWHh	Palustrine	n/a	Open Water/ Unknown Bottom	n/a	Permanently Flooded	diked/impounded
	PFO1A	Palustrine	n/a	Forested	Broad-Leaved Deciduous	Temporarily Flooded	n/a
South Brushy Creek (including Buttercup Creek)	POWHh	Palustrine	n/a	Open Water/ Unknown Bottom	n/a	Permanently Flooded	diked/impounded
	PEM1Ah						
	L1OWHh	Lacustrine	Limnetic	Open Water/ Unknown Bottom	n/a	Permanently Flooded	diked/impounded
	PFO1A	Palustrine	n/a	Forested	Broad-Leaved Deciduous	Temporarily Flooded	n/a
	R4SBC	Riverine	Intermittent	Streambed	n/a	Seasonally Flooded	n/a

5.2.2 Wildlife Habitat

Important species known to occur in Williamson County, and which may have habitat within the study area are listed in Table 12. This is a comprehensive list of species and their preferred habitats that have the potential to be present; however, it is not based on a detailed habitat assessment of the area.

Table 10 Important Species Having Habitat or Known to Occur

			Listing Entity			
Common Name	Scientific Name	Summary of Habitat Preference	USFWS1	TPWD1	TOES2,3	Potential Occurrence In County
American Peregrine Falcon	Falco peregrinus anatum	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	Falco peregrinus tundrius	Open country; cliffs		T	T	Nesting/Migrant
Black-capped Vireo	Vireo atricapillus	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Blanco Blind Salamander	Eurycea robusta	Troglobitic; Stream bed of the Blanco River		T	T	Resident
Blanco River Springs Salamander	Eurycea pterophila	Subaquatic; Springs and caves of the Blanco River				Resident
Blue Sucker	Cycleptus elongatus	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bracted Twistflower	Streptanthus bracteatus	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	Graptemys caglei	Waters of the Guadalupe River Basin	C		C	Resident
Canyon Mock-Orange	Philadelphus ernestii	Edwards Plateau			WL	Resident
Cascade Caverns Salamander	Eurycea latitans	Endemic; Subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	Myotis velifer	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Comal Blind Salamander	Eurycea tridentifera	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Comal Springs Dryopid Beetle	Stygoparnus comalensis	Cling to objects in streams; adults fly especially at night	E			Resident
Comal Springs Riffle Beetle	Heterelmis comalensis	Comal and San Marcos Springs	E			Resident
Comal Springs Salamander	Eurycea sp. 8	Endemic; Comal Springs				Resident
Dark Noseburn	Tragia nigricans	Deciduous woodlands, clay or clay loams, mesic canyons			WL	Resident
Edwards Aquifer Diving Beetle	Haideoporus texanus	Habitat poorly known; known from artesian well				Resident
Edwards Plateau Spring Salamander	Eurycea sp. 7	Troglobitic; Edwards Plateau				Resident
Flint's Net-Spinning Caddisfly	Cheumatopsyche flinti	"a spring"				Resident
Fountain Darter	Etheostoma fonticola	San Marcos and Comal rivers; springs and spring-fed streams	E	E	E	Resident
Golden-Cheeked Warbler	Dendroica chrysoparia	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	Micropterus treculi	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	Ammodramus henslowii	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant
Hill Country Wild-Mercury	Argythamnia aphoroides	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Horseshoe Liptooth	Polygyra hippocrepis	Steep, wooded hillsides of Land Park in New Braunfels				Resident
Keeled Earless Lizard	Holbrookia propinqua	Coastal dunes, Barrier islands and sandy areas				Resident
Lindheimer's Tickseed	Desmodium lindheimeri	Presumably flowers in mid-summer			WL	Resident
Peck's Cave Amphipod	Stygobromus pecki	Underground in Edwards aquifer	E			Resident
Plains Spotted Skunk	Spilogale putorius interrupta	Catholic; Wooded, brushy areas and tallgrass prairies				Resident
San Marcos Gambusia (extirpated)	Gambusia georgei	Endemic; upper San Marcos River	E	E	E	Resident
San Marcos Saddle-case Caddisfly	Protoptila arca	Swift; well-oxygenated warm water 1-2 m deep				Resident
San Marcos Salamander	Eurycea nana	Headwaters of the San Marcos River	T	T	T	Resident
Spot-tailed Earless Lizard	Holbrookia lacerata	Oak-juniper woodlands and mesquite-prickly pear				Resident
Texas Amorpha	Amorpha roemeriana					Resident
Texas Blind Salamander	Eurycea rathbuni	Troglobitic; Caverns along 6 mile stretch of San Marcos Springs Fault	E	E	T	Resident
Texas Garter Snake	Thamnophis sirtalis annectens	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	Phrynosoma cornutum	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	Philadelphus texensis	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Texas Salamander	Eurycea neotenes	Edwards Aquifer creek gravel bottoms, emergent vegetation; underground & rock ledges				Resident
Texas Wild-Rice	Zizania texana	Upper 2.5 km of the San Marcos River	E	E	E	Resident
Warnock's Coral Root	Hexalectris warnockii	Oak-juniper woodlands in mountain canyons; terraces along creekbeds				Resident
Whooping Crane	Grus americana	Potential migrant	E	E	E	Migrant
Zone-tailed Hawk	Buteo albonotatus	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

E = Endangered
T = Threatened
E/PT = Proposed Endangered or Threatened
C = Candidate Category, Substantial Information
WL = Conservation Watch List
Blank = Rare, but no regulatory listing status

5.3 CONSTRUCTION PHASING

Construction phasing should generally move from downstream to upstream. Since these projects are not hydraulically connected, or dependant upon another for implementation, these projects could be constructed in any sequence. Time required for the acquisition of right-of-way or easements, and input from the public, and the availability of funds are more likely to influence phasing of construction.

6.0 REFERENCES

City of Austin, Texas
Drainage Criteria

Espey Consultants, Inc.
Cypress Creek Commercial Development Cedar Park, TX
Hydrologic Impact Analysis
November 2001

Espey Padden Consultants, Inc.
Windsor Crossing Development
Improvements to Spanish Oak Creek
February 2000

Espey Padden Consultants, Inc.
Wal Mart Store No. 2991 Cedar Park, Texas
Stormwater Detention Plan
October 2000

Federal Emergency Management Agency, Federal Insurance Administration
Flood Insurance Study, Williamson County, Texas and Incorporated Areas
September 1991

Longaro & Clark, Inc.
Quest FEMA Letter of Map Revision Report
January 10, 1998

Texas Department of Water Resources
Phase I Inspection Report
National Dam Safety Program
Upper Brushy Creek WS Site No. 6
Date of Inspection: Ausgust 12, 1980

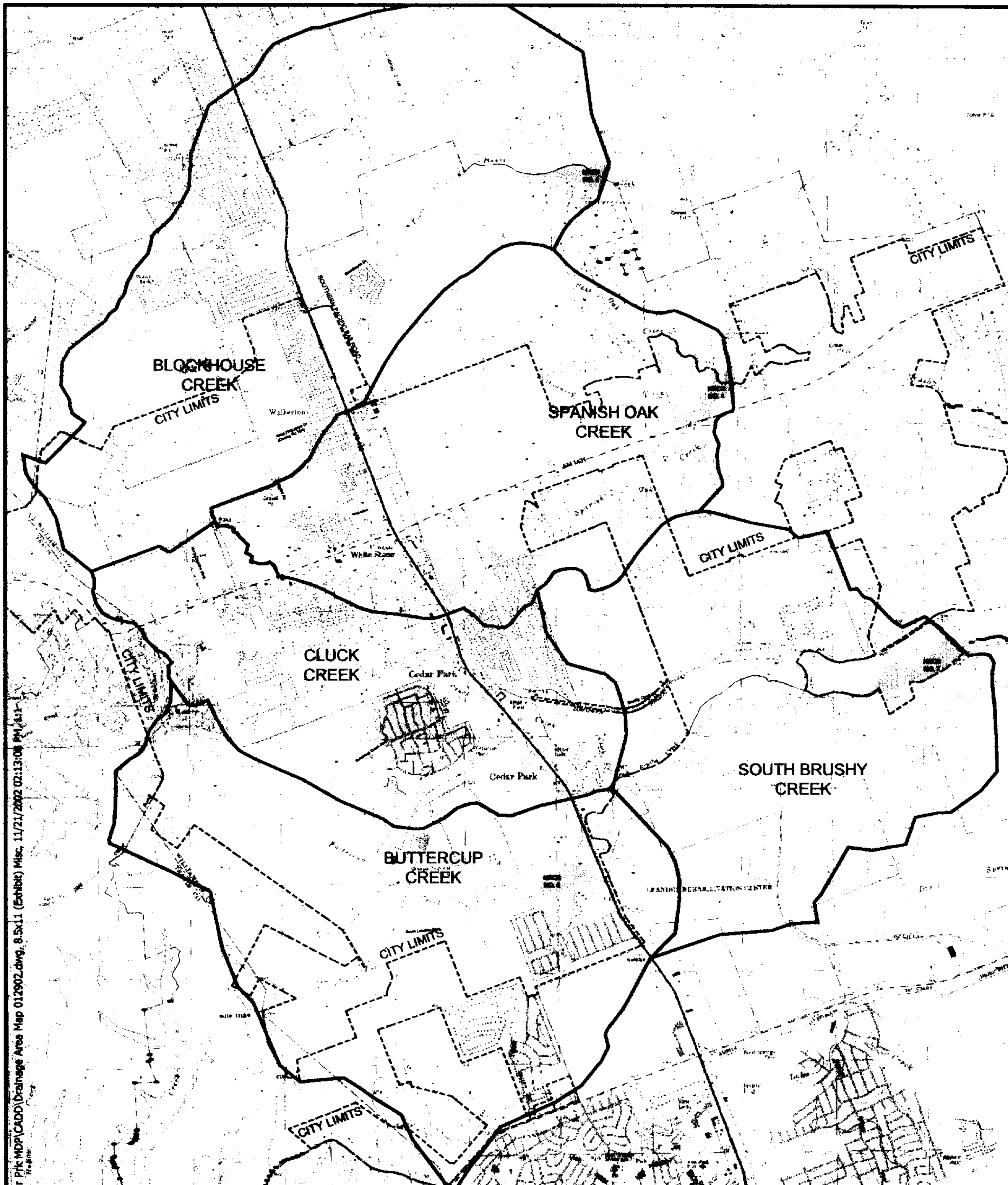
Turner Collie & Braden, Inc.
Drainage Master Plan Revision for Silverado
August 6, 2001

US Army Corps of Engineers, Hydrologic Engineering Center (HEC)
Flood Frequency Analysis User's Manual
May 1992
February 1995

US Army Corps of Engineers, Hydrologic Engineering Center (HEC)
HEC-1 Flood Hydrograph Package Users Manual
September 1990

US Army Corps of Engineers, Hydrologic Engineering Center (HEC)
HEC-RAS River Analysis System
January 2001

APPENDIX A - EXHIBITS



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Espey Consultants, Inc.

Environmental & Engineering Services

EXHIBIT #1

SITE LOCATION MAP

CEDAR PARK

MASTER DRAINAGE MAP

MAY 2002

PROJECT NUMBER 2000-43

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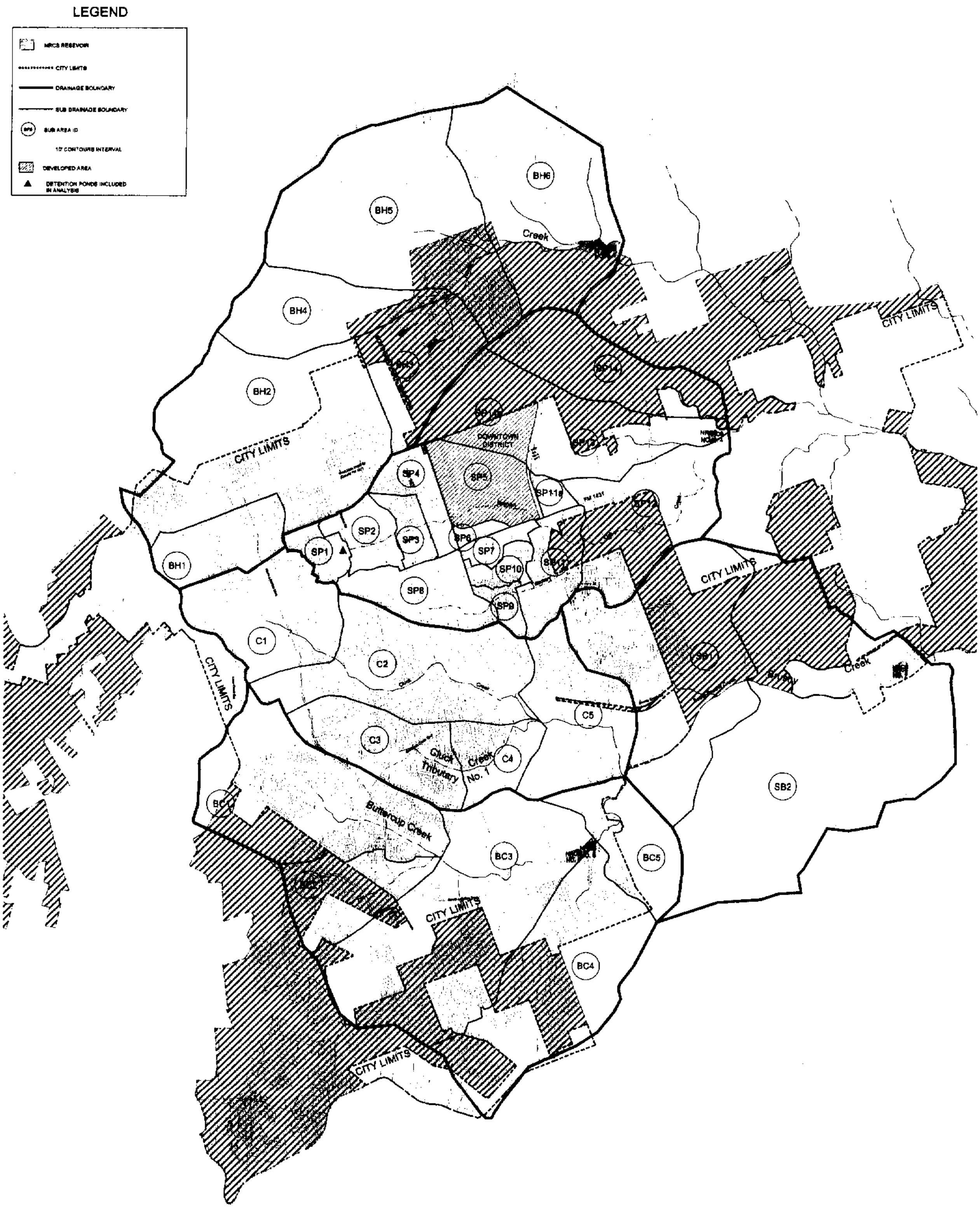

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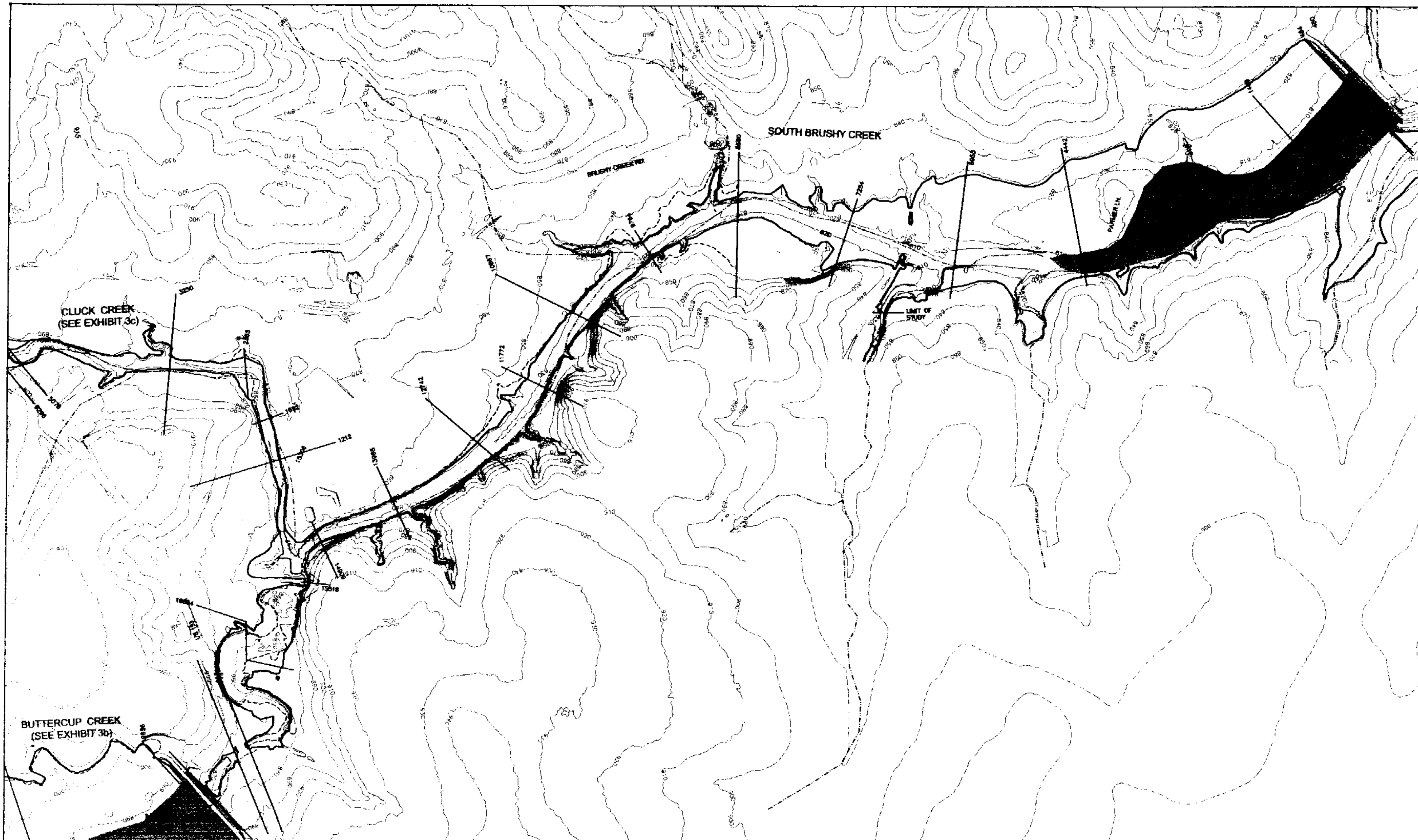
Espey Consultants, Inc.
Environmental & Engineering Services

EXHIBIT #2
DRAINAGE AREA MAP
CEDAR PARK
MASTER DRAINAGE PLAN

JUNE 2002

PROJECT NUMBER 2000-43

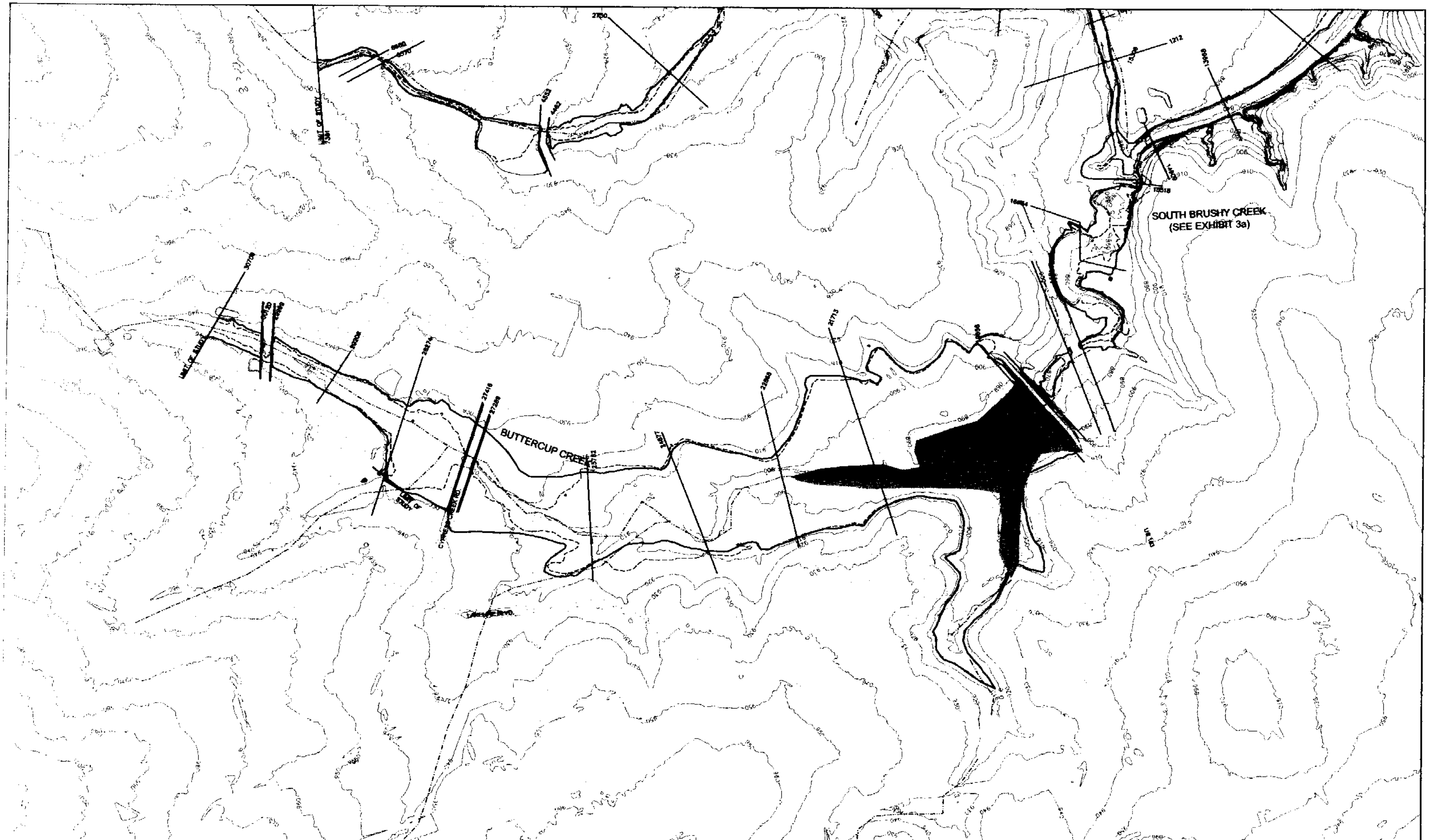


LEGEND	
	FPU 100YR
	FEMA 100YR ELEV.
12345	CROSS SECTION LABEL

Espey Consultants, Inc.
Environmental & Engineering Services

EXHIBIT 3a
SOUTH BRUSHY CREEK 100-YR FLOODPLAIN
CEDAR PARK
MASTER DRAINAGE PLAN

JUNE 2002



LEGEND	
———	FPU 100YR
- - - - -	FEMA 100YR ELEV.
——12345	CROSS SECTION LABEL

0 250 500 750 1000

Espey Consultants, Inc.

Environmental & Engineering Services

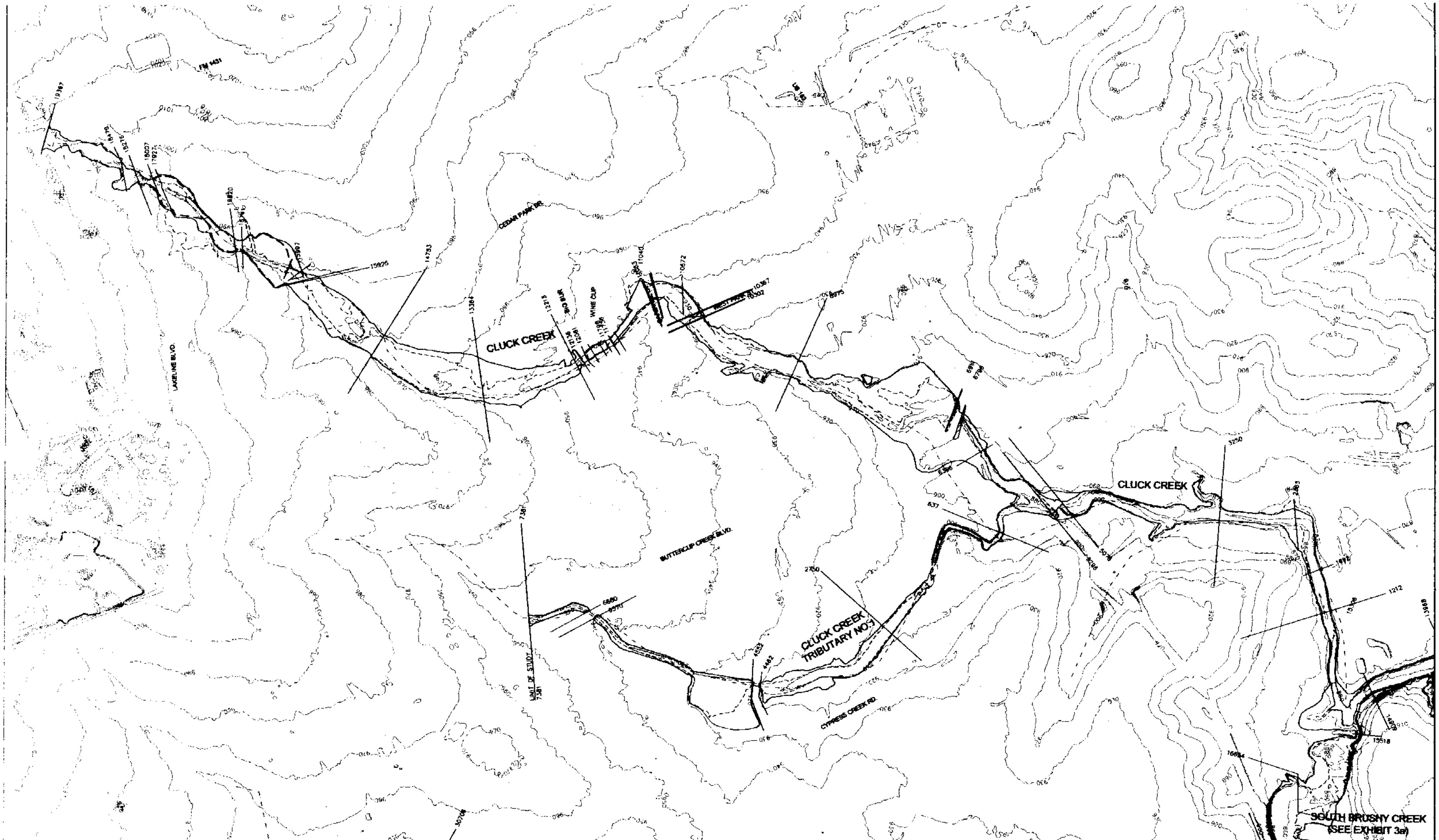
EXHIBIT 3b

BUTTERCUP CREEK 100-YR FLOODPLAIN

CEDAR PARK

MASTER DRAINAGE PLAN

JUNE 2002



LEGEND

———	FPU 100YR
- - - -	FEMA 100YR ELEV.
— — —	100YR ULT. W/ IMPROVEMENTS
——12345	CROSS SECTION LABEL

0 250 500 750 1000

Espey Consultants, Inc.

Environmental & Engineering Services

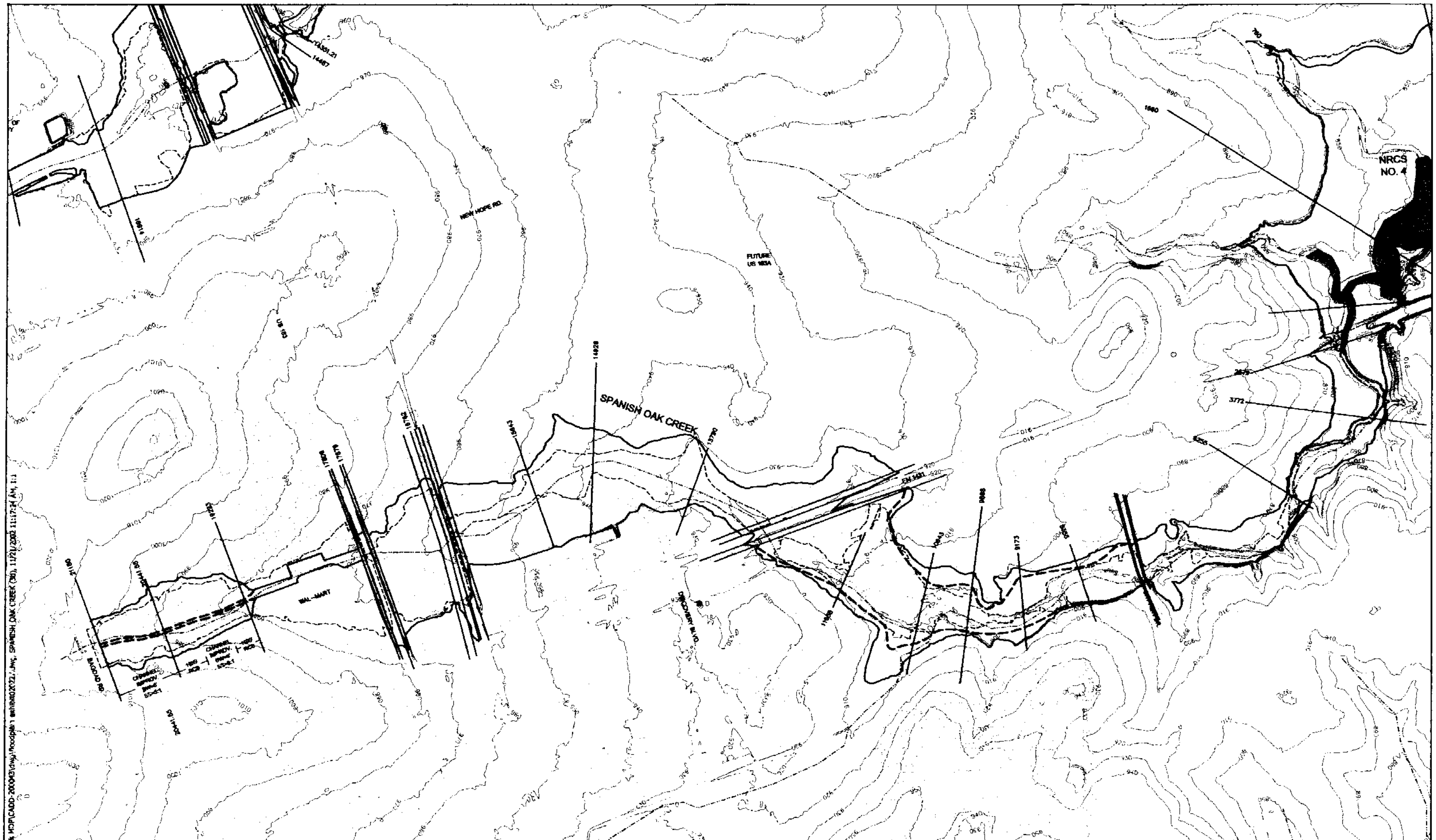
EXHIBIT 3c

CLUCK CREEK 100-YR FLOODPLAIN

CEDAR PARK

MASTER DRAINAGE PLAN

JUNE 2002

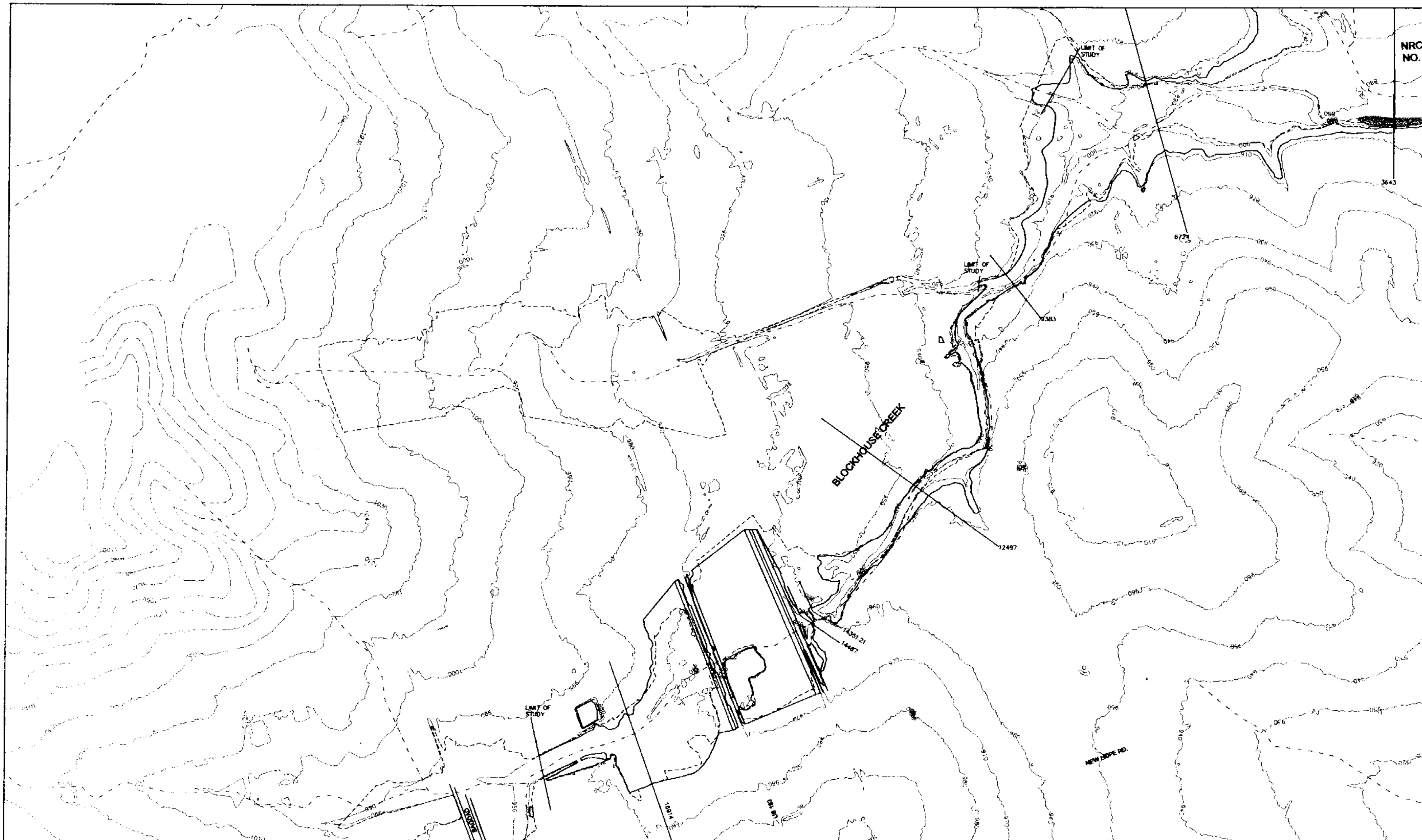


LEGEND	
——	FPU 100YR
- - - -	FEMA 100YR ELEV.
— — —	100YR ULT. W/ IMPROVEMENTS
——12345	CROSS SECTION LABEL

Espey Consultants, Inc.
Environmental & Engineering Services

EXHIBIT 3d
SPANISH OAK CREEK 100-YR FLOODPLAIN
CEDAR PARK
MASTER DRAINAGE PLAN

JUNE 2002



LEGEND

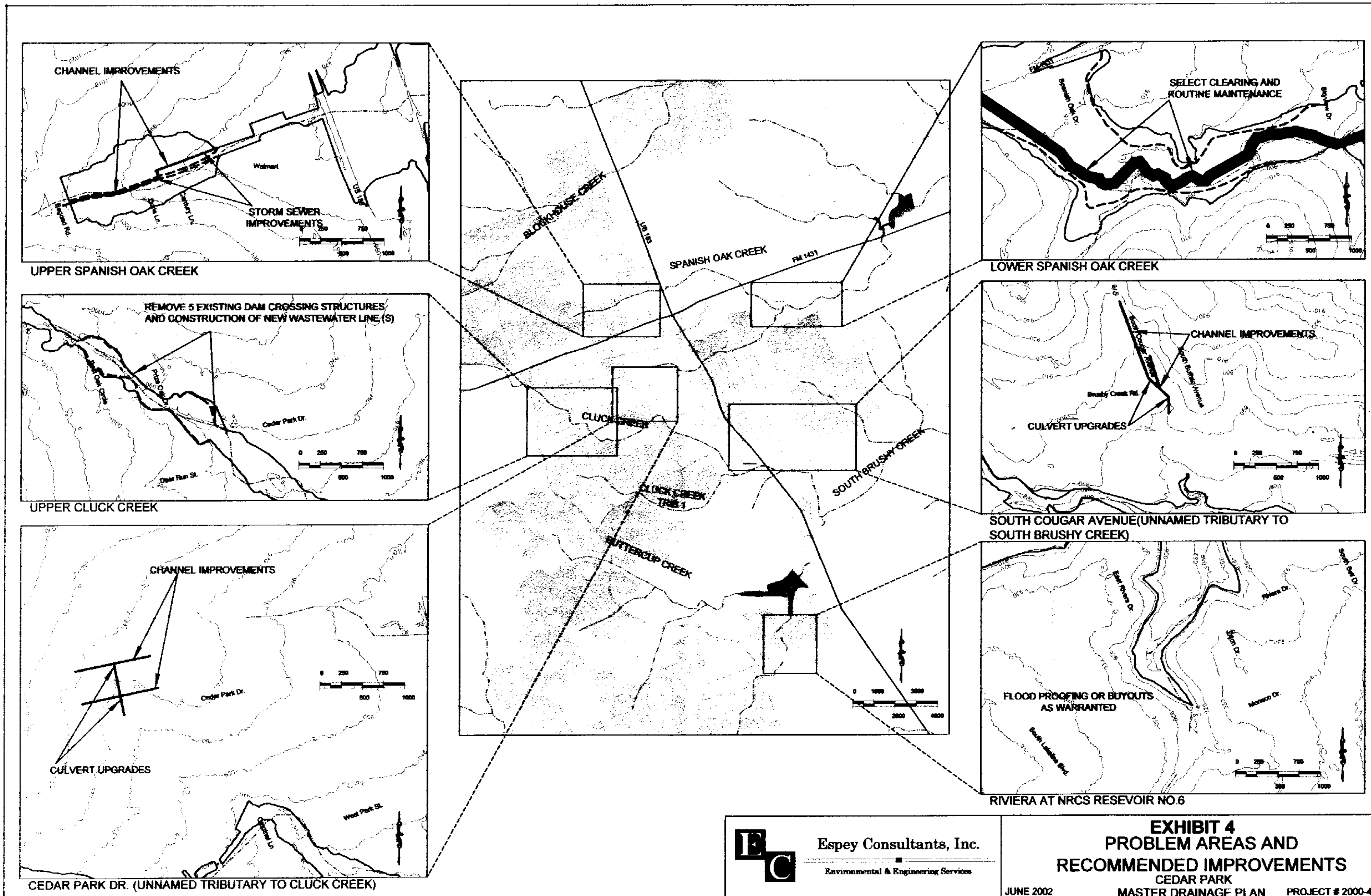
————	FPU 100YR
- - - - - -	FEMA 100YR ELEV.
——12345	CROSS SECTION LABEL

0 250 500 750 1000

Espey Consultants, Inc.
Environmental & Engineering Services

EXHIBIT 3e
BLOCKHOUSE CREEK 100-YR FLOODPLAIN
CEDAR PARK
MASTER DRAINAGE PLAN

JUNE 2002



Espey Consultants, Inc.
Environmental & Engineering Services

EXHIBIT 4
PROBLEM AREAS AND RECOMMENDED IMPROVEMENTS
CEDAR PARK
MASTER DRAINAGE PLAN

JUNE 2002 PROJECT # 2000-43

APPENDIX B – WATERSHED PARAMETER WORKSHEET AND HEC-1 MODEL OUTPUT

EXISTING CONDITION BLOCKHOUSE CREEK

TR-55 Method of Computing the Time of Concentration

			SUBAREA					
			BH1	BH2	BH3	BH4	BH5	BH6
Sheet Flow	variable	units						
Manning's roughness coef.	n	n/a	0.24	0.24	0.24	0.24	0.24	0.24
Flow Length	L	feet	300	300	300	300	300	300
2-year, 24-hour rainfall	P2	inches	4.1	4.1	4.1	4.1	4.1	4.1
Slope	s	ft/ft	0.0300	0.0960	0.0100	0.0600	0.0500	0.0700
Travel time (equation 3-3)	Tt	hours	0.430	0.270	0.668	0.326	0.351	0.307
Shallow Concentrated Flow		min.	25.8	16.2	40.1	19.6	21.0	18.4
Flow Length	L	feet	1,300	2,800	2,000	6,200	6,300	4,800
Slope	s	ft/ft	0.02	0.0240	0.0200	0.0120	0.0100	0.0250
Surface (1=paved or 2=unpaved)		n/a	2	2	2	2	1	1
Velocity (figure 3-1)	V	ft/sec	2.29	2.51	2.29	1.77	2.06	3.26
Travel time	Tt	hours	0.158	0.310	0.242	0.970	0.850	0.409
Manning's Equation		min.	9.5	18.6	14.5	58.2	51.0	24.6
Flow Length	L	feet	1,600	7,200	5,200	2,800	3,500	4,500
Slope	S	ft/ft	0.0105	0.0050	0.0100	0.0100	0.0130	0.0150
roughness	n	n/a	0.012	0.065	0.065	0.065	0.065	0.065
Open Channel								
Bottom Width	BW	feet	0	1	1	1	1	1
Side Slopes (H:1)	H	feet	0	5	5	5	5	10
Depth	d	feet	0	6	6	6	6	4
...or Closed Conduit								
Rise / Diameter	R / D	feet	3	0	0	0	1.5	1.5
Span (0 if circular)	S	feet	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	186.00	186.00	186.00	186.00	164.00
Flow Rate	Q	cfs	74.04	624.18	882.72	882.72	1006.45	732.51
Velocity (figure 3-1)	V	ft/sec	10.47	3.36	4.75	4.75	5.41	4.47
Travel time	Tt	hours	0.042	0.596	0.304	0.164	0.180	0.280
Flow Length	L	feet	2,500	-	-	-	-	-
Slope	S	ft/ft	0.0142	0.0100	0.0111	0.0046	0.0100	0.0100
roughness	n	n/a	0.065	0.05	0.05	0.05	0.05	0.05
Open Channel								
Bottom Width	BW	feet	1	15	10	10	1	1
Side Slopes (H:1)	H	feet	30	29	20	5	9	9
Depth	d	feet	4	5	5	6	6	6
...or Closed Conduit								
Rise / Diameter	R / D	feet	0	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	484.00	800.00	550.00	240.00	330.00	330.00
Flow Rate	Q	cfs	2098.07	4520.31	3269.57	1087.70	2044.22	2044.22
Velocity (figure 3-1)	V	ft/sec	4.33	5.65	5.94	4.53	6.19	6.19
Travel time	Tt	hours	0.160	-	-	-	-	-
Total Travel Time	TC	hours	0.791	1.176	1.215	1.460	1.380	0.996
	TC	min.	47.4	70.6	72.9	87.6	82.8	59.7
Lag Time	TL	hours	0.4743	0.7056	0.7287	0.8763	0.8280	0.5975
	TL	min.	28.5	42.3	43.7	52.6	49.7	35.8

ULTIMATE CONDITION BLOCKHOUSE CREEK

TR-55 Method of Computing the Time of Concentration

			SUBAREA					
			BH1	BH2	BH3	BH4	BH5	BH6
Sheet Flow	variable	units						
Manning's roughness coef.	n	n/a	0.24	0.24	0.24	0.24	0.24	0.24
Flow Length	L	feet	300	300	300	150	150	150
2-year, 24-hour rainfall	P2	inches	4.1	4.1	4.1	4.1	4.1	4.1
Slope	s	ft/ft	0.0300	0.0960	0.0100	0.0600	0.0500	0.0700
Travel time (equation 3-3)	Tt	hours	0.430	0.270	0.668	0.187	0.201	0.176
Shallow Concentrated Flow		min.	25.8	16.2	40.1	11.2	12.1	10.6
Flow Length	L	feet	1,300	2,800	2,000	6,200	6,300	4,800
Slope	s	ft/ft	0.02	0.0240	0.0200	0.0120	0.0100	0.0250
Surface (1=paved or 2=unpaved)		n/a	2	2	2	2	1	1
Velocity (figure 3-1)	V	ft/sec	2.29	2.51	2.29	1.77	2.06	3.26
Travel time	Tt	hours	0.158	0.310	0.242	0.970	0.850	0.409
Manning's Equation		min.	9.5	18.6	14.5	58.2	51.0	24.6
Flow Length	L	feet	1,600	7,200	5,200	2,800	3,500	4,500
Slope	S	ft/ft	0.0105	0.0050	0.0100	0.0100	0.0130	0.0150
roughness	n	n/a	0.012	0.065	0.065	0.065	0.065	0.065
Open Channel								
Bottom Width	BW	feet	0	1	1	1	1	1
Side Slopes (H:1)	H	feet	0	5	5	5	5	10
Depth	d	feet	0	6	6	6	6	4
...or Closed Conduit								
Rise / Diameter	R / D	feet	3	0	0	0	1.5	1.5
Span (0 if circular)	S	feet	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	186.00	186.00	186.00	186.00	164.00
Flow Rate	Q	cfs	74.04	624.18	882.72	882.72	1006.45	732.51
Velocity (figure 3-1)	V	ft/sec	10.47	3.36	4.75	4.75	5.41	4.47
Travel time	Tt	hours	0.042	0.596	0.304	0.164	0.180	0.280
Flow Length	L	feet	2,500	-	-	-	-	-
Slope	S	ft/ft	0.0142	0.0100	0.0111	0.0046	0.0100	0.0100
roughness	n	n/a	0.065	0.05	0.05	0.05	0.05	0.05
Open Channel								
Bottom Width	BW	feet	1	15	10	10	1	1
Side Slopes (H:1)	H	feet	30	29	20	5	9	9
Depth	d	feet	4	5	5	6	6	6
...or Closed Conduit								
Rise / Diameter	R / D	feet	0	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	484.00	800.00	550.00	240.00	330.00	330.00
Flow Rate	Q	cfs	2098.07	4520.31	3269.57	1087.70	2044.22	2044.22
Velocity (figure 3-1)	V	ft/sec	4.33	5.65	5.94	4.53	6.19	6.19
Travel time	Tt	hours	0.160	-	-	-	-	-
Total Travel Time	TC	hours	0.791	1.176	1.215	1.322	1.231	0.865
	TC	min.	47.4	70.6	72.9	79.3	73.8	51.9
Lag Time	TL	hours	0.4743	0.7056	0.7287	0.7930	0.7384	0.5192
	TL	min.	28.5	42.3	43.7	47.6	44.3	31.2

ULTIMATE CONDITION SPANISH OAK CREEK

TR-55 Method of Computing the Time of Concentration

	variable	units	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8
Sheet Flow	variable	units								
Manning's roughness coef	n	n/a	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Flow Length	L	feet	75	200	200	75	150	35	35	75
2-year, 24 hour rainfall	P2	inches	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Slope	s	ft/ft	0.0133	0.0200	0.0500	0.0267	0.0167	0.0133	0.0133	0.0133
Travel time (equation 3-3)	Tt	hours	0.197	0.366	0.254	0.149	0.313	0.107	0.107	0.197
Shallow Concentrated Flow		min	11.8	22.0	15.2	8.9	18.8	6.4	6.4	11.8
Flow Length	L	feet	500	800	800	400	2,600	300	500	500
Slope	s	ft/ft	0.0233	0.0250	0.0250	0.0700	0.0185	0.0033	0.0033	0.0180
Surface (1=paved or 2=unpaved)		n/a	1	2	2	1	2	1	1	1
Velocity (figure 3-1)	V	ft/sec	3.14	2.56	2.56	5.45	2.20	1.18	1.18	2.61
Travel time	Tt	hours	0.044	0.087	0.087	0.020	0.328	0.070	0.117	0.053
Manning's Equation		min	2.7	5.2	5.2	1.2	19.7	4.2	7.0	3.2
Flow Length	L	feet	2,000	3,100	2,100	2,300	2,700	2,500	3,100	6,400
Slope	S	ft/ft	0.0360	0.0115	0.0169	0.0167	0.0100	0.0125	0.0118	0.0146
roughness	n	n/a	0.012	0.065	0.012	0.065	0.065	0.065	0.065	0.065
Open Channel										
Bottom Width	BW	feet	0	1	0	10	10	10	10	10
Side Slopes (H:1)	H	feet	0	30	0	22	8	20	20	20
Depth	d	feet	0	2	0	2	3.4	0.6	0.9	2.5
or Closed Conduit										
Rise / Diameter	R/D	feet	3	0	3	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	122.00	7.07	108.00	126.48	13.20	25.20	150.00
Flow Rate	Q	cfs	137.10	300.63	93.93	340.21	451.50	17.91	41.87	509.15
Velocity (figure 3-1)	V	ft/sec	19.40	2.46	13.29	3.15	3.57	1.36	1.66	3.39
Travel time	Tt	hours	0.029	0.349	0.044	0.203	0.210	0.512	0.518	0.524
Flow Length	L	feet	-	-	-	1,600	-	-	-	-
Slope	S	ft/ft	0.0000	0.0000	0.0000	0.0060	0.0000	0.0000	0.0000	0.0000
roughness	n	n/a	0	0	0	0.012	0	0	0	0
Open Channel										
Bottom Width	BW	feet	0	0	0	0	0	0	0	0
Side Slopes (H:1)	H	feet	0	0	0	0	0	0	0	0
Depth	d	feet	0	0	0	0	0	0	0	0
or Closed Conduit										
Rise / Diameter	R/D	feet	0	0	0	3	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	0.00	0.00	0.00	7.07	0.00	0.00	0.00	0.00
Flow Rate	Q	cfs	n/a	n/a	n/a	55.97	n/a	n/a	n/a	n/a
Velocity (figure 3-1)	V	ft/sec	n/a	n/a	n/a	7.92	n/a	n/a	n/a	n/a
Travel time	Tt	hours	-	-	-	0.056	-	-	-	-
Flow Length	L	feet	-	-	-	-	-	-	-	-
Slope	S	ft/ft	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
roughness	n	n/a	0	0	0	0	0	0	0	0
Open Channel										
Bottom Width	BW	feet	0	0	0	0	0	0	0	0
Side Slopes (H:1)	H	feet	0	0	0	0	0	0	0	0
Depth	d	feet	0	0	0	0	0	0	0	0
or Closed Conduit										
Rise / Diameter	R/D	feet	0	0	0	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Rate	Q	cfs	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Velocity (figure 3-1)	V	ft/sec	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Travel time	Tt	hours	-	-	-	-	-	-	-	-
Total Travel Time	TC	hours	0.269	0.802	0.384	0.428	0.641	0.689	0.742	0.774
	TC	min	16.2	48.1	23.1	25.7	38.4	41.3	44.5	46.4
Lag Time	TL	hours	0.1616	0.4812	0.2305	0.2568	0.3844	0.4134	0.4454	0.4641
	TL	min	9.7	28.9	13.8	15.4	23.1	24.8	26.7	27.8

	variable	units	SP9	SP10	SP11	SP11A	SP12	SP13	SP14	overall
Sheet Flow	variable	units								
Manning's roughness coef	n	n/a	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Flow Length	L	feet	200	75	35	100	100	35	150	300
2-year, 24 hour rainfall	P2	inches	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Slope	s	ft/ft	0.0050	0.0133	0.0133	0.0050	0.0050	0.0133	0.0067	0.0133
Travel time (equation 3-3)	Tt	hours	0.637	0.197	0.107	0.366	0.366	0.107	0.450	0.596
Shallow Concentrated Flow		min	38.2	11.8	6.4	22.0	22.0	6.4	27.0	35.7
Flow Length	L	feet	300	300	600	1,900	3,900	7,500	700	2,300
Slope	s	ft/ft	0.0067	0.0067	0.0025	0.0164	0.0130	0.0140	0.0111	0.0233
Surface (1=paved or 2=unpaved)		n/a	1	1	1	2	2	2	2	2
Velocity (figure 3-1)	V	ft/sec	1.69	1.69	1.03	2.07	1.85	1.92	1.71	2.47
Travel time	Tt	hours	0.049	0.049	0.162	0.255	0.587	1.087	0.114	0.258
Manning's Equation		min	3.0	3.0	9.7	15.3	35.2	65.2	6.8	15.5
Flow Length	L	feet	1,500	2,700	2,500	1	5,500	2,300	3,500	19,000
Slope	S	ft/ft	0.0050	0.0141	0.0064	0.0100	0.0112	0.0133	0.0167	0.0070
roughness	n	n/a	0.012	0.065	0.012	0.065	0.065	0.065	0.065	0.065
Open Channel										
Bottom Width	BW	feet	0	1	0	100	10	1	1	30
Side Slopes (H:1)	H	feet	0	10	0	75	8	31	11	4
Depth	d	feet	0	1.4	0	0.09	4	3	4	5
or Closed Conduit										
Rise / Diameter	R/D	feet	3	0	3	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	21.00	7.07	9.61	168.00	282.00	180.00	250.00
Flow Rate	Q	cfs	51.09	45.82	57.81	4.23	698.98	977.39	848.16	1104.35
Velocity (figure 3-1)	V	ft/sec	7.23	2.18	8.18	0.44	4.16	3.47	4.71	4.42
Travel time	Tt	hours	0.058	0.344	0.085	0.001	0.367	0.184	0.206	1.195
Flow Length	L	feet	300	-	2,000	-	-	-	-	-
Slope	S	ft/ft	0.0100	0.0000	0.0071	0.0000	0.0000	0.0000	0.0000	0.0000
roughness	n	n/a	0.065	0	0.065	0	0	0	0	0
Open Channel										
Bottom Width	BW	feet	1	0	150	0	0	0	0	0
Side Slopes (H:1)	H	feet	10	0	25	0	0	0	0	0
Depth	d	feet	2	0	1.5	0	0	0	0	0
or Closed Conduit										
Rise / Diameter	R/D	feet	0	0	0	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	42.00	0.00	281.25	0.00	0.00	0.00	0.00	0.00
Flow Rate	Q	cfs	97.26	n/a	628.57	n/a	n/a	n/a	n/a	n/a
Velocity (figure 3-1)	V	ft/sec	2.32	n/a	2.23	n/a	n/a	n/a	n/a	n/a
Travel time	Tt	hours	0.036	-	0.249	-	-	-	-	-
Flow Length	L	feet	-	-	-	-	-	-	-	-
Slope	S	ft/ft	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
roughness	n	n/a	0	0	0	0	0	0	0	0
Open Channel										
Bottom Width	BW	feet	0	0	0	0	0	0	0	0
Side Slopes (H:1)	H	feet	0	0	0	0	0	0	0	0
Depth	d	feet	0	0	0	0	0	0	0	0
or Closed Conduit										
Rise / Diameter	R/D	feet	0	0	0	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Rate	Q	cfs	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Velocity (figure 3-1)	V	ft/sec	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Travel time	Tt	hours	-	-	-	-	-	-	-	-
Total Travel Time	TC	hours	0.780	0.590	0.602	0.621	1.320	1.378	0.770	2.049
	TC	min	46.8	35.4	36.1	37.3	79.2	82.7	46.2	122.9
Lag Time	TL	hours	0.4680	0.3538	0.3613	0.3727	0.7917	0.8268	0.4622	1.23
	TL	min	28.1	21.2	21.7	22.4	47.5	49.6	27.7	73.8

EXISTING CONDITION SPAN 9H OAK CREEK

R-55 Method of Computing the Time of Concentration

					SUBAREA								SUBAREA					
			SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10	SP11	SP11A	SP12	SP13	SP14A	SP14
heet Flow	variable	units																
Manning's roughness coef	n	n/a	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Flow Length	L	feet	75	200	200	75	300	75	75	75	200	75	75	200	200	75	75	300
2-year, 24-hour rainfall	P2	inches	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Slope	s	ft/ft	0.0133	0.0200	0.0500	0.0267	0.0167	0.0133	0.0133	0.0133	0.0050	0.0133	0.0133	0.0050	0.0050	0.0133	0.0133	0.0067
Travel time (equation 3-3)	Tt	hours	0.197	0.366	0.254	0.149	0.544	0.197	0.197	0.197	0.637	0.197	0.197	0.637	0.637	0.197	0.135	0.784
hallow Concentrated Flow		min	11.8	22.0	15.2	8.9	32.7	11.8	11.8	11.8	38.2	11.8	11.8	38.2	38.2	11.8	8.1	47.0
Flow Length	L	feet	500	800	800	400	2,600	300	500	500	300	300	600	1,900	3,900	7,500	1,400	700
Slope	s	ft/ft	0.0233	0.0250	0.0250	0.0700	0.0185	0.0033	0.0033	0.0160	0.0067	0.0067	0.0025	0.0164	0.0120	0.0140	0.0140	0.0111
Surface (1=paved or 2=unpaved)		n/a	1	2	2	1	2	1	1	1	1	1	1	2	2	2	2	2
Velocity (figure 3-1)	V	ft/sec	3.14	2.56	2.56	5.45	2.20	1.18	1.18	2.61	1.69	1.69	1.03	2.07	1.85	1.92	1.92	1.71
Travel time	Tt	hours	0.044	0.087	0.087	0.020	0.328	0.070	0.117	0.053	0.049	0.049	0.162	0.255	0.587	1.087	0.203	0.114
lanning's Equation		min	2.7	5.2	5.2	1.2	19.7	4.2	7.0	3.2	3.0	3.0	9.7	15.3	35.2	65.2	12.2	6.8
Flow Length	L	feet	2,000	3,100	2,100	2,300	2,700	2,500	3,100	6,400	1,500	2,700	2,500	1	5,500	2,300	4,700	3,500
Slope	S	ft/ft	0.0360	0.0115	0.0169	0.0167	0.0100	0.0125	0.0118	0.0146	0.0050	0.0141	0.0064	0.0100	0.0112	0.0133	0.0093	0.0167
roughness	n	n/a	0.012	0.065	0.012	0.065	0.065	0.065	0.065	0.065	0.012	0.065	0.012	0.065	0.065	0.065	0.1	0.065
Open Channel																		
Bottom Width	BW	feet	0	1	0	10	10	10	10	10	0	1	0	100	10	1	1	1
Side Slopes (H:1)	H	feet	0	30	0	22	8	20	20	20	0	10	0	75	8	31	11	11
Depth	d	feet	0	2	0	2	3.4	0.6	0.9	2.5	0	1.4	0	0.09	4	3	4	4
or Closed Conduit																		
Rise / Diameter	R / D	feet	3	0	3	0	0	0	0	0	3	0	3	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	122.00	7.07	108.00	126.48	13.20	25.20	150.00	7.07	21.00	7.07	9.61	168.00	282.00	180.00	180.00
Flow Rate	Q	cfs	137.10	300.63	93.93	340.21	451.50	17.91	41.87	509.15	51.09	45.82	57.81	4.23	698.98	977.39	411.41	848.16
Velocity (figure 3-1)	V	ft/sec	19.40	2.46	13.29	3.15	3.57	1.36	1.66	3.39	7.23	2.18	8.18	0.44	4.16	3.47	2.29	4.71
Travel time	Tt	hours	0.029	0.349	0.044	0.203	0.210	0.512	0.518	0.524	0.058	0.344	0.085	0.001	0.367	0.184	0.571	0.206
Flow Length	L	feet	-	-	-	1,600	-	-	-	-	300	-	2,000	-	-	-	-	-
Slope	S	ft/ft	0.0000	0.0000	0.0000	0.0060	0.0000	0.0000	0.0000	0.0000	0.0100	0.0000	0.0071	0.0000	0.0000	0.0000	0.0000	0.0000
roughness	n	n/a	0	0	0	0.012	0	0	0	0	0.065	0	0.065	0	0	0	0	0
Open Channel																		
Bottom Width	BW	feet	0	0	0	0	0	0	0	0	1	0	150	0	0	0	0	0
Side Slopes (H:1)	H	feet	0	0	0	0	0	0	0	0	10	0	25	0	0	0	0	0
Depth	d	feet	0	0	0	0	0	0	0	0	2	0	1.5	0	0	0	0	0
or Closed Conduit																		
Rise / Diameter	R / D	feet	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	0.00	0.00	0.00	7.07	0.00	0.00	0.00	0.00	42.00	0.00	281.25	0.00	0.00	0.00	0.00	0.00
Flow Rate	Q	cfs	n/a	n/a	n/a	55.97	n/a	n/a	n/a	n/a	97.26	n/a	628.57	n/a	n/a	n/a	n/a	n/a
Velocity (figure 3-1)	V	ft/sec	n/a	n/a	n/a	7.92	n/a	n/a	n/a	n/a	2.32	n/a	2.23	n/a	n/a	n/a	n/a	n/a
Travel time	Tt	hours	-	-	-	0.056	-	-	-	-	0.036	-	0.249	-	-	-	-	-
Flow Length	L	feet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slope	S	ft/ft	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
roughness	n	n/a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Open Channel																		
Bottom Width	BW	feet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Side Slopes (H:1)	H	feet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Depth	d	feet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
or Closed Conduit																		
Rise / Diameter	R / D	feet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Rate	Q	cfs	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Velocity (figure 3-1)	V	ft/sec	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Travel time	Tt	hours	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
otal Travel Time	TC	hours	0.269	0.802	0.381	0.428	0.872	0.779	0.832	0.774	0.780	0.590	0.692	0.892	1.591	1.469	0.909	1.104
	TC	min	16.2	48.1	23.1	25.7	52.3	46.7	49.9	46.4	46.8	35.4	41.5	53.5	95.4	88.1	54.5	66.2
ag Time	TL	hours	0.1616	0.4812	0.2305	0.2568	0.5234	0.4673	0.4993	0.4641	0.4680	0.3528	0.4154	0.5354	0.9544	0.8806	0.5454	0.6624
	TL	min	9.7	28.9	13.8	15.4	31.4	28.0	30.0	27.8	28.1	21.2	24.9	32.1	57.3	52.8	32.7	39.7

EXISTING CONDITION CLUCK CREEK

TR-55 Method of Computing the Time of Concentration

			SUBAREA				
			C1	C2	C3	C4	C5
Sheet Flow	variable	units					
Manning's roughness coef.	n	n/a	0.24	0.24	0.24	0.24	0.24
Flow Length	L	feet	300	300	200	300	300
2-year, 24-hour rainfall	P2	inches	4.1	4.1	4.1	4.1	4.1
Slope	s	ft/ft	0.0050	0.0100	0.0650	0.0133	0.0400
Travel time (equation 3-3)	Tt	hours	0.881	0.668	0.228	0.596	0.383
Shallow Concentrated Flow		min.	52.9	40.1	13.7	35.7	23.0
Flow Length	L	feet	1,600	2,400	1,150	1,300	600
Slope	s	ft/ft	0.0325	0.0227	0.0250	0.0167	0.0100
Surface (1=paved or 2=unpaved)		n/a	2	2	2	2	1
Velocity (figure 3-1)	V	ft/sec	2.92	2.44	2.56	2.09	2.06
Travel time	Tt	hours	0.152	0.273	0.125	0.173	0.081
Manning's Equation		min.	9.1	16.4	7.5	10.4	4.9
Flow Length	L	feet	1,900	4,700	1,700	1,800	3,400
Slope	S	ft/ft	0.0043	0.0129	0.0133	0.0091	0.0222
roughness	n	n/a	0.012	0.065	0.012	0.065	0.012
Open Channel							
Bottom Width	BW	feet	0	10	0	5	0
Side Slopes (H:1)	H	feet	0	15	0	10	0
Depth	d	feet	0	4	0	4	0
...or Closed Conduit							
Rise / Diameter	R / D	feet	3	0	3	0	3
Span (0 if circular)	S	feet	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	280.00	7.07	180.00	7.07
Flow Rate	Q	cfs	47.38	1210.90	83.33	645.32	107.66
Velocity (figure 3-1)	V	ft/sec	6.70	4.32	11.79	3.59	15.23
Travel time	Tt	hours	0.079	0.302	0.040	0.139	0.062
Flow Length	L	feet	3,700	5,700	4,800	2,000	4,200
Slope	S	ft/ft	0.0144	0.0100	0.0111	0.0046	0.0100
roughness	n	n/a	0.065	0.065	0.065	0.065	0.065
Open Channel							
Bottom Width	BW	feet	1	10	10	5	1
Side Slopes (H:1)	H	feet	15	20	10	10	10
Depth	d	feet	4	4	4	4	5
...or Closed Conduit							
Rise / Diameter	R / D	feet	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	244.00	360.00	200.00	180.00	255.00
Flow Rate	Q	cfs	1066.87	1356.14	817.91	458.81	1077.37
Velocity (figure 3-1)	V	ft/sec	4.37	3.77	4.09	2.55	4.22
Travel time	Tt	hours	0.235	0.420	0.326	0.218	0.276
Total Travel Time	TC	hours	1.347	1.663	0.719	1.126	0.803
	TC	min.	80.8	99.8	43.1	67.5	48.2
Lag Time	TL	hours	0.8082	0.9978	0.4315	0.6755	0.4815
	TL	min.	48.5	59.9	25.9	40.5	28.9

ULTIMATE CONDITION CLUCK CREEK

TR-55 Method of Computing the Time of Concentration

			SUBAREA				
			C1	C2	C3	C4	C5
Sheet Flow	variable	units					
Manning's roughness coef.	n	n/a	0.24	0.24	0.24	0.24	0.24
Flow Length	L	feet	300	300	200	300	150
2-year, 24-hour rainfall	P2	inches	4.1	4.1	4.1	4.1	4.1
Slope	s	ft/ft	0.0050	0.0100	0.0650	0.0133	0.0400
Travel time (equation 3-3)	Tt	hours	0.881	0.668	0.228	0.596	0.220
Shallow Concentrated Flow		min.	52.9	40.1	13.7	35.7	13.2
Flow Length	L	feet	1,600	2,400	1,150	1,300	600
Slope	s	ft/ft	0.0325	0.0227	0.0250	0.0167	0.0100
Surface (1=paved or 2=unpaved)		n/a	2	2	2	2	1
Velocity (figure 3-1)	V	ft/sec	2.92	2.44	2.56	2.09	2.06
Travel time	Tt	hours	0.152	0.273	0.125	0.173	0.081
Manning's Equation		min.	9.1	16.4	7.5	10.4	4.9
Flow Length	L	feet	1,900	4,700	1,700	1,800	3,400
Slope	S	ft/ft	0.0043	0.0129	0.0133	0.0091	0.0222
roughness	n	n/a	0.012	0.065	0.012	0.065	0.012
Open Channel							
Bottom Width	BW	feet	0	10	0	5	0
Side Slopes (H:1)	H	feet	0	15	0	10	0
Depth	d	feet	0	4	0	4	0
...or Closed Conduit							
Rise / Diameter	R / D	feet	3	0	3	0	3
Span (0 if circular)	S	feet	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	280.00	7.07	180.00	7.07
Flow Rate	Q	cfs	47.38	1210.90	83.33	645.32	107.66
Velocity (figure 3-1)	V	ft/sec	6.70	4.32	11.79	3.59	15.23
Travel time	Tt	hours	0.079	0.302	0.040	0.139	0.062
Flow Length	L	feet	3,700	5,700	4,800	2,000	4,200
Slope	S	ft/ft	0.0144	0.0100	0.0111	0.0046	0.0100
roughness	n	n/a	0.065	0.065	0.065	0.065	0.065
Open Channel							
Bottom Width	BW	feet	1	10	10	5	1
Side Slopes (H:1)	H	feet	15	20	10	10	10
Depth	d	feet	4	4	4	4	5
...or Closed Conduit							
Rise / Diameter	R / D	feet	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	244.00	360.00	200.00	180.00	255.00
Flow Rate	Q	cfs	1066.87	1356.14	817.91	458.81	1077.37
Velocity (figure 3-1)	V	ft/sec	4.37	3.77	4.09	2.55	4.22
Travel time	Tt	hours	0.235	0.420	0.326	0.218	0.276
Total Travel Time	TC	hours	1.347	1.663	0.719	1.126	0.639
	TC	min.	80.8	99.8	43.1	67.5	38.4
Lag Time	TL	hours	0.8082	0.9978	0.4315	0.6755	0.3836
	TL	min.	48.5	59.9	25.9	40.5	23.0

EXISTING CONDITION SOUTH BRUSHY CREEK

TR-55 Method of Computing the Time of Concentration

			SUBAREA	
			SB1	**SB2**
Sheet Flow	variable	units		
Manning's roughness coef.	n	n/a	0.24	0.24
Flow Length	L	feet	100	300
2-year, 24-hour rainfall	P2	inches	4.1	4.1
Slope	s	ft/ft	0.0100	0.0050
Travel time (equation 3-3)	Tt	hours	0.277	0.881
Shallow Concentrated Flow		min.	16.6	52.9
Flow Length	L	feet	3,100	3,500
Slope	s	ft/ft	0.0125	0.0114
Surface (1=paved or 2=unpaved)		n/a	2	2
Velocity (figure 3-1)	V	ft/sec	1.81	1.73
Travel time	Tt	hours	0.475	0.562
Manning's Equation		min.	28.5	33.7
Flow Length	L	feet	5,750	6,750
Slope	S	ft/ft	0.0086	0.0048
roughness	n	n/a	0.065	0.065
Open Channel				
Bottom Width	BW	feet	10	10
Side Slopes (H:1)	H	feet	5	55
Depth	d	feet	6	4
...or Closed Conduit				
Rise / Diameter	R / D	feet	2	2
Span (0 if circular)	S	feet	0	0
Cross-Sectional Area	X-A	feet^2	240.00	920.00
Flow Rate	Q	cfs	1144.02	2347.02
Velocity (figure 3-1)	V	ft/sec	4.77	2.55
Travel time	Tt	hours	0.335	0.735
Flow Length	L	feet	-	3,750
Slope	S	ft/ft	0.0000	0.0013
roughness	n	n/a	0	0.065
Open Channel				
Bottom Width	BW	feet	0	25
Side Slopes (H:1)	H	feet	0	5
Depth	d	feet	0	6
...or Closed Conduit				
Rise / Diameter	R / D	feet	0	0
Span (0 if circular)	S	feet	0	0
Cross-Sectional Area	X-A	feet^2	0.00	330.00
Flow Rate	Q	cfs	n/a	665.74
Velocity (figure 3-1)	V	ft/sec	n/a	2.02
Travel time	Tt	hours	-	0.516
Total Travel Time	TC	hours	1.088	2.694
	TC	min.	65.3	161.7
Lag Time	TL	hours	0.6527	1.6166
	TL	min.	39.2	97.0

ULTIMATE CONDITION SOUTH BRUSHY CREEK

TR-55 Method of Computing the Time of Concentration

			SUBAREA	
			SB1	**SB2**
Sheet Flow	variable	units		
Manning's roughness coef.	n	n/a	0.24	0.24
Flow Length	L	feet	50	150
2-year, 24-hour rainfall	P2	inches	4.1	4.1
Slope	s	ft/ft	0.0100	0.0050
Travel time (equation 3-3)	Tt	hours	0.159	0.506
Shallow Concentrated Flow		min.	9.6	30.4
Flow Length	L	feet	3,100	3,500
Slope	s	ft/ft	0.0125	0.0114
Surface (1=paved or 2=unpaved)		n/a	2	2
Velocity (figure 3-1)	V	ft/sec	1.81	1.73
Travel time	Tt	hours	0.475	0.562
Manning's Equation		min.	28.5	33.7
Flow Length	L	feet	5,750	6,750
Slope	S	ft/ft	0.0086	0.0048
roughness	n	n/a	0.065	0.065
Open Channel				
Bottom Width	BW	feet	10	10
Side Slopes (H:1)	H	feet	5	55
Depth	d	feet	6	4
...or Closed Conduit				
Rise / Diameter	R / D	feet	2	2
Span (0 if circular)	S	feet	0	0
Cross-Sectional Area	X-A	feet^2	240.00	920.00
Flow Rate	Q	cfs	1144.02	2347.02
Velocity (figure 3-1)	V	ft/sec	4.77	2.55
Travel time	Tt	hours	0.335	0.735
Flow Length	L	feet	-	3,750
Slope	S	ft/ft	0.0000	0.0013
roughness	n	n/a	0	0.065
Open Channel				
Bottom Width	BW	feet	0	25
Side Slopes (H:1)	H	feet	0	5
Depth	d	feet	0	6
...or Closed Conduit				
Rise / Diameter	R / D	feet	0	0
Span (0 if circular)	S	feet	0	0
Cross-Sectional Area	X-A	feet^2	0.00	330.00
Flow Rate	Q	cfs	n/a	665.74
Velocity (figure 3-1)	V	ft/sec	n/a	2.02
Travel time	Tt	hours	-	0.516
Total Travel Time	TC	hours	0.970	2.319
	TC	min.	58.2	139.2
Lag Time	TL	hours	0.5818	1.3916
	TL	min.	34.9	83.5

EXISTING CONDITION BUTTERCUP CREEK

TR-55 Method of Computing the Time of Concentration

			SUBAREA				
			BC1	BC2	BC3	BC4	BC5
Sheet Flow	variable	units					
Manning's roughness coef.	n	n/a	0.24	0.24	0.24	0.24	0.24
Flow Length	L	feet	300	300	300	300	300
2-year, 24-hour rainfall	P2	inches	4.1	4.1	4.1	4.1	4.1
Slope	s	ft/ft	0.0450	0.0150	0.0050	0.0150	0.0050
Travel time (equation 3-3)	Tt	hours	0.366	0.568	0.881	0.568	0.881
Shallow Concentrated Flow		min.	22.0	34.1	52.9	34.1	52.9
Flow Length	L	feet	1,500	500	550	1,200	3,600
Slope	s	ft/ft	0.0267	0.0233	0.0160	0.0225	0.0188
Surface (1=paved or 2=unpaved)		n/a	2	2	1	2	2
Velocity (figure 3-1)	V	ft/sec	2.65	2.47	2.61	2.43	2.22
Travel time	Tt	hours	0.157	0.056	0.059	0.137	0.450
Manning's Equation		min.	9.4	3.4	3.5	8.2	27.0
Flow Length	L	feet	2,800	1,200	2,100	1,500	4,300
Slope	S	ft/ft	0.0145	0.0154	0.0114	0.0178	0.0107
roughness	n	n/a	0.012	0.012	0.012	0.012	0.065
Open Channel							
Bottom Width	BW	feet	0	0	0	0	1
Side Slopes (H:1)	H	feet	0	0	0	0	10
Depth	d	feet	0	0	0	0	4
...or Closed Conduit							
Rise / Diameter	R / D	feet	3	3	3	3	0
Span (0 if circular)	S	feet	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	7.07	7.07	7.07	164.00
Flow Rate	Q	cfs	87.01	89.67	77.15	96.40	618.67
Velocity (figure 3-1)	V	ft/sec	12.31	12.69	10.91	13.64	3.77
Travel time	Tt	hours	0.063	0.026	0.053	0.031	0.317
Flow Length	L	feet	7,500	5,500	10,500	10,500	-
Slope	S	ft/ft	0.0077	0.0113	0.0064	0.0098	0.0000
roughness	n	n/a	0.065	0.065	0.065	0.065	0
Open Channel							
Bottom Width	BW	feet	10	1	1	5	0
Side Slopes (H:1)	H	feet	15	10	25	15	0
Depth	d	feet	5	4	5	5	0
...or Closed Conduit							
Rise / Diameter	R / D	feet	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	425.00	164.00	630.00	400.00	0.00
Flow Rate	Q	cfs	1632.99	635.78	2126.91	1700.76	n/a
Velocity (figure 3-1)	V	ft/sec	3.84	3.88	3.38	4.25	n/a
Travel time	Tt	hours	0.542	0.394	0.864	0.686	-
Total Travel Time	TC	hours	1.129	1.044	1.857	1.421	1.648
	TC	min.	67.7	62.7	111.4	85.3	98.9
Lag Time	TL	hours	0.6772	0.6266	1.1142	0.8528	0.9887
	TL	min.	40.6	37.6	66.9	51.2	59.3

ULTIMATE CONDITION BUTTERCUP CREEK

TR-55 Method of Computing the Time of Concentration

			SUBAREA				
			BC1	BC2	BC3	BC4	BC5
Sheet Flow	variable	units					
Manning's roughness coef.	n	n/a	0.24	0.24	0.24	0.24	0.24
Flow Length	L	feet	300	300	300	300	150
2-year, 24-hour rainfall	P2	inches	4.1	4.1	4.1	4.1	4.1
Slope	s	ft/ft	0.0450	0.0150	0.0050	0.0150	0.0050
Travel time (equation 3-3)	Tt	hours	0.366	0.568	0.881	0.568	0.506
Shallow Concentrated Flow		min.	22.0	34.1	52.9	34.1	30.4
Flow Length	L	feet	1,500	500	550	1,200	3,600
Slope	s	ft/ft	0.0267	0.0233	0.0160	0.0225	0.0188
Surface (1=paved or 2=unpaved)		n/a	2	2	1	2	2
Velocity (figure 3-1)	V	ft/sec	2.65	2.47	2.61	2.43	2.22
Travel time	Tt	hours	0.157	0.056	0.059	0.137	0.450
Manning's Equation		min.	9.4	3.4	3.5	8.2	27.0
Flow Length	L	feet	2,800	1,200	2,100	1,500	4,300
Slope	S	ft/ft	0.0145	0.0154	0.0114	0.0178	0.0107
roughness	n	n/a	0.012	0.012	0.012	0.012	0.065
Open Channel							
Bottom Width	BW	feet	0	0	0	0	1
Side Slopes (H:1)	H	feet	0	0	0	0	10
Depth	d	feet	0	0	0	0	4
...or Closed Conduit							
Rise / Diameter	R / D	feet	3	3	3	3	0
Span (0 if circular)	S	feet	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	7.07	7.07	7.07	164.00
Flow Rate	Q	cfs	87.01	89.67	77.15	96.40	618.67
Velocity (figure 3-1)	V	ft/sec	12.31	12.69	10.91	13.64	3.77
Travel time	Tt	hours	0.063	0.026	0.053	0.031	0.317
Flow Length	L	feet	7,500	5,500	10,500	10,500	-
Slope	S	ft/ft	0.0077	0.0113	0.0064	0.0098	0.0000
roughness	n	n/a	0.065	0.065	0.065	0.065	0
Open Channel							
Bottom Width	BW	feet	10	1	1	5	0
Side Slopes (H:1)	H	feet	15	10	25	15	0
Depth	d	feet	5	4	5	5	0
...or Closed Conduit							
Rise / Diameter	R / D	feet	0	0	0	0	0
Span (0 if circular)	S	feet	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	425.00	164.00	630.00	400.00	0.00
Flow Rate	Q	cfs	1632.99	635.78	2126.91	1700.76	n/a
Velocity (figure 3-1)	V	ft/sec	3.84	3.88	3.38	4.25	n/a
Travel time	Tt	hours	0.542	0.394	0.864	0.686	-
Total Travel Time	TC	hours	1.129	1.044	1.857	1.421	1.273
	TC	min.	67.7	62.7	111.4	85.3	76.4
Lag Time	TL	hours	0.6772	0.6266	1.1142	0.8528	0.7637
	TL	min.	40.6	37.6	66.9	51.2	45.8

```
*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1) *
*          MAY  1991                *
*        VERSION 4.0.1E             *
*  Lahey F77L-EM/32 version 5.01    *
*    Dodson & Associates, Inc.      *
* RUN DATE  06/06/02  TIME  23:43:37 *
*************************************

*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
*   HYDROLOGIC ENGINEERING CENTER   *
*        609 SECOND STREET          *
*     DAVIS, CALIFORNIA 95616       *
*        (916) 551-1748             *
*                                   *
*************************************

X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X               X
XXXXXXX  XXXX     X       XXXXX   X
X     X  X        X               X
X     X  X        X     X         X
X     X  XXXXXXX   XXXXX         XXX
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THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
                                        HEC-1 INPUT                                                    PAGE  1

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

              *DIAGRAM
  1           ID        COCP STUDY       ................CEDAR PARK, TEXAS
  2           ID       Existing Conditions Analysis....FEB 2002
  3           ID       BLOCKHOUSE CREEK................ FILENAME: EXISBLOCKHOUSE.IH1
  4           ID         PROJECT NO2000-43.............ESPEY CONSULTANTS, INC.
              *
  5           IT        3 01FEB02     0000      700
  6           IO        5
              *

  7           KK      BH1
  8           KO                                      21
              *
              *        SCS Type 3 Rainfall Pattern
  9           KM   100 YEAR
 10           IN        5 01FEB02     0000
 11           PI        0    0.061    0.064    0.068    0.073    0.077    0.083    0.089    0.098    0.108
 12           PI    0.199    0.135    0.154    0.181    0.219    0.275    0.369    0.549    0.990    0.713
 13           PI    0.443    0.316    0.244    0.198    0.167    0.144    0.124    0.113    0.102    0.094
 14           PI    0.087    0.080    0.074    0.066    0.062    0.059
              * 50 YEAR
              *      05 01FEB02     0000
              *       0    0.052    0.056    0.058    0.062    0.067    0.072    0.077    0.085    0.094
              *   0.104    0.177    0.135    0.159    0.192    0.244    0.329    0.494    0.910    0.648
              *   0.398    0.281    0.216    0.175    0.146    0.126    0.111    0.099    0.089    0.081
              *   0.075    0.069    0.065    0.061    0.057    0.054    0.051
              * 25 YEAR
              *       5 01FEB02     0000
              *   0.000    0.044    0.047    0.050    0.053    0.057    0.061    0.067    0.073    0.080
              *   0.089    0.101    0.117    0.138    0.168    0.214    0.291    0.540    0.820    0.520
              *   0.352    0.247    0.189    0.151    0.127    0.109    0.096    0.085    0.076    0.069
              *   0.064    0.060    0.055    0.051    0.048    0.046    0.043
              * 10 YEAR
              *       5 01FEB02     0000
              *   0.000    0.034    0.036    0.038    0.041    0.044    0.047    0.051    0.057    0.063
              *   0.070    0.079    0.092    0.109    0.134    0.172    0.238    0.368    0.720    0.494
              *   0.290    0.200    0.151    0.121    0.100    0.086    0.075    0.066    0.059    0.054
              *   0.050    0.046    0.042    0.040    0.037    0.035    0.033
 15           BA   .4652
 16           LS        0       80       27
 17           UD   .4743
              *

 18           KK   US183
 19           KM   ROUTE THUR BH2 TO US 183
 20           RD     6500     .005      .05              TRAP         1         5
              *

 21           KK      BH2
 22           BA   2.247
 23           LS        0       80       27
 24           UD   .7056
              *
```

```
                                   HEC-1 INPUT                                              PAGE  2

LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

          KK   US183
          KM  COMBINE BH1 AND BH2 AT US 183
          HC       2
          *

          KK   CONFL
          KM  ROUTE COMBINED HYDROGRAPHS THRU BH3 TO CONFLUENCE OF BLOCKHOUSE CREEK
          KM  AND BLOCKHOUSE CREEK TRIB 2
          RD    5900    .010     .05             TRAP       1       5
          *

          KK    BH3
          BA   .6901
          LS       0      80      27
          UD   .7287
          *

          KK    BH4
          BA   .7561
          LS       0      80      27
          UD   .8763
          *

          KK  CONFLY
          KM  COMBINE 3 HYDROGRAPHS AT CONFLUENCE OF BLOCKHOUSE CREEK
          KM  AND BLOCKHOUSE TRIB 2
          HC       3
          *

          KK   CONFL
          KM  ROUTE COMBINED HYDROGRAPHS THRU BH5 TO CONFLUENCE BLOCKHOUSE CREEK
          KM  AND BLOCKHOUSE CREEK TRIB 1
          RD    2400    .013     .05             TRAP       1       5
          *

          KK    BH5
          BA   2.047
          LS       0      80      27
          UD   .8280
          *

          KK   CONFL
          KM  COMBINE 2 HYDROGRAPHS
          HC       2
          *

          KK    SCS3
          KM  ROUTE COMBINED HYDROGRAPHS THRU BH6 TO SCS NO. 3
          RD    5500    .015     .05             TRAP       1      10
          *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 58           KK     BH6
 59           BA   1.604
 60           LS       0      80      27
 61           UD   .5975
              *

 62           KK    SCS3
 63           KM  COMBINE 2 HYDROGRAPHS AT SCS NO. 3
 64           HC       2
              *

 65           KK    SCS3
 66           KM  ROUTE ALL HYDROGRAPHS THRU SCS 3
 67           RS       1    STOR      -1
 68           SV     370     579     847    1195    1630    2153    2746    3481    3668    3861
 69           SV    4061    4268    4486    4744    4969    5201    5476    5733    6032    6319
 70           SE   876.7   880.2   883.6  887.10  890.60  894.10   897.5     901   901.8   902.6
 71           SE   903.4   904.2  905.00   905.9   906.7  907.50  908.40   909.2  910.10     911
 72           SQ       0       1       3       5      10      17      31      56     344    1065
 73           SQ    2125    3448    5064    7172    9121   14308   38568   62327   94222  130730
              *

 74           ZZ
```

```
                    SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE          (V)  ROUTING             (--->)  DIVERSION OR PUMP FLOW

 NO.           (.)  CONNECTOR           (<---)  RETURN OF DIVERTED OR PUMPED FLOW

   7             BH1
                   V
                   V
  16           US183
                   .
                   .
  21               .          BH2
                   .           .
                   .           .
  25           US183............
                   V
                   V
  28           CONFL
                   .
                   .
  32               .          BH3
                   .           .
                   .           .
  36               .           .           BH4
                   .           .            .
                   .           .            .
  40          CONFLY.........................
                   V
                   V
  44           CONFL
                   .
                   .
  48               .          BH5
                   .           .
                   .           .
  52           CONFL............
                   V
                   V
  55            SCS3
                   .
                   .
  58               .          BH6
                   .           .
                   .           .
  62            SCS3............
                   V
                   V
  65            SCS3

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
**************************************
*                                    *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1) *
*          MAY  1991                 *
*        VERSION 4.0.1E              *
*   Lahey F77L-EM/32 version 5.01    *
*     Dodson & Associates, Inc.      *
* RUN DATE  06/06/02  TIME  23:43:37 *
**************************************

**************************************
*                                    *
*   U.S. ARMY CORPS OF ENGINEERS     *
*   HYDROLOGIC ENGINEERING CENTER    *
*        609 SECOND STREET           *
*     DAVIS, CALIFORNIA 95616        *
*        (916) 551-1748              *
*                                    *
**************************************
```

```
                        COCP STUDY      ...............CEDAR PARK, TEXAS
                       Existing Conditions Analysis....FEB 2002
                       BLOCKHOUSE CREEK................ FILENAME: EXISBLOCKHOUSE.IH1
                        PROJECT NO2000-43.............ESPEY CONSULTANTS, INC.

  6 IO        OUTPUT CONTROL VARIABLES
                    IPRNT           5  PRINT CONTROL
                    IPLOT           0  PLOT CONTROL
                    QSCAL          0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN            3  MINUTES IN COMPUTATION INTERVAL
                    IDATE      1FEB 2  STARTING DATE
                    ITIME        0000  STARTING TIME
                       NQ         700  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE      2FEB 2  ENDING DATE
                   NDTIME        1057  ENDING TIME
                   ICENT           19  CENTURY MARK

               COMPUTATION INTERVAL     0.05 HOURS
                    TOTAL TIME BASE    34.95 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

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

           **************
           *            *
  7 KK     *     BH1    *
           *            *
           **************

  8 KO        OUTPUT CONTROL VARIABLES
                    IPRNT           5  PRINT CONTROL
                    IPLOT           0  PLOT CONTROL
                    QSCAL          0.  HYDROGRAPH PLOT SCALE
                    IPNCH           0  PUNCH COMPUTED HYDROGRAPH
                     IOUT          21  SAVE HYDROGRAPH ON THIS UNIT
                    ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                    ISAV2         700  LAST ORDINATE PUNCHED OR SAVED
                   TIMINT       0.050  TIME INTERVAL IN HOURS
```

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 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BH1	1317.31	2.10	260.	65.	45.	0.465		
ROUTED TO	US183	1284.35	2.40	260.	65.	45.	0.465		
HYDROGRAPH AT	BH2	5100.24	2.35	1257.	314.	216.	2.247		
2 COMBINED AT	US183	6381.57	2.35	1517.	379.	260.	2.712		
ROUTED TO	CONFL	6264.51	2.50	1517.	379.	260.	2.712		
HYDROGRAPH AT	BH3	1534.70	1.40	386.	97.	66.	0.690		
HYDROGRAPH AT	BH4	1502.68	2.55	423.	106.	73.	0.756		
3 COMBINED AT	CONFLY	9359.84	2.50	2326.	582.	399.	4.158		
ROUTED TO	CONFL	9349.23	2.55	2326.	582.	399.	4.158		
HYDROGRAPH AT	BH5	4216.23	2.50	1145.	286.	197.	2.047		
2 COMBINED AT	CONFL	13563.10	2.50	3471.	368.	596.	6.205		
ROUTED TO	SCS3	13549.67	2.60	3470.	868.	596.	6.205		
HYDROGRAPH AT	BH6	4002.53	2.25	897.	224.	154.	1.604		
2 COMBINED AT	SCS3	16632.31	2.55	4367.	1092.	750.	7.809		
ROUTED TO	SCS3	25.87	6.30	26.	25.	23.	7.809	896.25	6.40

```
                                 SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
                                     (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)
                                                                          INTERPOLATED TO
                                                                      COMPUTATION INTERVAL
         ISTAQ   ELEMENT      DT      PEAK     TIME TO     VOLUME      DT      PEAK    TIME TO      VOLUME
                                                PEAK                                     PEAK

                            (MIN)    (CFS)      (MIN)       (IN)     (MIN)    (CFS)     (MIN)        (IN)

         US183   MANE        3.00   1284.35    144.00       5.19      3.00   1284.35    144.00       5.19

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1291E+03 EXCESS=0.0000E+00 OUTFLOW=0.1289E+03 BASIN STORAGE=0.7150E-02 PERCENT ERROR=   0.1

         CONFL   MANE        3.00   6364.51    150.00       5.20      3.00   6364.51    150.00       5.20

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7523E+03 EXCESS=0.0000E+00 OUTFLOW=0.7522E+03 BASIN STORAGE=0.5096E-02 PERCENT ERROR=   0.0

         CONFL   MANE        3.00   9349.23    153.00       5.20      3.00   9349.23    153.00       5.20

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1153E+04 EXCESS=0.0000E+00 OUTFLOW=0.1153E+04 BASIN STORAGE=0.2400E-02 PERCENT ERROR=   0.0

          SCS3   MANE        3.00  13549.67    156.00       5.20      3.00  13549.67    156.00       5.20

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1721E+04 EXCESS=0.0000E+00 OUTFLOW=0.1721E+04 BASIN STORAGE=0.5864E-02 PERCENT ERROR=   0.0


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

```
****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           MAY  1991                  *
*        VERSION 4.0.1E                *
*  Lahey F77L-EM/32 version 5.01       *
*    Dodson & Associates, Inc.         *
* RUN DATE  06/06/02  TIME  18:52:59   *
****************************************

****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
*   HYDROLOGIC ENGINEERING CENTER      *
*        609 SECOND STREET             *
*     DAVIS, CALIFORNIA 95616          *
*         (916) 551-1748               *
*                                      *
****************************************

X     X  XXXXXXX   XXXXX           X
X     X  X        X     X         XX
X     X  X        X                X
XXXXXXX  XXXX     X         XXXXX  X
X     X  X        X                X
X     X  X        X     X          X
X     X  XXXXXXX   XXXXX          XXX

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM
```

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                                      HEC-1 INPUT                                                  PAGE  1

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

              *DIAGRAM
  1           ID        COCP STUDY      ................CEDAR PARK, TEXAS
  2           ID        Proposed Conditions Analysis....FEB 2002
  3           ID        BLOCKHOUSE CREEK................ FILENAME: BLOCKHOUSE.IH1
  4           ID          PROJECT NO2000-43.............ESPEY CONSULTANTS, INC.
              *
  5           IT       3 01FEB02    0000     700
  6           IO       5
              *

  7           KK      BH1
  8           KO                                        21
  9           IN      05 01FEB02    0000
 10           KM  100 YEAR
 11           PI       0   0.061   0.064   0.068   0.073   0.077   0.083   0.089   0.098   0.108
 12           PI   0.199   0.135   0.154   0.181   0.219   0.275   0.369   0.549   0.990   0.713
 13           PI   0.443   0.316   0.244   0.198   0.167   0.144   0.124   0.113   0.102   0.094
 14           PI   0.087   0.080   0.074   0.066   0.062   0.059
              *       0   0.052   0.056   0.058   0.062   0.067   0.072   0.077   0.085   0.094
              *   0.104   0.177   0.135   0.159   0.192   0.244   0.329   0.494   0.910   0.648
              *   0.398   0.281   0.216   0.175   0.146   0.126   0.111   0.099   0.089   0.081
              *   0.075   0.069   0.065   0.061   0.057   0.054   0.051
              * 25 YEAR
              *       0   0.044   0.047   0.050   0.053   0.057   0.061   0.067   0.073   0.080
              *   0.089   0.101   0.117   0.138   0.168   0.214   0.291   0.540   0.820   0.520
              *   0.352   0.247   0.189   0.151   0.127   0.109   0.096   0.085   0.076   0.069
              *   0.064   0.060   0.055   0.051   0.048   0.046   0.043
              * 10 YEAR
              *       0   0.034   0.036   0.038   0.041   0.044   0.047   0.051   0.057   0.063
              *   0.070   0.079   0.092   0.109   0.134   0.172   0.228   0.268   0.720   0.494
              *   0.290   0.200   0.151   0.121   0.100   0.086   0.075   0.066   0.059   0.054
              *   0.050   0.046   0.042   0.040   0.037   0.035   0.033
 15           BA   .4652
 16           LS       0      80      42
 17           UD   .4743
              *

 18           KK   US183
 19           KM  ROUTE THUR BH2TO US 183
 20           RD    6500    .005     .05             TRAP       1       5
              *

 21           KK     BH2
 22           BA   2.247
 23           LS       0      80      42
 24           UD   .7056
              *

 25           KK   US183
 26           KM  COMBINE BH1 AND BH2 AT US 183
 27           HC       2
              *
```

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                                        HEC-1 INPUT                                                       PAGE  2

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  28          KK   CONFL
  29          KM  ROUTE COMBINED HYDROGRAPHS THRU BH2 TO CONFLUENCE OF BLOCKHOUSE CREEK
  30          KM  AND BLOCKHOUSE CREEK TRIB 2
  31          RD    5900    .010     .05              TRAP       1       5
              *

  32          KK     BH3
  33          BA   .6901
  34          LS       0      80      42
  35          UD   .7287
              *

  36          KK     BH4
  37          BA   .7561
  38          LS       0      80      42
  39          UD   .7930
              *

  40          KK   CONFL
  41          KM  COMBINE 3 HYDROGRAPHS AT CONFLUENCE OF BLOCKHOUSE CREEK
  42          KM  AND BLOCKHOUSE CREEK TRIB 2
  43          HC       3
              *

  44          KK   CONFL
  45          KM  ROUTE COMBINED HYDROGRAPHS THRU BH5 TO CONFLUENCE OF BLOCKHOUSE CREEK
  46          KM   AND BLOCKHOUSE CREEK TRIB 1
  47          RD    2400    .013     .05              TRAP       1       5
              *

  48          KK     BH5
  49          BA   2.047
  50          LS       0      80      42
  51          UD   .7384
              *

  52          KK   CONFL
  53          KM  COMBINE 2 HYDROGRAPHS AT CONFLUENCE OF BLOCKHOUSE CREEK
  54          KM  AND BLOCKHOUSE CREEK TRIB 1
  55          HC       2
              *

  56          KK    SCS3
  57          KM  ROUTE COMBINED HYDROGRAPHS THRU BH6 TO SCS NO. 3
  58          RD    5500    .015     .05              TRAP       1      10
              *

  59          KK     BH6
  60          BA   1.604
  61          LS       0      80      42
  62          UD   .5192
              *
```

```
                              HEC-1 INPUT                                          PAGE  3

ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

KK    SCS3
KM  COMBINE 2 HYDROGRAPHS AT SCS NO. 3
HC       2
*

KK    SCS3
KM  ROUTE ALL HYDROGRAPHS THRU SCS 3
RS       1    STOR      -1
SV     370     579     847    1195    1630    2153    2746    3481    3668    3861
SV    4061    4268    4486    4744    4969    5201    5476    5723    6032    6319
SE   876.7   880.2   883.6  887.10  890.60  894.10   897.5     901   901.8   902.6
SE   903.4   904.2  905.00   905.9   906.7  907.50  908.40   909.2  910.10     911
SQ       0       1       3       5      10      17      31      56     344    1065
SQ    2125    3448    5064    7172    8121   14308   38568   62327   94222  130730
*
ZZ
```

```
                    SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE         (V)  ROUTING            (--->)  DIVERSION OR PUMP FLOW

 NO.          (.)  CONNECTOR          (<---)  RETURN OF DIVERTED OR PUMPED FLOW

   7            BH1
                 V
                 V
  18           US183
                 .
                 .
  21             .            BH2
                 .             .
                 .             .
  25           US183............
                 V
                 V
  28           CONFL
                 .
                 .
  32             .            BH3
                 .             .
                 .             .
  36             .             .           BH4
                 .             .            .
                 .             .            .
  40           CONFL.........................
                 V
                 V
  44           CONFL
                 .
                 .
  48             .            BH5
                 .             .
                 .             .
  52           CONFL............
                 V
                 V
  56            SCS3
                 .
                 .
  59             .            BH6
                 .             .
                 .             .
  63            SCS3............
                 V
                 V
  66            SCS3

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
***************************************
*                                     *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            MAY  1991                *
*          VERSION 4.0.1E             *
*   Lahey F77L-EM/32 version 5.01     *
*     Dodson & Associates, Inc.       *
*  RUN DATE  06/06/02  TIME  18:52:59 *
***************************************

***************************************
*                                     *
*   U.S. ARMY CORPS OF ENGINEERS      *
*   HYDROLOGIC ENGINEERING CENTER     *
*         609 SECOND STREET           *
*      DAVIS, CALIFORNIA 95616        *
*         (916) 551-1748              *
*                                     *
***************************************
```

```
                        COCP STUDY       ................CEDAR PARK, TEXAS
                        Proposed Conditions Analysis....FEB 2002
                        BLOCKHOUSE CREEK................ FILENAME: BLOCKHOUSE.IH1
                          PROJECT NO2000-43.............ESPEY CONSULTANTS, INC.

   6 IO        OUTPUT CONTROL VARIABLES
                     IPRNT          5  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE

     IT        HYDROGRAPH TIME DATA
                      NMIN          3  MINUTES IN COMPUTATION INTERVAL
                     IDATE     1FEB 2  STARTING DATE
                     ITIME       0000  STARTING TIME
                        NQ        700  NUMBER OF HYDROGRAPH ORDINATES
                    NDDATE     2FEB 2  ENDING DATE
                    NDTIME       1057  ENDING TIME
                     ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL    0.05 HOURS
                     TOTAL TIME BASE   34.95 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

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

             **************
             *            *
   7 KK      *    BH1     *
             *            *
             **************

   8 KO        OUTPUT CONTROL VARIABLES
                     IPRNT          5  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE
                     IPNCH          0  PUNCH COMPUTED HYDROGRAPH
                      IOUT         21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2        700  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT      0.050  TIME INTERVAL IN HOURS
```

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 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BH1	1377.78	2.10	278.	69.	48.	0.465		
ROUTED TO	US183	1343.59	2.35	277.	69.	48.	0.465		
HYDROGRAPH AT	BH2	5251.55	2.35	1340.	335.	230.	2.247		
2 COMBINED AT	US183	6695.14	2.35	1618.	404.	278.	2.712		
ROUTED TO	CONFL	6669.39	2.50	1617.	404.	278.	2.712		
HYDROGRAPH AT	BH3	1612.32	2.35	412.	103.	71.	0.690		
HYDROGRAPH AT	BH4	1680.26	2.45	451.	113.	77.	0.756		
3 COMBINED AT	CONFL	9934.25	2.45	2480.	620.	426.	4.158		
ROUTED TO	CONFL	9930.35	2.50	2480.	620.	426.	4.158		
HYDROGRAPH AT	BH5	4742.11	2.35	1221.	305.	210.	2.047		
2 COMBINED AT	CONFL	14566.77	2.45	3701.	925.	635.	6.205		
ROUTED TO	SCS3	14553.54	2.55	3701.	925.	635.	6.205		
HYDROGRAPH AT	BH6	4528.40	2.15	957.	239.	164.	1.604		
2 COMBINED AT	SCS3	17660.07	2.50	4657.	1165.	800.	7.809		
ROUTED TO	SCS3	29.24	6.20	29.	29.	26.	7.809	897.07	6.20

SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
(FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)

ISTAQ	ELEMENT	DT	PEAK	TIME TO PEAK	VOLUME	DT	INTERPOLATED TO COMPUTATION INTERVAL PEAK	TIME TO PEAK	VOLUME
		(MIN)	(CFS)	(MIN)	(IN)	(MIN)	(CFS)	(MIN)	(IN)
US183	MANE	3.00	1343.59	141.00	5.54	3.00	1343.59	141.00	5.54

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1376E+03 EXCESS=0.0000E+00 OUTFLOW=0.1374E+03 BASIN STORAGE=0.7200E-02 PERCENT ERROR= 0.1

CONFL	MANE	3.00	6669.39	150.00	5.54	3.00	6669.39	150.00	5.54

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.8021E+03 EXCESS=0.0000E+00 OUTFLOW=0.8020E+03 BASIN STORAGE=0.5132E-02 PERCENT ERROR= 0.0

CONFL	MANE	3.00	9930.35	150.00	5.55	3.00	9930.35	150.00	5.55

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1230E+04 EXCESS=0.0000E+00 OUTFLOW=0.1230E+04 BASIN STORAGE=0.1983E-02 PERCENT ERROR= 0.0

SCS3	MANE	3.00	14553.54	153.00	5.55	3.00	14553.54	153.00	5.55

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1835E+04 EXCESS=0.0000E+00 OUTFLOW=0.1835E+04 BASIN STORAGE=0.5268E-02 PERCENT ERROR= 0.0

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

```
***************************************
*                                     *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1) *
*              MAY  1991              *
*           VERSION 4.0.1E            *
*     Lahey F77L-EM/32 version 5.01   *
*       Dodson & Associates, Inc.     *
* RUN DATE  06/06/02  TIME  18:25:24  *
***************************************
```

```
***************************************
*                                     *
*   U.S. ARMY CORPS OF ENGINEERS      *
*   HYDROLOGIC ENGINEERING CENTER     *
*         609 SECOND STREET           *
*      DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748             *
*                                     *
***************************************
```

```
X     X  XXXXXXX   XXXXX           X
X     X  X        X     X         XX
X     X  X        X                X
XXXXXXX  XXXX     X         XXXXX  X
X     X  X        X                X
X     X  X        X     X          X
X     X  XXXXXXX   XXXXX          XXX
```

```
THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM
```

```
                                        HEC-1 INPUT                                                   PAGE  1

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

              *DIAGRAM
  1           ID        COCP STUDY      ................CEDAR PARK, TEXAS
  2           ID        Existing Conditions Analysis....FEB 2002
  3           ID          SPANISH OAK CREEK............ FILENAME: SPANISH.IH1
  4           ID          PROJECT NO2000-43............ESPEY CONSULTANTS, INC.
              *
  5           IT        3 01FEB02     0000     2000
  6           IO        5
              *

  7           KK      SP1
  8           KO                                         21
  9           KM     100YR
 10           IN        5 01FEB02      000
 11           PI        0   0.061   0.064   0.068   0.073   0.077   0.083   0.089   0.098   0.108
 12           PI    0.199   0.135   0.154   0.181   0.219   0.275   0.369   0.549   0.990   0.713
 13           PI    0.443   0.316   0.244   0.198   0.167   0.144   0.124   0.113   0.102   0.094
 14           PI    0.087   0.080   0.074   0.066   0.062   0.059
              *    50YR
              *      05 01FEB02     0000
              *       0   0.052   0.056   0.058   0.062   0.067   0.072   0.077   0.085   0.094
              *   0.104   0.177   0.135   0.159   0.192   0.244   0.329   0.494   0.910   0.648
              *   0.398   0.281   0.216   0.175   0.146   0.126   0.111   0.099   0.089   0.081
              *   0.075   0.069   0.065   0.061   0.057   0.054   0.051
              *     25YR
              *       5 01FEB02     0000
              *   0.000   0.044   0.047   0.050   0.053   0.057   0.061   0.067   0.073   0.080
              *   0.089   0.101   0.117   0.138   0.168   0.214   0.291   0.540   0.820   0.520
              *   0.352   0.247   0.189   0.151   0.127   0.109   0.096   0.085   0.076   0.069
              *   0.064   0.060   0.055   0.051   0.048   0.046   0.043
              *    10YR
              *       5 01FEB02     0000
              *   0.000   0.034   0.036   0.038   0.041   0.044   0.047   0.051   0.057   0.063
              *   0.070   0.079   0.092   0.109   0.134   0.172   0.238   0.368   0.720   0.494
              *   0.290   0.200   0.151   0.121   0.100   0.086   0.075   0.066   0.059   0.054
              *   0.050   0.046   0.042   0.040   0.037   0.035   0.033
 15           BA    .1489
 16           LS        0      80      46
 17           UD    .1616
              *

 18           KK     POND
 19           KM  ROUTE SP1 THRU CARRIAGE HILL POND
 20           RS        1    STOR      -1
 21           SV     0.00    0.16    0.73    1.75    3.01    4.42    4.68    7.13   10.23   13.59
 22           SV    17.00   20.00
 23           SE      997     998     999    1000    1001 1001.84    1002    1003    1004    1005
 24           SE     1006  1006.3
 25           SQ        0       5      10      15      16      30      40      50      70      90
 26           SQ      110     120     180     240     300
 27           SE      997  999.43 1000.36 1002.05 1002.27 1002.75 1003.02 1003.28 1003.73 1004.15
 28           SE   1004.5 1004.74 1005.76 1006.65 1007.48
              *
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                                   HEC-1 INPUT                                                  PAGE  2

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 29         KK  CENTRD
 30         RD    2200   .0115    .05           TRAP       1      50
            *

 31         KK     SP2
 32         BA  .24141
 33         LS       0      80     25
 34         UD   .4812
            *

 35         KK     SP3
 36         BA   .1519
 37         LS       0      80     62
 38         UD   .2305
            *

 39         KK  CENTRD
 40         KM  COMBINE SP3 WITH EXISTING HYDROGRAPH
 41         HC       3
            *

 42         KK   US183
 43         KM  ROUTE COMBINED HYDROGRAPH THRU WALMART POND
 44         RS       1    STOR     -1
 45         SV       0      10     16      22      25      28      30
 46         SQ       0     330    550     770     880    1100    1210
            *

 47         KK      RR
 48         KM  ROUTE POND OUTFLOW THRU SP4 TO RAILROAD TRACKS
 49         RD     800   .0150    .05           TRAP     180     100
            *

 50         KK     SP4
 51         BA  .24698
 52         LS       0      80     59
 53         UD   .2568
            *

 54         KK      RR
 55         KM  COMBINE TWO HYDROGRAPHS AT RAILROAD TRACKS
 56         HC       2
            *

 57         KK    1431
 58         KM  ROUTE HYDROGRAPH THRU SP5 TO FM 1431
 59         RD    3700   .0143    .05           TRAP      30     100
            *
```

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                                   HEC-1 INPUT                                                    PAGE  3

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 60           KK     SP5
 61           BA  .43926
 62           LS       0       80      60
 63           UD   .5234
              *

 64           KK     SP6
 65           BA   .0463
 66           LS       0       80      76
 67           UD   .4673
              *

 68           KK  FM1431
 69           KM  COMBINE 2 HYDROGRAPHS AT 1431
 70           HC       3
              *

 71           KK     SP7
 72           BA   .1028
 73           LS       0       80      49
 74           UD   .4993
              *

 75           KK  FM1431
 76           KM  COMBINE 2 HYDROGRAPHS DOWNSTREAM OF FM1431
 77           HC       2
              *

 78           KK   SOCRK
 79           KM  ROUTE COMBINED HYDROGAPH THRU SP11
 80           RD    2100   .0071     .05             TRAP      10      55
              *

 81           KK   SP11A
 82           BA   .0856
 83           LS       0       80      31
 84           UD   .5354
              *

 85           KK   SOCRK
 86           KM  ROUTE HYDROGRAPH SP11A THRU SP11 TO SPANISH OAK CREEK
 87           RD    1500   .0164     .05             TRAP      10      15
              *

 88           KK   SOCRK
 89           KM  COMBINE HYDROGRAPHS AT SPANISH OAK CREEK CONF
 90           HC       2
              *
```

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                                         HEC-1 INPUT                                                 PAGE  4

LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  91           KK     SP8
  92           BA  .45394
  93           LS       0      80      54
  94           UD   .4641
               *

  95           KK   PPPND
  96           KM  ROUTE SP8 THRU PARK PLACE POND
  97           RS       1    STOR      -1
  98           SV       0   .0093   .0741   .2502   .6760   1.568   3.164   5.784   7.400   9.197
  99           SV   11.18   13.40
 100           SQ       0    23.7    67.1   122.8   189.2   264.0   346.4   430.0   522.2   853.6
 101           SQ  1579.5  2755.4
 102           SE     937     938     939     940     941     942     943     944   944.5     945
 103           SE   945.5     946
               *

 104           KK    QPND
 105           KM  ROUTE POND OUTFLOW THRU SP9
 106           RD    2000     .01     .05            TRAP       1      10
               *

 107           KK     SP9
 108           BA   .0919
 109           LS       0      80      36
 110           UD   .4680
               *

 111           KK    QPND
 112           KM  COMBINE 2 HYDROGRAPHS
 113           HC       2
               *

 114           KK    SP10
 115           BA   .1208
 116           LS       0      80      38
 117           UD   .3538
               *

 118           KK    QPND
 119           KM  ROUTE SP10 THRU QUEST POND
 120           RS       1    FLOW      -1
 121           SA       0   0.298   1.281   2.705   3.817   4.272   4.557   4.769   4.943   5.091
 122           SA   5.241
 123           SQ       0     2.7     4.6     6.0     7.1     8.0     8.9    39.6    95.2   196.9
 124           SQ   336.5
 125           SE     917     918     919     920     921     922     923     924     925     926
 126           SE     927
               *
```

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                                   HEC-1 INPUT                                              PAGE  5

 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  127          KK    QPND
  128          KM   COMBINE 2 HYDROGRAPHS AT QUEST POND OUTLET
  129          HC        2
               *

  130          KK   SOCRK
  131          KM  ROUTE COMBINED HYDROGRAPH THRU SP11 TO SPANISH OAK CREEK
  132          RD     2900   .0071     .05              TRAP      10      55
               *

  133          KK    SP11
  134          BA  .45111
  135          LS        0      80      31
  136          UD   .4151
               *

  137          KK   SOCRK
  138          KM  COMBINE 3 HYDROGRAPHS TO SPANISH OAK CREEK
  139          HC        3
               *

  140          KK  NRCS 4
  141          KM  ROUTE COMBINED HYDROGRAPH THRU SP12 TO  NRCS 4
  142          RD     8200   .0112     .05              TRAP      10       8
               *

  143          KK    SP12
  144          BA  .99025
  145          LS        0      80      27
  146          UD   .9544
               *

  147          KK  NRCS 4
  148          KM  COMBINE FLOWS INTO NRCS 4
  149          HC        2
               *

  150          KK    SP13
  151          BA  .80239
  152          LS        0      80      15
  153          UD   .8806
               *

  154          KK    SP14
  155          BA  1.2334
  156          LS        0      80      13
  157          UD   .6624
               *
```

```
                                  HEC-1 INPUT                                          PAGE  6

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 158       KK  NRCS 4
 159       KM  COMBINE 3 HYDROGRAPHS AT NRCS 4
 160       HC       3
           *

 161       KK  NRCS 4
 162       KM  ROUTE ALL HYDROGRAPHS THRU NRCS 4
 163       RS       1    STOR      -1
 164       SV     200     302     446     627     855    1132    1470    1887    1985    2088
 165       SV    2196    2309    2428    2550    2668    2824    2989    3164    3349    3544
 166       SE   838.3   841.2   844.2   847.1   850.1     853   855.9   858.9   859.6   860.3
 167       SE     861   861.7   862.4  863.10  863.90   864.9   865.9   866.9   867.9   868.9
 168       SQ       0       1       2       5       8      14      24      43     235     715
 169       SQ    1407    2279    3307    4244    4861    9636   25197   41807   61463   63790
           *
 170       ZZ
```

```
                 SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
LINE         (V) ROUTING            (--->) DIVERSION OR PUMP FLOW

 NO.         (.) CONNECTOR          (<---) RETURN OF DIVERTED OR PUMPED FLOW

   7             SP1
                   V
                   V
  18            POND
                   V
                   V
  29          CENTRD
                   .
                   .
  31               .         SP2
                   .           .
                   .           .
  35               .           .           SP3
                   .           .             .
                   .           .             .
  39          CENTRD.........................
                   V
                   V
  42           US183
                   V
                   V
  47              RR
                   .
                   .
  50               .         SP4
                   .           .
                   .           .
  54              RR............
                   V
                   V
  57            1431
                   .
                   .
  60               .         SP5
                   .           .
                   .           .
  64               .           .           SP6
                   .           .             .
                   .           .             .
  68          FM1431.........................
                   .
                   .
  71               .         SP7
                   .           .
                   .           .
  75          FM1431............
                   V
                   V
  78           SOCRK
                   .
                   .
  81               .       SP11A
                   .           V
                   .           V
  85               .       SOCRK
                   .           .
                   .           .
  88           SOCRK............
                   .
                   .
  91               .         SP8
                   .           V
                   .           V
  95               .       PPPND
                   .           V
                   .           V
 104               .        QPND
                   .           .
                   .           .
 107               .           .           SP9
                   .           .             .
                   .           .             .
 111               .        QPND.............
                   .           .
                   .           .
 114               .           .          SP10
                   .           .             V
                   .           .             V
 118               .           .          QPND
                   .           .             .
                   .           .             .
 127               .        QPND.............
                   .           V
                   .           V
 130               .       SOCRK
                   .           .
                   .           .
```

```
133                .               .        SP11
                   .               .           .
                   .               .           .
137            SOCRK............................
                   V
                   V
140           NRCS 4
                   .
                   .
143                .            SP12
                   .               .
                   .               .
147           NRCS 4................
                   .
                   .
150                .            SP13
                   .               .
                   .               .
154                .               .        SP14
                   .               .           .
                   .               .           .
158           NRCS 4............................
                   V
                   V
161           NRCS 4

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
***************************************
*                                     *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1) *
*            MAY  1991                *
*         VERSION 4.0.1E              *
*    Lahey F77L-EM/32 version 5.01    *
*      Dodson & Associates, Inc.      *
* RUN DATE  06/06/02  TIME  18:25:24  *
***************************************

***************************************
*                                     *
*   U.S. ARMY CORPS OF ENGINEERS      *
*   HYDROLOGIC ENGINEERING CENTER     *
*        609 SECOND STREET            *
*     DAVIS, CALIFORNIA 95616         *
*         (916) 551-1748              *
*                                     *
***************************************


                         COCP STUDY      ................CEDAR PARK, TEXAS
                        Existing Conditions Analysis....FEB 2002
                         SPANISH OAK CREEK............ FILENAME: SPANISH.IH1
                         PROJECT NO2000-43.............ESPEY CONSULTANTS, INC.

  6 IO          OUTPUT CONTROL VARIABLES
                      IPRNT           5  PRINT CONTROL
                      IPLOT           0  PLOT CONTROL
                      QSCAL          0.  HYDROGRAPH PLOT SCALE

   IT           HYDROGRAPH TIME DATA
                       NMIN           3  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1FEB 2  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ        2000  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      5FEB 2  ENDING DATE
                     NDTIME        0357  ENDING TIME
                      ICENT          19  CENTURY MARK

                 COMPUTATION INTERVAL    0.05 HOURS
                      TOTAL TIME BASE   99.95 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


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

         **************
         *            *
  7 KK   *      SP1   *
         *            *
         **************

  8 KO          OUTPUT CONTROL VARIABLES
                      IPRNT           5  PRINT CONTROL
                      IPLOT           0  PLOT CONTROL
                      QSCAL          0.  HYDROGRAPH PLOT SCALE
                      IPNCH           0  PUNCH COMPUTED HYDROGRAPH
                       IOUT          21  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2        2000  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT       0.050  TIME INTERVAL IN HOURS
```

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 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SP1	690.27	1.75	90.	23.	8.	0.149		
ROUTED TO	POND	299.19	2.10	82.	23.	8.	0.149	1007.47	2.10
ROUTED TO	CENTRD	298.88	2.25	83.	23.	8.	0.149		
HYDROGRAPH AT	SP2	673.98	2.10	134.	33.	11.	0.241		
HYDROGRAPH AT	SP3	647.91	1.80	98.	25.	8.	0.152		
3 COMBINED AT	CENTRD	1357.78	2.00	313.	81.	27.	0.542		
ROUTED TO	US183	1181.70	2.25	313.	81.	27.	0.542		
ROUTED TO	RR	1181.72	2.30	313.	81.	27.	0.542		
HYDROGRAPH AT	SP4	1008.61	1.85	158.	39.	13.	0.247		
2 COMBINED AT	RR	1699.17	2.15	470.	120.	40.	0.789		
ROUTED TO	1431	1684.80	2.40	470.	120.	40.	0.789		
HYDROGRAPH AT	SP5	1301.24	2.15	282.	70.	23.	0.439		
HYDROGRAPH AT	SP6	151.93	2.05	32.	8.	3.	0.046		
3 COMBINED AT	FM1431	3079.07	2.15	781.	198.	66.	1.275		
HYDROGRAPH AT	SP7	302.30	2.10	63.	16.	5.	0.103		
2 COMBINED AT	FM1431	3380.00	2.15	844.	214.	71.	1.378		
ROUTED TO	SOCRK	3364.00	2.25	844.	214.	71.	1.378		
HYDROGRAPH AT	SP11A	229.37	2.15	49.	12.	4.	0.086		
ROUTED TO	SOCRK	229.32	2.25	49.	12.	4.	0.086		
2 COMBINED AT	SOCRK	3593.32	2.25	893.	226.	75.	1.463		
HYDROGRAPH AT	SP8	1404.01	2.05	284.	71.	24.	0.454		
ROUTED TO	PPPND	1400.15	2.10	284.	71.	24.	0.454	945.38	2.10
ROUTED TO	QPND	1395.39	2.20	284.	71.	24.	0.454		
HYDROGRAPH AT	SP9	268.86	2.10	53.	13.	4.	0.092		
2 COMBINED AT	QPND	1658.16	2.15	338.	84.	28.	0.546		
HYDROGRAPH AT	SP10	407.08	1.95	71.	18.	6.	0.121		
ROUTED TO	QPND	114.23	2.80	42.	16.	6.	0.121	925.19	2.80
2 COMBINED AT	QPND	1703.38	2.20	378.	100.	34.	0.667		
ROUTED TO	SOCRK	1689.10	2.35	378.	100.	34.	0.667		
HYDROGRAPH AT	SP11	1278.59	2.05	257.	64.	21.	0.451		
3 COMBINED AT	SOCRK	6333.67	2.25	1526.	391.	131.	2.581		
ROUTED TO	NRCS 4	6323.87	2.45	1526.	391.	131.	2.581		
HYDROGRAPH AT	SP12	1864.57	2.65	554.	139.	46.	0.990		
2 COMBINED AT	NRCS 4	8114.03	2.45	2078.	529.	177.	3.571		
HYDROGRAPH AT	SP13	1526.29	2.55	425.	106.	35.	0.802		
HYDROGRAPH AT	SP14	2772.38	2.30	647.	162.	54.	1.233		
3 COMBINED AT	NRCS 4	12282.79	2.45	3149.	797.	266.	5.607		
ROUTED TO	NRCS 4	36.85	7.05	37.	36.	33.	5.607	857.93	7.15

SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
(FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)

ISTAQ	ELEMENT	DT	PEAK	TIME TO PEAK	VOLUME	INTERPOLATED TO COMPUTATION INTERVAL DT	PEAK	TIME TO PEAK	VOLUME
		(MIN)	(CFS)	(MIN)	(IN)	(MIN)	(CFS)	(MIN)	(IN)
CENTRD	MANE	3.00	298.88	135.00	5.64	3.00	298.88	135.00	5.64
CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4477E+02 EXCESS=0.0000E+00 OUTFLOW=0.4478E+02 BASIN STORAGE=0.2691E-02 PERCENT ERROR= 0.0									
RR	MANE	3.00	1181.72	138.00	5.53	3.00	1181.72	138.00	5.53
CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1598E+03 EXCESS=0.0000E+00 OUTFLOW=0.1598E+03 BASIN STORAGE=0.1538E-02 PERCENT ERROR= 0.0									
1431	MANE	3.00	1684.30	144.00	5.66	3.00	1684.30	144.00	5.66
CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2380E+03 EXCESS=0.0000E+00 OUTFLOW=0.2380E+03 BASIN STORAGE=0.5153E-02 PERCENT ERROR= 0.0									
SOCRK	MANE	3.00	3364.00	135.00	5.78	3.00	3364.00	135.00	5.78
CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4246E+03 EXCESS=0.0000E+00 OUTFLOW=0.4245E+03 BASIN STORAGE=0.3243E-02 PERCENT ERROR= 0.0									
SOCRK	MANE	3.00	229.82	135.00	5.29	3.00	229.82	135.00	5.29
CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2417E+02 EXCESS=0.0000E+00 OUTFLOW=0.2417E+02 BASIN STORAGE=0.1468E-02 PERCENT ERROR= 0.0									
QPND	MANE	3.00	1395.39	132.00	5.82	3.00	1395.39	132.00	5.82
CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1409E+03 EXCESS=0.0000E+00 OUTFLOW=0.1409E+03 BASIN STORAGE=0.2134E-02 PERCENT ERROR= 0.0									
SOCRK	MANE	3.00	1689.10	141.00	5.70	3.00	1689.10	141.00	5.70
CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2026E+03 EXCESS=0.0000E+00 OUTFLOW=0.2026E+03 BASIN STORAGE=0.4661E-02 PERCENT ERROR= 0.0									
NRCS 4	MANE	3.00	6323.87	147.00	5.66	3.00	6323.87	147.00	5.66
CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7786E+03 EXCESS=0.0000E+00 OUTFLOW=0.7786E+03 BASIN STORAGE=0.7837E-02 PERCENT ERROR= 0.0									

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