Windmill Gulch Detention Basin #2

Colorado Springs, Colorado

File with DBPS's

Kiowa Engineering Corporation

Windmill Gulch Detention Basin #2

Colorado Springs, Colorado

Prepared for:

Rockwell Minchow Consultants, Inc.
1873 Austin Bluffs Parkway
Colorado Springs, CO 80918

Prepared by:
Kiowa Engineering Corporation
1604 South 21st Street
Colorado Springs, Colorado 80904

Kiowa Project No. 02072

November 8, 2002
Revised December 4, 2002

ENGINEER'S STATEMENT:

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

Kiowa Engineering Corporation, 1604 South 21st Street, Colorado Springs, Colorado 80904

Registered Engineer #19310 — Date: 12/30/02
For and on Behalf of Kiowa Engineering Corporation

DEVELOPER'S STATEMENT:

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

BY: _____ — Date: 1/6/03
Ron O'Canna, Development Manager

ADDRESS: Classic Development – Soaring Eagles LLC
6385 Corporate Drive
Colorado Springs, Colorado 80919

CITY OF COLORADO SPRINGS:

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

For the City Engineer — Date: 1/7/03

Conditions:

I. General Location and Description

The proposed Windmill Gulch Detention Basin #2 is located at the northwest corner of Drennan Road and Powers Boulevard. The site is currently undeveloped. The site is bounded to the west and northwest by the Soaring Eagles Subdivision, to the northeast and east by Powers Boulevard, and to the south by Drennan Road. The detention basin is to be located in a proposed park area to be owned by the City of Colorado Springs. The park is to include within the storage pool of the detention basin an area suitable for two soccer fields. The site is shown on Figure 1.

II. Drainage Basin and Subbasins

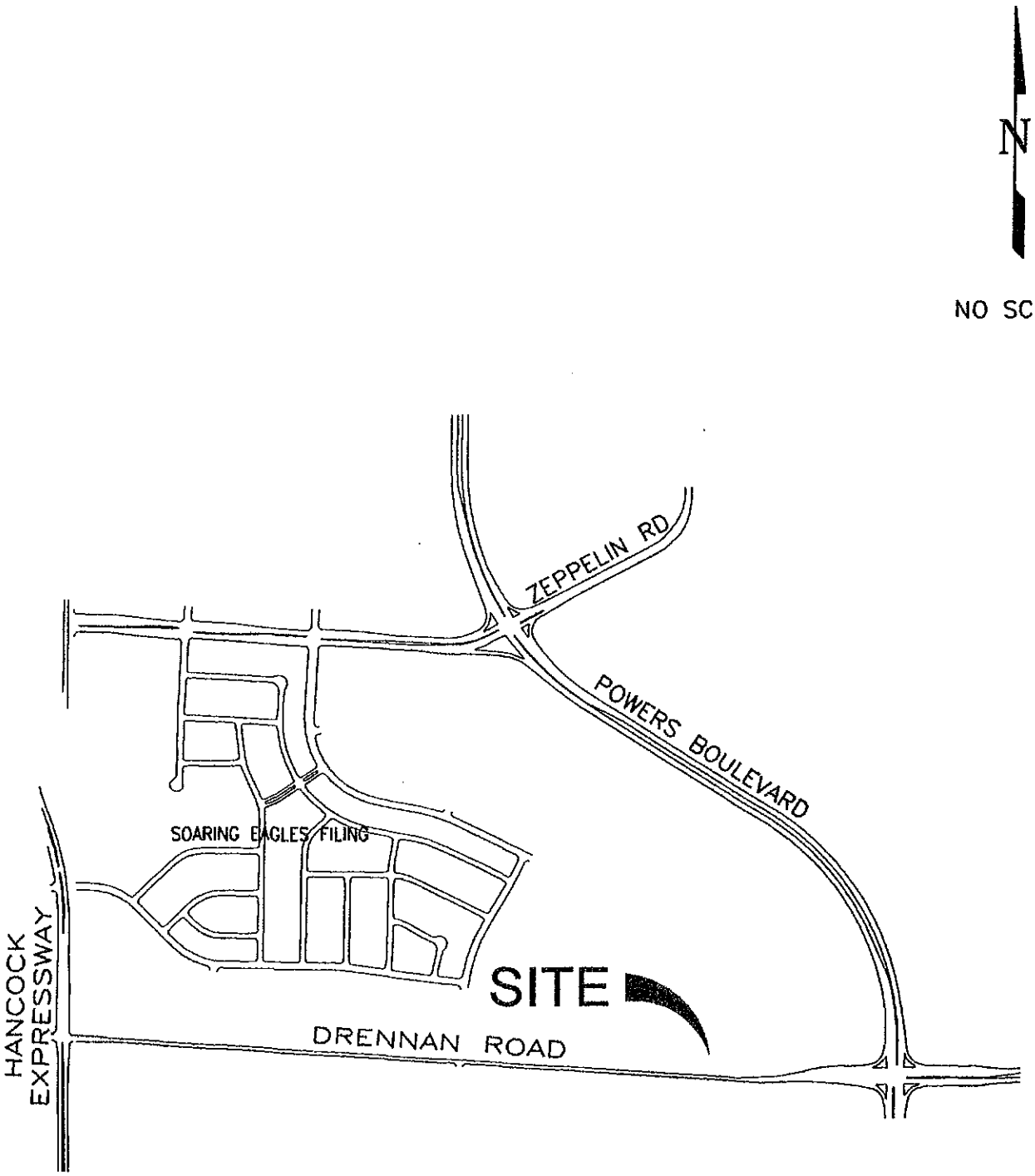
The following reports, plans, and studies were reviewed in the process of preparing this preliminary/final drainage plan:

1. *Windmill Gulch Drainage Basin Planning Study (DBPS)* prepared by Wilson & Company, dated January 1991, revised June 1991 and February 1992.
2. City of Colorado Springs and El Paso County *Drainage Criteria Manual*, October 1987, revised November 1991.
3. *Soil Survey for El Paso County, Colorado.* U.S. Department of Agriculture, Soil Conservation Service, June 1980.

Presently, storm runoff generated from the tributary area outfalls to an existing 43"x68" HERCP culvert located under Drennan Road. This outfall point was designated as Design Point L in the DBPS. A portion of Soaring Eagles Filing No. 3 within Sub-basin 1 drains to this point via two swales. Sub-basin 2 and the remainder of Sub-basin 1 are currently undeveloped. Storm runoff generated from these areas travel overland to the existing culvert under Drennan Road. Sub-basin 3 consists of softball fields. Runoff drains from this area to a culvert under Powers Boulevard and is conveyed to the culvert under Drennan Road via a roadside ditch. Sub-basin 4 is also undeveloped and currently drains to 4 culverts located under Powers Boulevard just north of Drennan Road. A roadside swale carries this storm runoff to Design Point L. See Exhibit 1 for existing drainage patterns.

In this analysis, all sub-basins were assumed to be undeveloped under the existing basin model just as the DBPS was modeled. It was assumed that all sub-basins consisted of open space with grass cover in fair condition. No single-family homes in the western portion of Sub-basin 1 or softball fields in Sub-basin 3 had been constructed. Powers Boulevard and Drennan Road were included in the existing conditions.

The proposed detention basin is located within the Windmill Gulch Drainage Basin. This regional detention basin was modeled and proposed in Reference 1. In the DBPS, the land use assumed for each of the sub-basins draining to the proposed detention basin was industrial (Sub-basins 56, 58, and 60). Runoff generated from Sub-basin 62 located at the northeast corner of Drennan Road and Powers Boulevard was anticipated to be rerouted and drain to the south. These sub-basins are shown on Exhibit 2.



VICINITY MAP

FIGURE 1

III. Hydrology Design Criteria and Results

The hydrology for this site was estimated using the methods outlined in the *City of Colorado Springs and El Paso County, Drainage Criteria Manual.* The topography for the site was compiled using a two-foot contour interval and is presented at a horizontal scale of 1-inch to 400-feet in Exhibits 1 and 2. The hydrologic calculations were made assuming both existing and future development conditions. The peak flow rates for the drainage basins were estimated by using the U.S. Army Corps of Engineers HEC-1 Hydrograph Package. Runoff for the 5-year and 100-year recurrence intervals were determined.

The curve numbers used in the hydrologic modeling were obtained from Table 5-5 of the *City of Colorado Springs and El Paso County, Drainage Criteria Manual.* The existing hydrologic calculations were performed assuming Hydrological Soil Group A, except for a small portion of Sub-basin 1 which was categorized as Hydrological Soil Group B. The developed hydrologic calculations were performed assuming Hydrological Soil Group B for all sub-basins per the *City/County Drainage Criteria Manual.* Rainfall depths of 3.0 and 4.5 inches were used in the model for the 5-year and 100-year storm events, respectively.

Table 1 below summarizes the calculated flow rates at Design Point 1 for existing and future conditions.

Table 1

FLOW RATES AT DESIGN POINT 1

	Existing Conditions	Future Conditions
5-year	47 cfs	283 cfs
100-year	203 cfs	541 cfs

IV. Drainage Facility Design

The future development of the area will consist of single-family homes and a park area in Sub-basins 1 and 2, respectively. An interchange is planned for the intersection of Powers Boulevard and Drennan Road. As part of the interchange construction, an access road will be located along the north side of Drennan Road. The detention basin will be located on the north side of this access road. Drainage patterns will remain similar to the existing patterns for Sub-basins 1, 2, and 3. Runoff from these sub-basins will continue to drain to the north side of Drennan Road. The proposed detention basin will collect runoff from these sub-basins before releasing the runoff under Drennan Road and to the drainageway that lies south of Drennan. With the development of Soaring Eagles in Sub-basin 1, storm runoff from this area will be collected in a storm sewer system and conveyed to the west side of the proposed detention basin. According to the Windmill Gulch DBPS, runoff generated from Sub-basin 4 will be rerouted to the south and will not drain to the proposed detention basin.

The proposed detention basin has been designed for flood control as well as water quality. As a part of flood control, the basin will release runoff at or below historic rates. See Table 2 below for a summary of the detention basin inflow and outflow rates.

Table 2
DETENTION BASIN DATA

	In	Out
5-year	283 cfs	47 cfs
100-year	541 cfs	203 cfs

As part of water quality, the lower part of the detention basin was designed for sediment to settle out with a 24-hour drain time. See Table 3 below for a summary of the approximate required volumes for the proposed detention basin. Presented on Exhibit 2 is the detention basin data.

Table 3
DETENTION BASIN VOLUMES

Water Quality	2.78 acre-feet
5-year	9.86 acre-feet
100-year	15.39 acre-feet

APPENDIX

Hydrologic Calculations

Water Quality Calculations

All Sub-basins Soil A except:

6.2 Ac. in Sub-basin 1 is Soil B

For future condition → assume All Soil B

Land Use	Runoff Curve No. Soil A	Soil B
Open Space - fair condition	60	74
Soaring Eagles - 1/8 Acre lots	—	85
Pavement		98

Existing Condition - Assume undeveloped - openspace

Sub-basin 1 $CN = [6.2Ac(74) + 65.8(60)]/72.04 = 61.2$

All other basins Assume $CN = 60$

Future Condition

Sub-basin 1 - 1/8 Ac lots $CN = 85$

Sub-basin 2 Assume 20% pavement in park area plus part of Powers Blvd.

$CN = 0.20(78) + 0.80(74) = 78.8$

Sub-basin 3 softball fields - Assume 25% pavement

$CN = 0.25(78) + 0.75(74) = 80.0$

TABLE 5-5
RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL COVER COMPLEXES - URBAN AND SUBURBAN CONDITIONS 1/
(Antecedent Moisture Condition II)
(From: U.S. Dept. of Agriculture, Soil Conservation Service, 1977)

Land Use		Hydrologic Soil Group A	B	C	D
Open spaces, lawns, parks, golf courses, cemeteries, etc.					
	Good condition: grass cover on 75% or more of the area	39*	61	74	80
	Fair condition: grass cover on 50% to 75% of the area	49*	69	79	84
Commercial and Business areas (85% Impervious)		89*	92	94	95
Industrial Districts 72% Impervious)		81*	88	91	93
Residential: 2/					
Acres per Dwelling Unit	Average % Impervious 3/				
1/8 acre or less	65	77*	85	90	92
1/4 acre	38	61*	75	83	87
1/3 acre	30	57*	72	81	86
1/2 acre	25	54*	70	80	85
1 acre	20	51*	68	79	84
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and Roads:					
paved with curbs and storm sewers		98	98	98	98
gravel		76*	85	89	91
dirt		72*	82	87	89

1/ For a more detailed description of agricultural land use curve numbers, refer to the National Engineering Handbook (U.S. Dept. of Agriculture, Soil Conservation Service, 1972).
2/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.
3/ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

* Not to be used wherever overlot grading or filling is to occur.

Windmill Gulch Detention Basin
Time of Concentration Calculation

Basin	Runoff Curve Number	Area		Slope			Length			Run Coef.	Velocity		T_c			T_c		Lag ($0.6*T_c$)	Basin
				O'land 1	Chan. 1	Chan. 2	O'land 1	Chan. 1	Chan. 2	(5-year)	Chan. 1	Chan. 2	O'land 1	Chan. 1	Chan. 2				
1	61.2	72.04 acres	0.1126 sq. mi.	2.2 %	3.3 %		900 lf	1,700 lf		0.25	4.1 ft/sec		36.7 min.	6.9 min.		**43.6 min.**	**0.73 hours**	**0.436 hours**	1
2	60	47.64 acres	0.0744 sq. mi.	2.5 %	0.6 %	3.1 %	200 lf	1,800 lf	2,150 lf	0.25	2.0 ft/sec	3.9 ft/sec	16.6 min.	15.0 min.	9.2 min.	**40.8 min.**	**0.68 hours**	**0.408 hours**	2
3	60	45.88 acres	0.0717 sq. mi.	4.5 %	1.8 %		400 lf	1,600 lf		0.25	2.6 ft/sec		19.3 min.	10.3 min.		**29.5 min.**	**0.49 hours**	**0.295 hours**	3
4	60	126.55 acres	0.1977 sq. mi.	3.0 %	1.8 %		400 lf	3,200 lf		0.25	3.4 ft/sec		22.1 min.	15.7 min.		**37.7 min.**	**0.63 hours**	**0.377 hours**	4
	60.3	292.11 acres																	
1	85	80.61 acres	0.1260 sq. mi.	1.3 %	1.8 %	1.8 %	150 lf	570 lf	2,350 lf	0.60	2.2 ft/sec	14.5 ft/sec	10.5 min.	4.3 min.	2.7 min.	**17.5 min.**	**0.29 hours**	**0.175 hours**	1
2	78.8	33.92 acres	0.0530 sq. mi.	3.5 %	2.4 %		170 lf	1,670 lf		0.38	4.1 ft/sec		11.6 min.	6.8 min.		**18.4 min.**	**0.31 hours**	**0.184 hours**	2
3	80	48.76 acres	0.0762 sq. mi.	1.8 %	2.6 %		170 lf	1,600 lf		0.46	6.1 ft/sec		12.8 min.	4.4 min.		**17.2 min.**	**0.29 hours**	**0.172 hours**	3
	82.2	163.29 acres																	

Equations:

Time of Concentration (Overland) = $1.87(1.1-C_5)L^{0.5}S^{-0.333}$

C_5 = Runoff coefficient for five-year flow

L = Length of overland flow in feet

S = Slope of flow path in percent

Velocity (Channel) = $(1.49 \cdot n)R_n^{2/3}S^{1/2}$

Slope (S) = Slope of the channel

n = Manning's number

R_n = Hydraulic Radius (Reynold's Number)

Time of Concentration Calcs - Existing Conditions

Sub-basin 1 overland 900' Δ20' 2.22%

channel 5' bottom 7.5:1 side slopes n=0.030
Assume Q = 14 cfs 1700' Δ56' 3.3%

⇒ V = 4.1 fps

Sub-basin 2 overland 200' Δ5' 2.5%

channel 1800' Δ11' 0.6% Assume Q = 7 cfs
5' bottom 5:1 side slopes n=0.030

⇒ V = 2.0 fps

channel 2150' Δ66' 3.1% Assume Q=7 cfs
0' bottom (V-ditch) 3:1 sides n=0.035

⇒ V = 3.9 fps

Sub-basin 3 overland 400' Δ18' 4.5%

channel 1000' Δ28' 1.75% Assume Q=8 cfs
5' bottom 10:1 side slopes n=0.030

⇒ V = 2.16 fps

Sub-basin 4 overland 400' Δ12' 3.0%

channel 3,200' Δ56' 1.75% Assume Q=21 cfs
5' bottom 10:1 side slopes n=0.030

⇒ V = 3.4 fps

Time of Concentration - Future Conditions

Sub-basin 1

overland 150' @ 1.3% Δ2'

swale 570' @ 1.8% Assume Q = 5cfs
10' bottom 5:1 side slopes n = 0.030
⇒ V = 2.2 fps

Pipe flow Avg pipe size 36"
2350' Δ43 @ 1.8%
Assume full pipe flow
⇒ V = 14.5 fps

Sub-basin 2

overland 170' Δ6' 3.5%

channel 1470' Δ40' 2.4% Assume Q = 150cfs
3' bottom 3:1 side slopes n = 0.035
⇒ V = 4.1 fps

Sub-basin 3

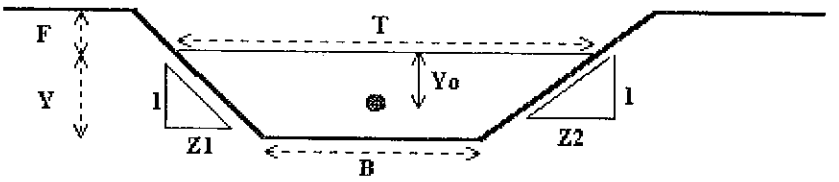
overland 170' Δ3' 1.8%

channel 1600' Δ42' 2.6% Assume Q = 600cfs
5' bottom 5:1 side slopes n = 0.030
⇒ V = 6.1 fps

Analysis of Trapezoidal Grass-Lined Channel

Project: 02072 Windmill Gulch Detention Basin #2

Channel ID: Sub-basin 1 Existing Condition (5-year)



Design Information

Grass Type:	A	B	C	D	E
Limiting Manning's N	0.060	0.040	0.033	0.030	0.024

Soil Type:	Max. Velocity (V_{max})	Max. Froude No. (F_{max})
Non-Sandy	7.0 fps	0.80
Sandy	5.0 fps	0.60

Design Information			
Enter Grass Manning's N	N =	0.030	
Type of Grass (A,B,C,D, or E)		D	
Channel Invert Slope	So =	0.0330	ft/ft
Bottom Width	B =	5.00	ft
Left Side Slope	Z1 =	7.50	ft/ft
Right Side Slope	Z2 =	7.50	ft/ft
Design Discharge	**Q =**	**14.0**	**cfs**
Check one of the following soil types			
	Sandy Soil	X	check, OR
	Non-Sandy Soil		check

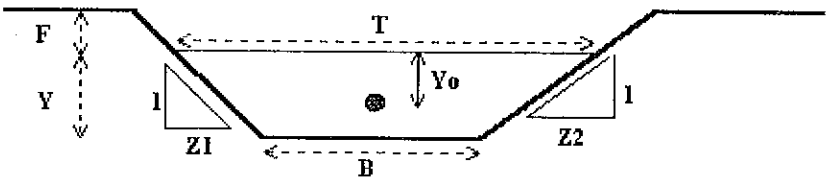
	Flow Condition (Calculated)			
	Water Depth	**Y =**	**0.43**	**ft**
	Top Width	T =	11.45	ft
	Flow Area	A =	3.54	sq ft
	Wetted Perimeter	P =	11.51	ft
	Hydraulic Radius	R =	0.31	ft
	Flow Velocity	V =	4.11	fps
	Hydraulic Depth	D =	0.31	ft
Warning 04	**Froude Number**	**Fr =**	**1.30**	
	Discharge (Check)	**Q=**	**14.5**	**cfs**

Warning 04: Froude No. exceeds USDCM Criteria Manual Volume II recommendation.

Analysis of Trapezoidal Grass-Lined Channel

Project: 02072 Windmill Gulch Detention Basin #2

Channel ID: Sub-basin 2 Existing Condition (5-year)



Design Information

Grass Type:	A	B	C	D	E
Limiting Manning's N	0.060	0.040	0.033	0.030	0.024

Soil Type:	Max. Velocity (V_{max})	Max. Froude No. (F_{max})
Non-Sandy	7.0 fps	0.80
Sandy	5.0 fps	0.60

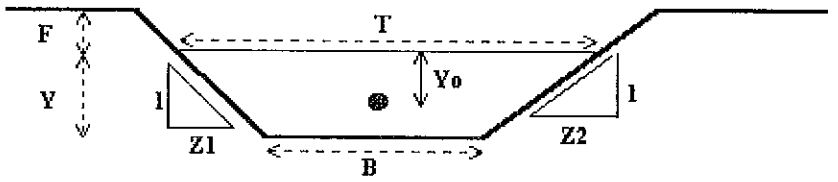
Design Information			
Enter Grass Manning's N	N =	0.030	
Type of Grass (A,B,C,D, or E)		D	
Channel Invert Slope	So =	0.0060	ft/ft
Bottom Width	B =	5.00	ft
Left Side Slope	Z1 =	5.00	ft/ft
Right Side Slope	Z2 =	5.00	ft/ft
Design Discharge	**Q =**	**7.0**	**cfs**
Check one of the following soil types			
	Sandy Soil	X	check, OR
	Non-Sandy Soil		check

Flow Condition (Calculated)			
Water Depth	**Y =**	**0.49**	**ft**
Top Width	T =	9.90	ft
Flow Area	A =	3.65	sq ft
Wetted Perimeter	P =	10.00	ft
Hydraulic Radius	R =	0.37	ft
Flow Velocity	V =	1.97	fps
Hydraulic Depth	D =	0.37	ft
Froude Number	**Fr =**	**0.57**	
Discharge (Check)	**Q=**	**7.2**	**cfs**

Analysis of Trapezoidal Grass-Lined Channel

Project: 02072 Windmill Gulch Detention Basin #2

Channel ID: Sub-basin 2 Existing Condition (5-year)



Design Information

Grass Type:	A	B	C	D	E
Limiting Manning's N	0.060	0.040	0.033	0.030	0.024

Soil Type:	Max. Velocity (V_{max})	Max. Froude No. (F_{max})
Non-Sandy	7.0 fps	0.80
Sandy	5.0 fps	0.60

	Design Information			
	Enter Grass Manning's N	N =	0.035	
	Type of Grass (A,B,C,D, or E)		Other Grass	
	Channel Invert Slope	So =	0.0310	ft/ft
	Bottom Width	B =	0.00	ft
Warning 01	Left Side Slope	Z1 =	3.00	ft/ft
Warning 01	Right Side Slope	Z2 =	3.00	ft/ft
	Design Discharge	**Q =**	**7.0**	**cfs**
	Check one of the following soil types			
		Sandy Soil	X	check, OR
		Non-Sandy Soil		check

	Flow Condition (Calculated)			
	Water Depth	**Y =**	**0.78**	**ft**
	Top Width	T =	4.68	ft
	Flow Area	A =	1.83	sq ft
	Wetted Perimeter	P =	4.93	ft
	Hydraulic Radius	R =	0.37	ft
	Flow Velocity	V =	3.86	fps
	Hydraulic Depth	D =	0.39	ft
Warning 04	**Froude Number**	**Fr =**	**1.09**	
	Discharge (Check)	**Q=**	**7.1**	**cfs**

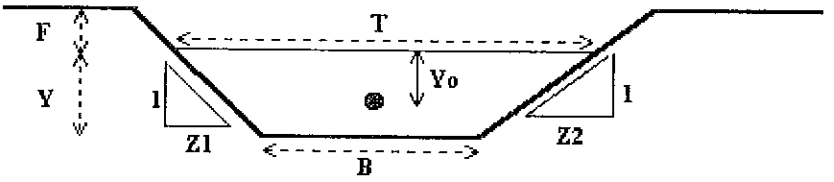
Warning 01: Sideslope steepness exceeds USDCM Volume II recommendation.

Warning 04: Froude No. exceeds USDCM Criteria Manual Volume II recommendation.

Analysis of Trapezoidal Grass-Lined Channel

Project: 02072 Windmill Gulch Detention Basin #2

Channel ID: Sub-basin 3 Existing Condition (5-year)



Design Information

Grass Type:	A	B	C	D	E
Limiting Manning's N	0.060	0.040	0.033	0.030	0.024

Soil Type:	Max. Velocity (V_{max})	Max. Froude No. (F_{max})
Non-Sandy	7.0 fps	0.80
Sandy	5.0 fps	0.60

Design Information			
Enter Grass Manning's N	N =	0.030	
Type of Grass (A,B,C,D, or E)		D	
Channel Invert Slope	So =	0.0175	ft/ft
Bottom Width	B =	5.00	ft
Left Side Slope	Z1 =	10.00	ft/ft
Right Side Slope	Z2 =	10.00	ft/ft
Design Discharge	**Q =**	**8.0**	**cfs**
Check one of the following soil types			
Sandy Soil		X	check, OR
Non-Sandy Soil			check

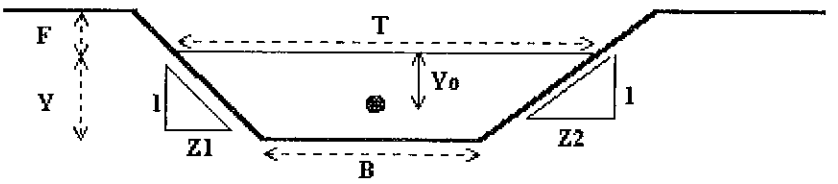
Flow Condition (Calculated)			
Water Depth	**Y =**	**0.36**	**ft**
Top Width	T =	12.20	ft
Flow Area	A =	3.10	sq ft
Wetted Perimeter	P =	12.24	ft
Hydraulic Radius	R =	0.25	ft
Flow Velocity	V =	2.63	fps
Hydraulic Depth	D =	0.25	ft
Warning 04 **Froude Number**	**Fr =**	**0.92**	
Discharge (Check)	**Q=**	**8.1**	**cfs**

Warning 04: Froude No. exceeds USDCM Criteria Manual Volume II recommendation.

Analysis of Trapezoidal Grass-Lined Channel

Project: 02072 Windmill Gulch Detention Basin #2

Channel ID: Sub-basin 4 Existing Condition (5-year)



Design Information

Grass Type:	A	B	C	D	E
Limiting Manning's N	0.060	0.040	0.033	0.030	0.024

Soil Type:	Max. Velocity (V_{max})	Max. Froude No. (F_{max})
Non-Sandy	7.0 fps	0.80
Sandy	5.0 fps	0.60

Design Information			
Enter Grass Manning's N	N =	0.030	
Type of Grass (A,B,C,D, or E)		D	
Channel Invert Slope	So =	0.0175	ft/ft
Bottom Width	B =	5.00	ft
Left Side Slope	Z1 =	10.00	ft/ft
Right Side Slope	Z2 =	10.00	ft/ft
Design Discharge	**Q =**	**21.0**	**cfs**
Check one of the following soil types			
	Sandy Soil	X	check, OR
	Non-Sandy Soil		check

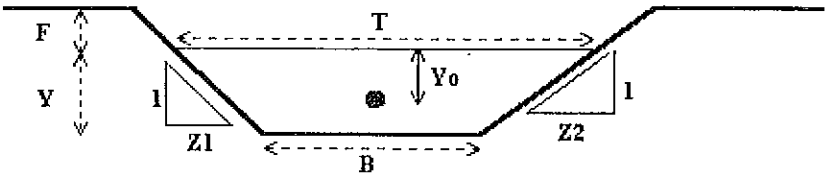
Flow Condition (Calculated)			
Water Depth	**Y =**	**0.58**	**ft**
Top Width	T =	16.60	ft
Flow Area	A =	6.26	sq ft
Wetted Perimeter	P =	16.66	ft
Hydraulic Radius	R =	0.38	ft
Flow Velocity	V =	3.42	fps
Hydraulic Depth	D =	0.38	ft
Warning 04 **Froude Number**	**Fr =**	**0.98**	
Discharge (Check)	**Q=**	**21.4**	**cfs**

Warning 04: Froude No. exceeds USDCM Criteria Manual Volume II recommendation.

Analysis of Trapezoidal Grass-Lined Channel

Project: 02072 Windmill Gulch Detention Basin #2

Channel ID: Sub-basin 1 Future Condition (5-year)



Design Information

Grass Type:	A	B	C	D	E
Limiting Manning's N	0.060	0.040	0.033	0.030	0.024

Soil Type:	Max. Velocity (V_{max})	Max. Froude No. (F_{max})
Non-Sandy	7.0 fps	0.80
Sandy	5.0 fps	0.60

Design Information			
Enter Grass Manning's N	N =	0.030	
Type of Grass (A,B,C,D, or E)		D	
Channel Invert Slope	So =	0.0180	ft/ft
Bottom Width	B =	10.00	ft
Left Side Slope	Z1 =	5.00	ft/ft
Right Side Slope	Z2 =	5.00	ft/ft
Design Discharge	**Q =**	**5.0**	**cfs**
Check one of the following soil types			
	Sandy Soil	X	check, OR
	Non-Sandy Soil		check

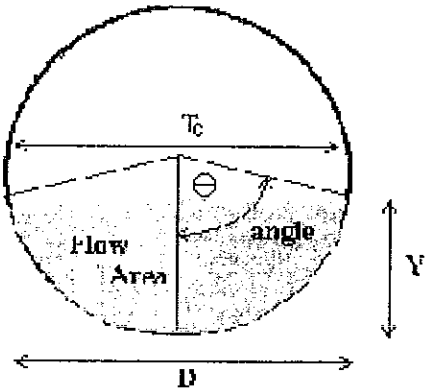
Flow Condition (Calculated)			
Water Depth	**Y =**	**0.21**	**ft**
Top Width	T =	12.10	ft
Flow Area	A =	2.32	sq ft
Wetted Perimeter	P =	12.14	ft
Hydraulic Radius	R =	0.19	ft
Flow Velocity	V =	2.21	fps
Hydraulic Depth	D =	0.19	ft
Warning 04 **Froude Number**	**Fr =**	**0.89**	
Discharge (Check)	**Q=**	**5.1**	**cfs**

Warning 04: Froude No. exceeds USDCM Criteria Manual Volume II recommendation.

Circular Pipe Flow

Project: 02072 Windmill Gulch Detention Basin #2

Pipe ID: Sub-basin 1 Future Condition Avg 36" RCP (5-year)

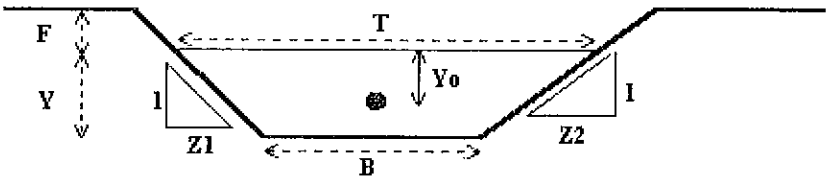


Design Information (Input)			
Pipe Invert Slope	So =	0.0180	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	36.00	inches
Design discharge	**Q =**	**89.7**	**cfs**
Full-flow Capacity (Calculated)			
Full-flow area	Af =	7.07	sq ft
Full-flow wetted perimeter	Pf =	9.42	ft
Half Central Angle	Theta =	3.14	rad
Full-flow capacity	**Qf =**	**89.7**	**cfs**
Calculation of Normal Flow Condition			
Half Central angle (0<Theta<3.14)	Theta =	2.26	rad
Flow area	An =	6.20	sq ft
Wetted perimeter	Pn =	6.79	ft
Flow depth	Yn =	2.46	ft
Flow velocity	Vn =	14.47	fps
Discharge	**Qn =**	**89.7**	**cfs**
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.68	rad
Critical flow area	Ac =	6.93	sq ft
Critical top width	Tc =	1.33	ft
Critical flow depth	Yc =	2.84	ft
Critical flow velocity	Vc =	12.95	fps
Froude number	**Fr =**	**1.00**	

Analysis of Trapezoidal Grass-Lined Channel

Project: 02072 Windmill Gulch Detention Basin #2

Channel ID: Sub-basin 2 Future Condition (5-year)



Design Information

Grass Type:	A	B	C	D	E
Limiting Manning's N	0.060	0.040	0.033	0.030	0.024

Soil Type:	Max. Velocity (V_{max})	Max. Froude No. (F_{max})
Non-Sandy	7.0 fps	0.80
Sandy	5.0 fps	0.60

	Design Information			
	Enter Grass Manning's N	N =	0.035	
	Type of Grass (A,B,C,D, or E)		Other Grass	
	Channel Invert Slope	So =	0.0240	ft/ft
	Bottom Width	B =	3.00	ft
Warning 01	Left Side Slope	Z1 =	3.00	ft/ft
Warning 01	Right Side Slope	Z2 =	3.00	ft/ft
	Design Discharge	**Q =**	**15.0**	**cfs**
	Check one of the following soil types			
		Sandy Soil	**X**	check, OR
		Non-Sandy Soil		check

	Flow Condition (Calculated)			
	Water Depth	**Y =**	**0.72**	**ft**
	Top Width	T =	7.32	ft
	Flow Area	A =	3.72	sq ft
	Wetted Perimeter	P =	7.55	ft
	Hydraulic Radius	R =	0.49	ft
	Flow Velocity	V =	4.11	fps
	Hydraulic Depth	D =	0.51	ft
Warning 04	**Froude Number**	**Fr =**	**1.02**	
	Discharge (Check)	**Q=**	**15.3**	**cfs**

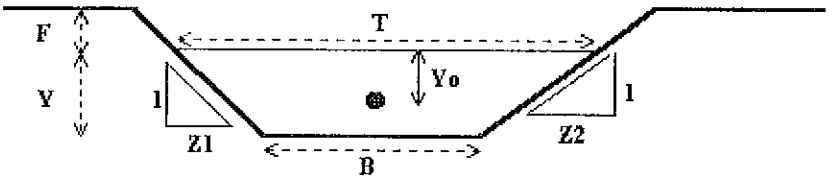
Warning 01: Sideslope steepness exceeds USDCM Volume II recommendation.

Warning 04: Froude No. exceeds USDCM Criteria Manual Volume II recommendation.

Analysis of Trapezoidal Grass-Lined Channel

Project: 02072 Windmill Gulch Detention Basin #2

Channel ID: Sub-basin 3 Future Condition (5-year)



Design Information

Grass Type:	A	B	C	D	E
Limiting Manning's N	0.060	0.040	0.033	0.030	0.024

Soil Type:	Max. Velocity (V_{max})	Max. Froude No. (F_{max})
Non-Sandy	7.0 fps	0.80
Sandy	5.0 fps	0.60

Design Information			
Enter Grass Manning's N	N =	0.030	
Type of Grass (A,B,C,D, or E)		D	
Channel Invert Slope	So =	0.0260	ft/ft
Bottom Width	B =	5.00	ft
Left Side Slope	Z1 =	5.00	ft/ft
Right Side Slope	Z2 =	5.00	ft/ft
Design Discharge	**Q =**	**60.0**	**cfs**
Check one of the following soil types			
	Sandy Soil	X	check, OR
	Non-Sandy Soil		check

	Flow Condition (Calculated)			
	Water Depth	**Y =**	**1.00**	**ft**
	Top Width	T =	15.00	ft
	Flow Area	A =	10.00	sq ft
	Wetted Perimeter	P =	15.20	ft
	Hydraulic Radius	R =	0.66	ft
Warning 03	Flow Velocity	V =	6.06	fps
	Hydraulic Depth	D =	0.67	ft
Warning 04	**Froude Number**	**Fr =**	**1.31**	
	Discharge (Check)	**Q=**	**60.6**	**cfs**

Warning 03: Velocity exceeds USDCM Criteria Manual Volume II recommendation.

Warning 04: Froude No. exceeds USDCM Criteria Manual Volume II recommendation.

Water Quality Calculations

Percent Impervious

1/8 Ac lots 65% impervious
pavement 100% impervious
grass (open space) 0% impervious

Sub-basin 1 – 1/8 Ac lots 65% impervious

0.65 * 80.61 Ac = 52.40 Ac impervious

Sub-basin 2 – 20% pavement ⇒ 20% impervious

0.20 * 33.92 Ac = 6.78 Ac impervious

Sub-basin 3 – 25% pavement

0.25 * 48.76 Ac = 12.19 Ac impervious

total 71.37 Ac impervious

% impervious = $\frac{71.37 \text{ Ac}}{163.29 \text{ Ac}}$ = 43.71% impervious

Use 24-hour drain time ⇒ a = 0.9

WQCV = $a[0.71i^3 - 1.19i^2 + 0.78i] = 0.9[0.9(0.437)^3 - 1.19(.437)^2 + .78(.437)]$

WQCV = 0.17"

Design Volume = $\frac{WQCV}{12} * Area * 1.2 = \frac{0.17"}{12}(163.29)(1.2)$

Design Volume = 2.78 Ac-feet

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN  1998                *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   01NOV02  TIME  11:20:25   *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************
```

```
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
```

Existing Conditions

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


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

  1           ID        WINDMILL GULCH DETENTION BASIN FINAL DESIGN
  2           ID        ASSUMPTIONS FOR EXISTING CONDITIONS SIMILAR TO WILSON & COMPANY
  3           ID        DBPS TR-20 MODEL(SUB-BASINS 56, 58, 60, 62)
  4           ID        NOVEMBER 1, 2002
  5           ID        5-YEAR AND 100-YEAR 24-HOUR STORMS
  6           ID        EXISTING CONDITION (DRAINS TO FUTURE DETENTION BASIN)
  7           ID        FILENAME: WGEXIST.DAT
              *DIAGRAM
  8           IT       5            800     300
  9           IO       5
 10           JR    PREC     .67   1.0
```

```
11          KK       3
12          KM           Sub-basin 3 (softball fields)
13          BA    .0717
14          PB      4.5
15          IN       15
16          PC    .0005   .0015   .0030   .0045   .0060   .0080   .0100   .0120   .0143   .0165
17          PC    .0188   .0210   .0233   .0255   .0278   .0320   .0390   .0460   .0530   .0600
18          PC    .0750   .1000   .4000   .7000   .7250   .7500   .7650   .7800   .7900   .8000
19          PC    .8100   .8200   .8250   .8300   .8350   .8400   .8450   .8500   .8550   .8600
20          PC    .8638   .8675   .8713   .8750   .8788   .8825   .8863   .8900   .8938   .8975
21          PC    .9013   .9050   .9083   .9115   .9148   .9180   .9210   .9240   .9270   .9300
22          PC    .9325   .9350   .9375   .9400   .9425   .9450   .9475   .9500   .9525   .9550
23          PC    .9575   .9600   .9625   .9650   .9675   .9700   .9725   .9750   .9775   .9800
24          PC    .9813   .9825   .9838   .9850   .9863   .9875   .9888   .9900   .9913   .9925
25          PC    .9938   .9950   .9963   .9975   .9988   1.000
26          LS               60
27          UD    .295

28          KK     3-1
29          KM           Route Sub-basin 3 to Sub-basin 4
30          RK    1900    .020    .030            TRAP       3       5

31          KK       4
32          KM           Sub-basin 4 (NEC Powers & Drennan)
33          BA    .1977
34          LS               60
35          UD    .377

36          KK     DP0
37          KM           Combine Sub-basins 3 and 4
38          HC       2

39          KK     4-1
40          KM           Route Sub-basins 3 and 4 to Design Point 1
41          RK    1000    .028    .035            TRAP       0       3

42          KK       1
43          KM           Sub-basin 1 (west of design point)
44          BA    .1126
45          LS             61.2
46          UD    .436
```

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

  47          KK       2
  48          KM            Sub-basin 2 (east of design point & west of Powers)
  49          BA    .0744
  50          LS               60
  51          UD     .408

  52          KK      DP1
  53          KM            Combine Sub-basins 1, 2, 3, and 4
  54          HC       3
  55          ZZ
```

1

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
 LINE     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

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

  11          3
              V
              V
  28        3-1
              .
              .
  31          .           4
              .           .
              .           .
  36        DP0...........
              V
              V
  39        4-1
              .
              .
  42          .           1
              .           .
              .           .
  47          .           .           2
              .           .           .
              .           .           .
  52        DP1.........................
```

```
 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*               JUN   1998             *
*            VERSION 4.1               *
*                                      *
*  RUN DATE   01NOV02  TIME  11:20:25  *
*                                      *
****************************************
```


```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER     *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 756-1104             *
*                                      *
****************************************
```


WINDMILL GULCH DETENTION BASIN FINAL DESIGN
ASSUMPTIONS FOR EXISTING CONDITIONS SIMILAR TO WILSON & COMPANY
DBPS TR-20 MODEL(SUB-BASINS 56, 58, 60, 62)
NOVEMBER 1, 2002
5-YEAR AND 100-YEAR 24-HOUR STORMS
EXISTING CONDITION (DRAINS TO FUTURE DETENTION BASIN)
FILENAME: WGEXIST.DAT

9 IO OUTPUT CONTROL VARIABLES

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

IT HYDROGRAPH TIME DATA

NMIN		5	MINUTES IN COMPUTATION INTERVAL
IDATE	1	0	STARTING DATE
ITIME		0800	STARTING TIME
NQ		300	NUMBER OF HYDROGRAPH ORDINATES
NDDATE	2	0	ENDING DATE
NDTIME		0855	ENDING TIME
ICENT		19	CENTURY MARK

COMPUTATION INTERVAL .08 HOURS
TOTAL TIME BASE 24.92 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

JP MULTI-PLAN OPTION
NPLAN 1 NUMBER OF PLANS

JR MULTI-RATIO OPTION
RATIOS OF PRECIPITATION
.67 1.00

1

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIOS APPLIED TO PRECIPITATION RATIO 1 .67	RATIO 2 1.00
HYDROGRAPH AT						
+	3	.07	1	FLOW	9.	37.
				TIME	6.00	5.92
ROUTED TO						
+	3-1	.07	1	FLOW	9.	37.
				TIME	6.08	6.00
HYDROGRAPH AT						
+	4	.20	1	FLOW	20.	87.
				TIME	6.08	6.00
2 COMBINED AT						
+	DP0	.27	1	FLOW	29.	124.
				TIME	6.08	6.00
ROUTED TO						
+	4-1	.27	1	FLOW	28.	122.
				TIME	6.08	6.08
HYDROGRAPH AT						
+	1	.11	1	FLOW	12.	49.
				TIME	6.17	6.08
HYDROGRAPH AT						
+	2	.07	1	FLOW	7.	31.
				TIME	6.17	6.08
3 COMBINED AT						
+	DP1	.46	1	FLOW	47.	203.
				TIME	6.17	6.08

1

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)
FOR PLAN = 1 RATIO= .67									
3-1	MANE	2.40	8.66	364.46	.34	5.00	8.61	365.00	.34

CONTINUITY SUMMARY (AC-FT) - INFLOW= .1295E+01 EXCESS= .0000E+00 OUTFLOW= .1295E+01 BASIN STORAGE= .5480E-03 PERCENT ERROR= .0

FOR PLAN = 1 RATIO= 1.00									
3-1	MANE	1.62	36.99	359.49	1.02	5.00	36.97	360.00	1.02

CONTINUITY SUMMARY (AC-FT) - INFLOW= .3900E+01 EXCESS= .0000E+00 OUTFLOW= .3899E+01 BASIN STORAGE= .6128E-03 PERCENT ERROR= .0

FOR PLAN = 1 RATIO= .67									
4-1	MANE	.90	28.69	367.08	.34	5.00	28.15	365.00	.34

CONTINUITY SUMMARY (AC-FT) - INFLOW= .4867E+01 EXCESS= .0000E+00 OUTFLOW= .4866E+01 BASIN STORAGE= .6221E-03 PERCENT ERROR= .0

FOR PLAN = 1 RATIO= 1.00									
4-1	MANE	.67	123.78	361.36	1.02	5.00	122.09	365.00	1.02

CONTINUITY SUMMARY (AC-FT) - INFLOW= .1465E+02 EXCESS= .0000E+00 OUTFLOW= .1465E+02 BASIN STORAGE= .1076E-02 PERCENT ERROR= .0

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

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*               JUN   1998              *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   01NOV02  TIME  11:47:30   *
*                                       *
*****************************************
```


```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*         609 SECOND STREET             *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************
```


```
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
```

Future Condition w/o Detention

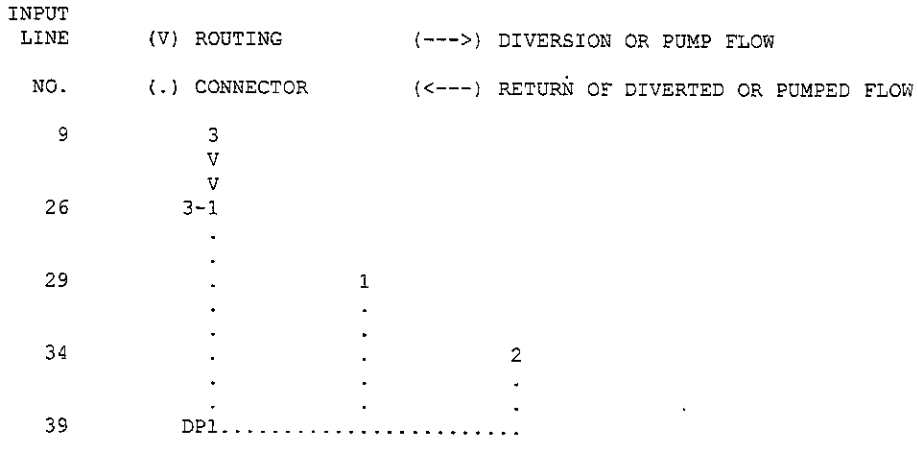
THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

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


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

   1          ID        WINDMILL GULCH DETENTION BASIN FINAL DESIGN
   2          ID        NOVEMBER 1, 2002
   3          ID        5-YEAR AND 100-YEAR 24-HOUR STORMS
   4          ID        FUTURE CONDITION WITHOUT DETENTION
   5          ID        FILENAME: WGFUTURE.DAT
              *DIAGRAM
   6          IT       5            800     300
   7          IO       5
   8          JR    PREC     .67   1.0
```

```
 9          KK       3
10          KM           Sub-basin 3 (softball fields)
11          BA    .0762
12          PB     4.5
13          IN      15
14          PC    .0005   .0015   .0030   .0045   .0060   .0080   .0100   .0120   .0143   .0165
15          PC    .0188   .0210   .0233   .0255   .0278   .0320   .0390   .0460   .0530   .0600
16          PC    .0750   .1000   .4000   .7000   .7250   .7500   .7650   .7800   .7900   .8000
17          PC    .8100   .8200   .8250   .8300   .8350   .8400   .8450   .8500   .8550   .8600
18          PC    .8638   .8675   .8713   .8750   .8788   .8825   .8863   .8900   .8938   .8975
19          PC    .9013   .9050   .9083   .9115   .9148   .9180   .9210   .9240   .9270   .9300
20          PC    .9325   .9350   .9375   .9400   .9425   .9450   .9475   .9500   .9525   .9550
21          PC    .9575   .9600   .9625   .9650   .9675   .9700   .9725   .9750   .9775   .9800
22          PC    .9813   .9825   .9838   .9850   .9863   .9875   .9888   .9900   .9913   .9925
23          PC    .9938   .9950   .9963   .9975   .9988   1.000
24          LS               80
25          UD    .172

26          KK     3-1
27          KM           Route Sub-basin 3 to Design Point 1
28          RK    1800    .023    .035            TRAP       3       5

29          KK       1
30          KM           Sub-basin 1 (Soaring Eagles)
31          BA    .1260
32          LS               85
33          UD    .175

34          KK       2
35          KM           Sub-basin 2 (Detention Basin)
36          BA    .0530
37          LS            78.8
38          UD    .184

39          KK     DP1
40          KM           Combine Sub-basins 1, 2, and 3
41          HC       3
42          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK



(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*               JUN   1998              *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   01NOV02  TIME  11:47:30   *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************
```

WINDMILL GULCH DETENTION BASIN FINAL DESIGN
NOVEMBER 1, 2002
5-YEAR AND 100-YEAR 24-HOUR STORMS
FUTURE CONDITION WITHOUT DETENTION
FILENAME: WGFUTURE.DAT

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

```
IT          HYDROGRAPH TIME DATA
                 NMIN           5  MINUTES IN COMPUTATION INTERVAL
                IDATE      1    0  STARTING DATE
                ITIME        0800  STARTING TIME
                   NQ         300  NUMBER OF HYDROGRAPH ORDINATES
               NDDATE      2    0  ENDING DATE
               NDTIME        0855  ENDING TIME
               ICENT           19  CENTURY MARK

             COMPUTATION INTERVAL     .08 HOURS
                  TOTAL TIME BASE   24.92 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

JP          MULTI-PLAN OPTION
                 NPLAN           1  NUMBER OF PLANS

JR          MULTI-RATIO OPTION
               RATIOS OF PRECIPITATION
               .67      1.00
1

          PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                              FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                          TIME TO PEAK IN HOURS


                                                                  RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN                 RATIO 1  RATIO 2
                                                             .67      1.00

 HYDROGRAPH AT
+                    3       .08     1    FLOW             76.      151.
                                          TIME            5.83     5.83

 ROUTED TO
+                  3-1       .08     1    FLOW             73.      148.
                                          TIME            5.83     5.83

 HYDROGRAPH AT
+                    1       .13     1    FLOW            162.      293.
                                          TIME            5.83     5.83
```

```
 HYDROGRAPH AT
+                      2        .05      1   FLOW          49.      99.
                                            TIME          5.83     5.83

  3 COMBINED AT
+                     DP1       .26      1   FLOW         283.     541.
                                            TIME          5.83     5.83
1
                                    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)

          FOR PLAN = 1  RATIO=  .67
               3-1  MANE         1.48      75.40    352.56      1.26     5.00      72.75    350.00        1.26

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .5126E+01 EXCESS= .0000E+00 OUTFLOW= .5127E+01 BASIN STORAGE= .1994E-03 PERCENT ERROR=     .0


          FOR PLAN = 1  RATIO= 1.00
               3-1  MANE         1.30     149.50    351.63      2.46     5.00     148.27    350.00        2.46

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1000E+02 EXCESS= .0000E+00 OUTFLOW= .1001E+02 BASIN STORAGE= .3229E-03 PERCENT ERROR=     .0



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

```
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*               JUN   1998             *
*            VERSION 4.1               *
*                                      *
*  RUN DATE   04DEC02  TIME  15:25:07  *
*                                      *
****************************************
```


```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER     *
*         609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 756-1104             *
*                                      *
****************************************
```


```
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
```

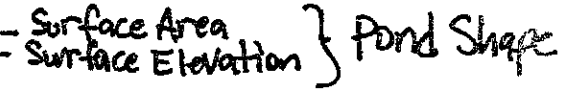
Future Condition w/ Detention

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


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

  1           ID        WINDMILL GULCH DETENTION BASIN FINAL DESIGN
  2           ID        NOVEMBER 1, 2002
  3           ID        5-YEAR AND 100-YEAR 24-HOUR STORMS
  4           ID        FUTURE CONDITION WITH DETENTION
  5           ID        FILENAME: WGFUDET.DAT
              *DIAGRAM
  6           IT      5             800     300
  7           IO      5
  8           JR    PREC     .67   1.0
```

```
 9          KK       3
10          KM            Sub-basin 3 (softball fields)
11          BA    .0762
12          PB     4.5
13          IN       15
14          PC    .0005    .0015    .0030    .0045    .0060    .0080    .0100    .0120    .0143    .0165
15          PC    .0188    .0210    .0233    .0255    .0278    .0320    .0390    .0460    .0530    .0600
16          PC    .0750    .1000    .4000    .7000    .7250    .7500    .7650    .7800    .7900    .8000
17          PC    .8100    .8200    .8250    .8300    .8350    .8400    .8450    .8500    .8550    .8600
18          PC    .8638    .8675    .8713    .8750    .8788    .8825    .8863    .8900    .8938    .8975
19          PC    .9013    .9050    .9083    .9115    .9148    .9180    .9210    .9240    .9270    .9300
20          PC    .9325    .9350    .9375    .9400    .9425    .9450    .9475    .9500    .9525    .9550
21          PC    .9575    .9600    .9625    .9650    .9675    .9700    .9725    .9750    .9775    .9800
22          PC    .9813    .9825    .9838    .9850    .9863    .9875    .9888    .9900    .9913    .9925
23          PC    .9938    .9950    .9963    .9975    .9988   1.000
24          LS               80
25          UD    .172

26          KK     3-1
27          KM            Route Sub-basin 3 to Design Point 1
28          RK    1800     .023     .035            TRAP       3       5

29          KK       1
30          KM            Sub-basin 1 (Soaring Eagles)
31          BA    .1260
32          LS               85
33          UD    .175

34          KK       2
35          KM            Sub-basin 2 (Detention Basin)
36          BA    .0530
37          LS             78.8
38          UD    .184

39          KK     DP1
40          KM            Combine Sub-basins 1, 2, and 3
41          HC       3

42          KK    DB1
43          KM         DETENTION BASIN AT DESIGN POINT 1
44          RS       1     STOR       -1
45          SQ       0      0.8      0.8       15       47      170      203
46          SE    5947   5949.4     5950     5952     5953     5954     5955
47          SA       0    1.349    1.627    2.092    2.892    3.180
48          SE    5947     5948     5950     5952     5954     5956
```



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

            49          ZZ
1
                SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

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

     9           3
                 V
                 V
    26         3-1
                 .
                 .
    29           .           1
                 .           .
                 .           .
    34           .           .           2
                 .           .           .
                 .           .           .
    39         DP1.......................
                 V
                 V
    42        DB1

  (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
 *                                       *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
 *               JUN   1998              *
 *            VERSION 4.1                *
 *                                       *
 *  RUN DATE   04DEC02  TIME  15:25:07   *
 *                                       *
 *****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************
```

WINDMILL GULCH DETENTION BASIN FINAL DESIGN
NOVEMBER 1, 2002
5-YEAR AND 100-YEAR 24-HOUR STORMS
FUTURE CONDITION WITH DETENTION
FILENAME: WGFUDET.DAT

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

   IT           HYDROGRAPH TIME DATA
                     NMIN           5  MINUTES IN COMPUTATION INTERVAL
                    IDATE      1    0  STARTING DATE
                    ITIME         0800  STARTING TIME
                       NQ          300  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE      2    0  ENDING DATE
                   NDTIME         0855  ENDING TIME
                    ICENT           19  CENTURY MARK

                  COMPUTATION INTERVAL      .08 HOURS
                      TOTAL TIME BASE    24.92 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

   JP          MULTI-PLAN OPTION
                    NPLAN           1  NUMBER OF PLANS

   JR          MULTI-RATIO OPTION
                RATIOS OF PRECIPITATION
                .67      1.00
1

          PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                              FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                          TIME TO PEAK IN HOURS

                                                                  RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION      AREA     PLAN                 RATIO 1  RATIO 2
                                                               .67      1.00

 HYDROGRAPH AT
+                    3        .08      1   FLOW              76.      151.
                                           TIME             5.83     5.83

 ROUTED TO
+                   3-1       .08      1   FLOW              73.      148.
                                           TIME             5.83     5.83
```

5-Yr 100-Yr

HYDROGRAPH AT
+ 1 .13 1 FLOW 162. 293.
TIME 5.83 5.83

HYDROGRAPH AT
+ 2 .05 1 FLOW 49. 99.
TIME 5.83 5.83

3 COMBINED AT
+ DP1 .26 1 FLOW 283. 541. ← Developed (Q_{in} - pond)
TIME 5.83 5.83

ROUTED TO
+ DB1 .26 1 FLOW 47. 203. ← Historic (Q_{out} - pond)
TIME 6.33 6.08

** PEAK STAGES IN FEET **
1 STAGE 5953.00 5954.99 ← Max Water Surface Elevation
TIME 6.33 6.08

1

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)
FOR PLAN = 1 RATIO= .67									
3-1	MANE	1.48	75.40	352.56	1.26	5.00	72.75	350.00	1.26

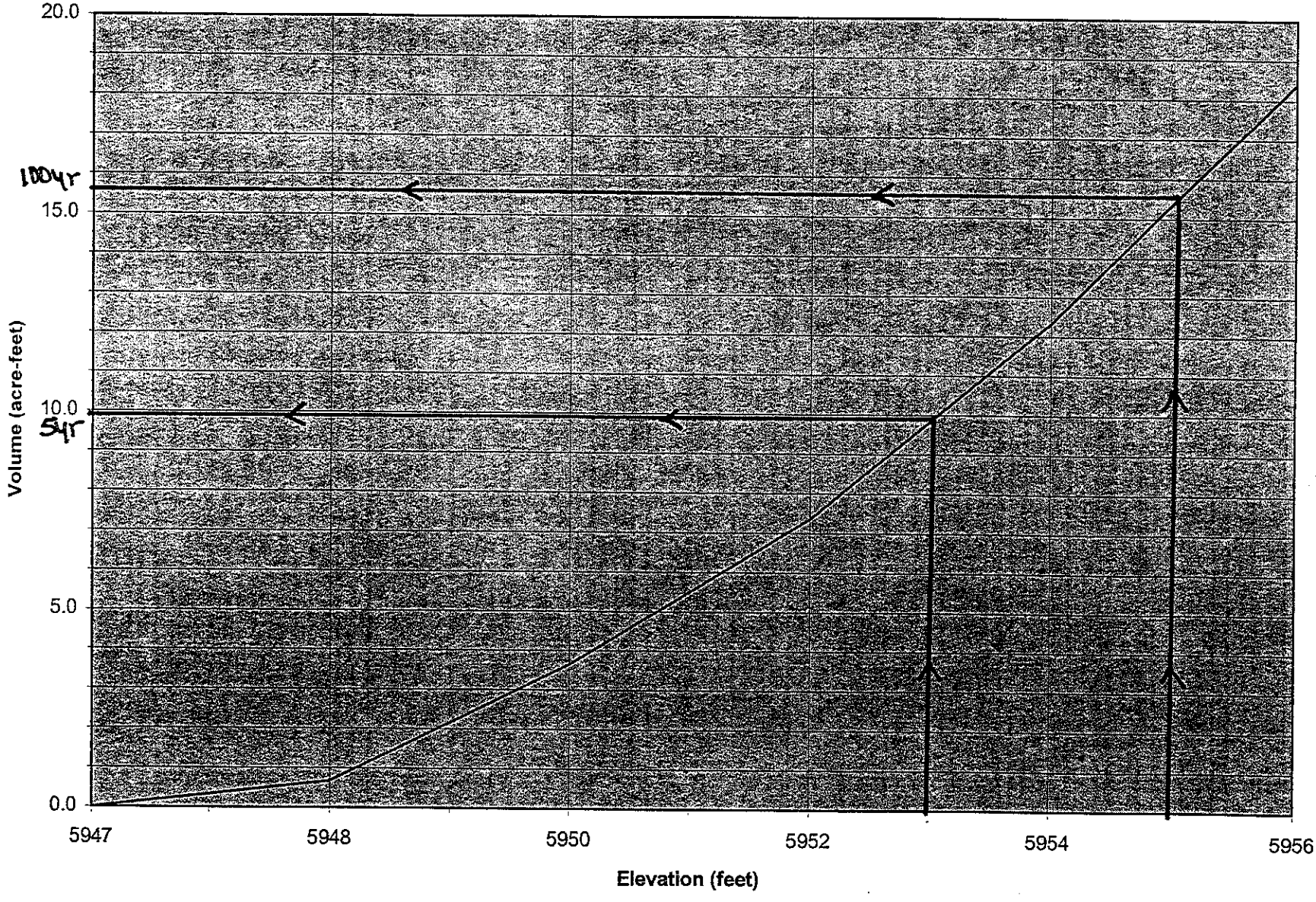
CONTINUITY SUMMARY (AC-FT) - INFLOW= .5126E+01 EXCESS= .0000E+00 OUTFLOW= .5127E+01 BASIN STORAGE= .1994E-03 PERCENT ERROR= .0

FOR PLAN = 1 RATIO= 1.00									
3-1	MANE	1.30	149.50	351.63	2.46	5.00	148.27	350.00	2.46

CONTINUITY SUMMARY (AC-FT) - INFLOW= .1000E+02 EXCESS= .0000E+00 OUTFLOW= .1001E+02 BASIN STORAGE= .3229E-03 PERCENT ERROR= .0

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

Project 02072
Windmill Gulch Detention Basin #2
Volume vs. Elevation



02072volumecalc Chart Actual
Date Printed: 12/4/02

Kiowa Engineering Corporation
Project No. 02072

Windmill Gulch Detention Basin #2
Volume Calculation

Stage	Elevation	Area Ac-ft	Avg. Area	Increment	Incremental Volume	Cumulative Volume
0	5947	0.00				
			0.67	1	0.67	0.67
1	5948	1.35				
			1.49	2	2.98	3.65
2	5950	1.63				
			1.86	2	3.72	7.37
2	5952	2.09				
			2.49	2	4.98	12.35
2	5954	2.89				
			3.04	2	6.07	18.43
2	5956	3.18				

Detention Basin Volumes

5-year Storm - peak water elevation 5953.00 (see HEC run)

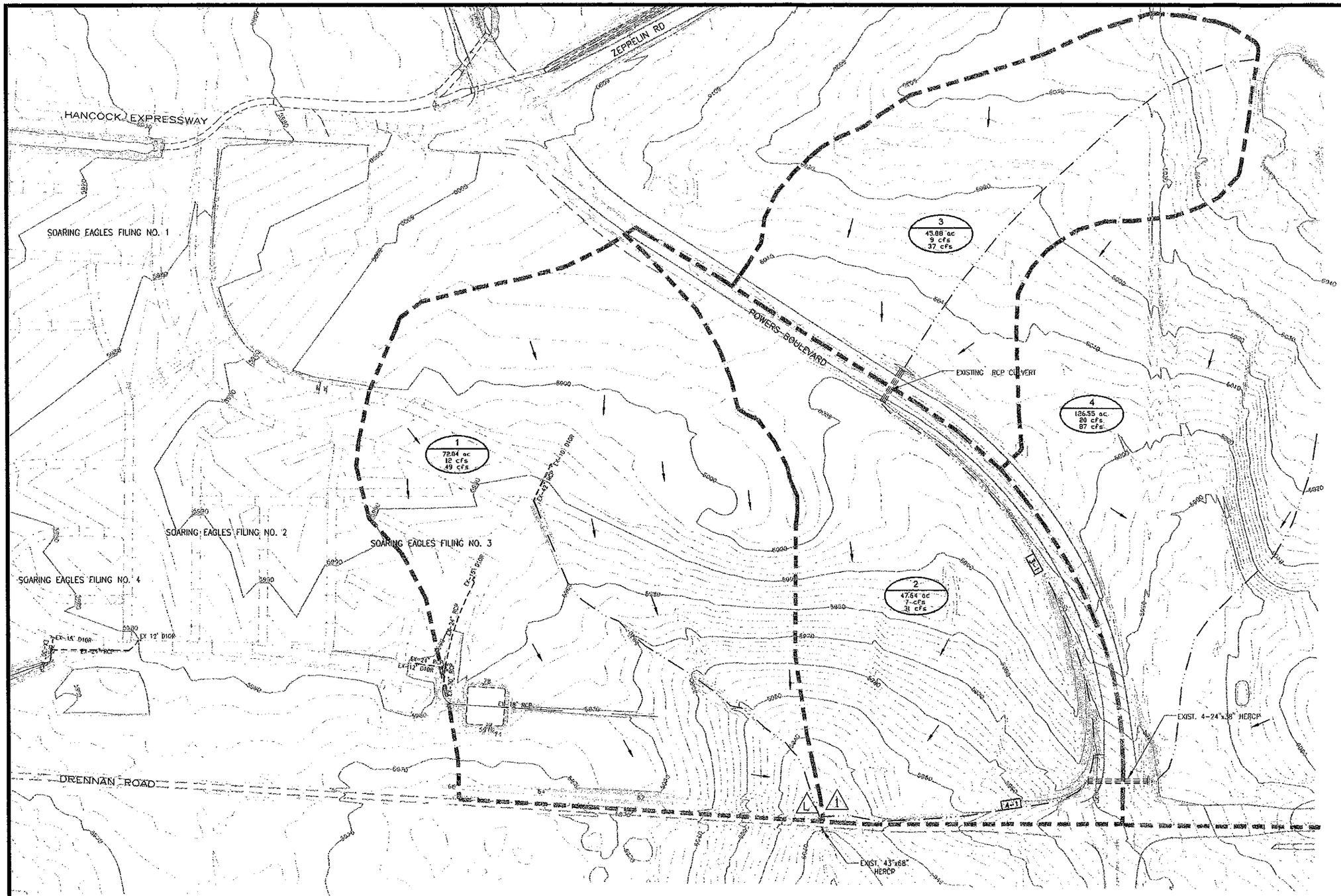
elev.	Vol.
5952	7.37
5954	12.35

Vol. @ 5953 = $\frac{7.37 + 12.35}{2}$ = 9.86 Ac-feet

100-year Storm - peak water elevation 5955.00 (see HEC run)

elev.	Vol.
5954	12.35
5956	18.43

Vol. @ 5955 = $\frac{12.35 + 18.43}{2}$ = 15.39 Ac-feet



NOTE: FIMS MAPPING USED TO DETERMINE BASIN BOUNDARIES

0 200' 400'

SCALE: 1"=400'

DESIGN POINT FLOWS	5-YEAR	100-YEAR
1	47 cfs	203 cfs
WINDMILL GULCH DBPS		
L	50 cfs	230 cfs

LEGEND

- 2 / 33.92 ac / 62 cfs / 122 cfs — DRAINAGE BASIN DESIGNATION; DRAINAGE BASIN AREA; 5-YEAR BASIN RUNOFF; 100-YEAR BASIN RUNOFF
- DRAINAGE BASIN BOUNDARY
- FLOW DIRECTION
- DESIGN POINT
- 6420 — EXISTING 2' CONTOUR
- EXISTING 10' CONTOUR

Kiowa Engineering Corporation
1604 South 21st Street
Colorado Springs, Colorado 80904
(719) 630-7342

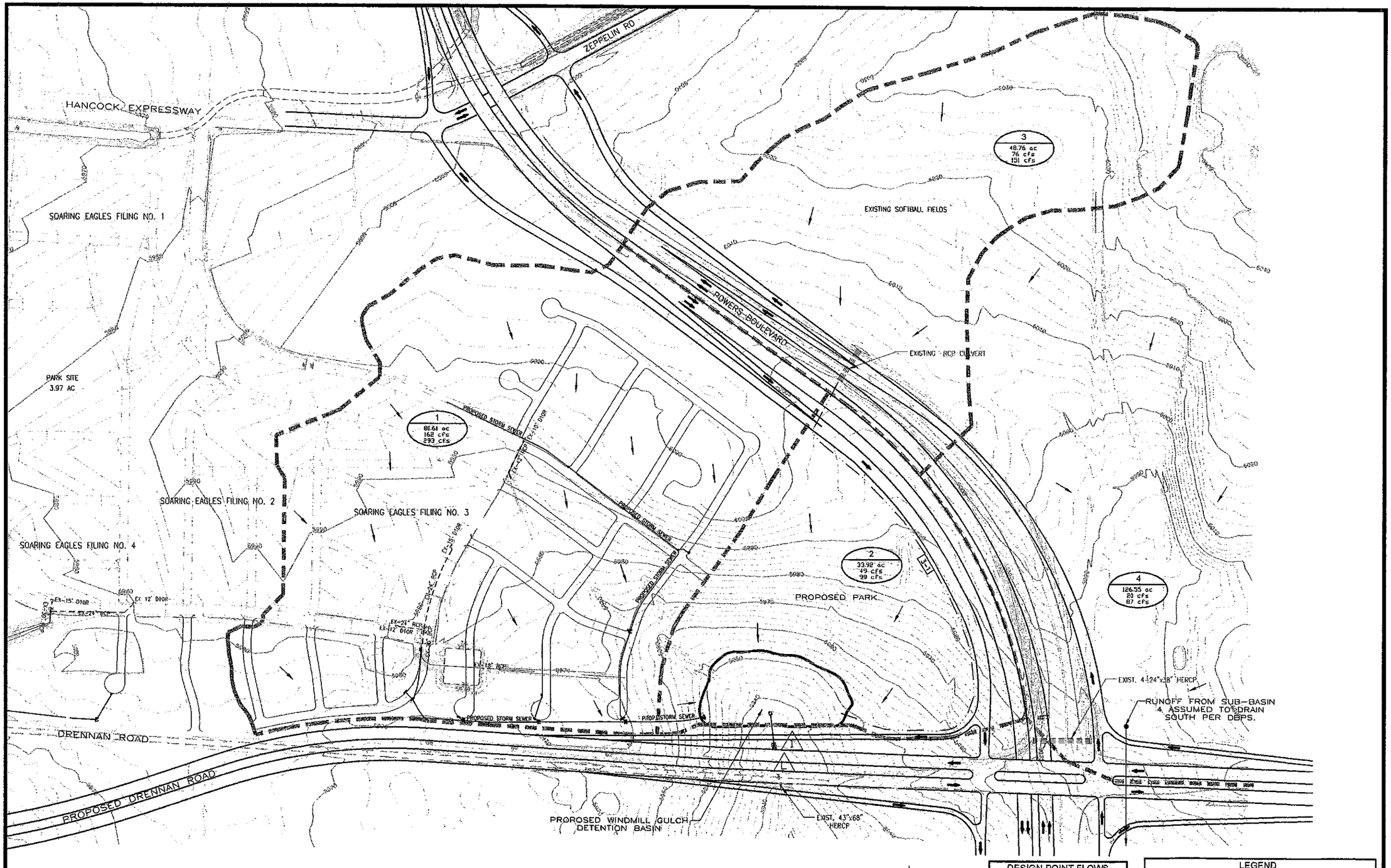
WINDMILL GULCH DETENTION BASIN
EXISTING BASIN CONDITIONS

COLORADO SPRINGS, COLORADO

Project No: 02072
Date: November 5, 2002
Design: JGD
Drawn: JGD
Check: RNW
Revisions:

SHEET 1 OF 2 SHEETS

02072 Retention Basin(PKG)11/30/5/2002



DESIGN POINT FLOWS		
	5-YEAR	100-YEAR
1	283 cfs	541 cfs

DETENTION BASIN DATA

1 WINDMILL GULCH DBPS

Q_5 IN = 440 cfs
Q_5 OUT = 165 cfs
Q_{100} IN = 780 cfs
Q_{100} OUT = 240 cfs
Vol_{100} = 20.7 ac-ft

LEGEND

- 2 / 33.92 ac / 62 cfs / 122 cfs — DRAINAGE BASIN DESIGNATION; DRAINAGE BASIN AREA; 5-YEAR BASIN RUNOFF; 100-YEAR BASIN RUNOFF
- DRAINAGE BASIN BOUNDARY
- FLOW DIRECTION
- 1 — DESIGN POINT
- 6010 — EXISTING 10' CONTOUR
- EXISTING 2' CONTOUR

Kiowa Engineering Corporation
1604 South 21st Street
Colorado Springs, Colorado 80904
(719) 630-7342

WINDMILL GULCH DETENTION BASIN
FUTURE BASIN CONDITIONS

COLORADO SPRINGS, COLORADO

Project No: 02072
Date: November 5, 2002
Design: JGD
Drawn: JGD
Check: RNW
Revisions:

SHEET 2 OF 2 SHEETS