

Water Resources, Drainage and Flooding

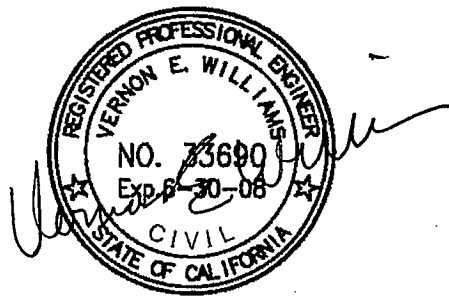
APPENDIX G

Appendix G
Water Resources, Drainage and Flooding

DRAINAGE STUDY

SANTA BARBARA BOTANIC GARDENS

1212 MISSION CANYON ROAD
SANTA BARBARA, CALIFORNIA
August, 2006



FLOWERS & ASSOCIATES, INC.
500 E. Montecito Street, Santa Barbara, CA 93103
(805) 966-2224 Fax (805) 965-337

PURPOSE

The purpose of this report is to analyze existing and proposed drainage characteristics of the project site development areas and to propose designs that will mitigate impacts, if any, to existing downstream properties and other watershed elements.

PROJECT DESCRIPTION

See Appendix "A", Site and Vicinity Map, for location information.

The project site is located northerly of the intersection and between Mission Canyon and Tunnel Roads and continues easterly and northerly of Las Canoas Road. The Owner proposes to construct new buildings, parking and access areas in some cases replacing existing similar facilities. Drainage collection systems are proposed to prevent erosion of site slopes. Where there is a significant increase in runoff due to the proposed improvements detention is proposed at the terminus of these systems to keep peak flows at or below the existing peak flows. Where significant runoff could create a pollution hazard Bio-Swales are proposed.

DRAINAGE STUDY AREAS (See Appendix "B"-Drainage Study Area Exhibit)

Guild Studio Area

The proposed construction for this area consists of a gravel parking area with a continuation of the existing sheet flow, an extension of the existing culvert under the parking area and a foot/cart bridge over Mission creek. The site hydrology does not change significantly so the only calculation provided is for the confirmation of the bridge height over Mission Creek and this calculation is included in Appendix "C". Based on these calculations the bridge easily clears the 100-year storm flows.

Hanson Site

Significant additional construction of buildings and pavement is proposed for this area. The calculations in Appendix "D" show that the Q_{25} peak flow will increase by approximately 0.8 CFS which can be mitigated to the existing peak flowrate by the proposed detention pond. A bio-swale is provided downstream of the basin to filter the runoff prior to discharging it into Las Canoas Creek.

Horticultural Area

Significant additional construction of buildings and pavement is proposed for this area. The calculations in Appendix "E" show that the Q_{25} peak flow will increase by approximately 0.9 CFS which can be mitigated to the existing peak flowrate by the proposed detention pond. A bio-swale is provided downstream of the basin to filter the runoff prior to discharging it into Mission Creek.

Cavalli Path Area

The calculations in Appendix "F" show that the paving of the proposed 8-foot wide path through this area will not significantly affect the area hydrology. Note that the path section is sloped outward so it will not intercept the existing sheet flows. Landscaping below the path section will provide for slowing and filtering of the runoff. The hydrologic and hydraulic calculations show that the proposed foot/cart bridge over Las Canoas creek easily clears the projected 100 year storm flow elevation.

Cavalli Residential Site

Although construction of buildings and pavement is proposed for this area, the calculations in Appendix "G" show that the Q_{25} peak flow will not significantly increase from the existing condition. A detention basin and bio-swale are provided to minimize the local effect of the proposed development.

West Campus

Although significant construction is proposed for this area the calculations in Appendix "H" show that the net increase in the 25-year storm peak run-off is less than 5% which does not warrant facilities to dampen the peak flows. Filter inserts are proposed for the drain inlets to collect the undesirable elements of the initial runoff prior to discharging into the existing swale which eventually flows to Mission Creek

METHOD OF ANALYSIS

Except as indicted this analysis is based on field topography provided by Davis Land Surveying, Inc. and Penfield and Smith Engineers Inc. and Aerial topography compiled by Terron Aerial Surveying dated December 2001 with in-fill from City of Santa Barbara Aerial Topography dated April 1995 revised April 1997.

Property improvements shown are based on plans provided by B³ Architects.

Except as indicated the project peak flows were modeled using the Rational Method and runoff intensities from Santa Barbara County Flood Control and Water Conservation District's Rainfall Intensity-Duration curves for the South Coast Region. To more clearly distinguish the proposed surface improvements the values for the runoff coefficient "C" used in the rational formula are from the Placer County Land Development Manual "Values of Coefficient of Runoff". Time of Concentration was calculated using the Santa Barbara County Department of Public Works Road Division "Time of Concentration of Small Drainage Basins-Figure 3"

Where design of detention facilities is warranted HydroCAD Version 7.1 (5 Node) is used to confirm the basin and outlet size required to meet the requirement of not increasing the peak flows.

CONCLUSION

As indicated under the specific study areas above, the proposed improvements are projected to result in no net increase in peak flows or pollutants offsite due to the improvements to the properties.

APPENDIX LIST

- A. Drainage Study Vicinity Map
- B. Drainage Study Areas Map
- C. Calculations for the Guild Studio Area
- D. Calculations for the Hanson Site
- E. Calculations for the Horticultural Area
- F. Calculations for the Cavalli Trail Area
- G. Calculations for the Cavalli Residential Site
- H. Calculations for the West Campus Area

APPENDIX "A"

DRAINAGE STUDY VICINITY MAP

Mission Creek foot / cart bridge clearance calculation:

Hydrology

Use 2142 cfs from attached calculation from SBCFCD.

Hydraulic

See attached print-out from SBCFCD channel.exe program showing a maximum water depth of approximately 5 ½' for the 100-year storm event.

The attached creek section at the proposed foot / cart bridge shows the bridge / water level relationship:

Botanic Gardens – Mission Creek
Runoff Calculations

Date: 1/9/2006
By: J. Tromp

Purpose

This is a rough calculation of the runoff for Mission Creek in the area of the Santa Barbara Botanic Gardens. Two different methods of calculation were used: the Regional Method and the Partial Method. Using the South Coast Watershed Map, the portion of the sub-watershed MC-1 being used was calculated to have 1799 acres (2.81 square miles).

Regional Method

Source: Nationwide Summary of U.S. Geological Survey
Regional Regression Equations for Estimating Magnitude
and Frequency of Floods for Ungaged Sites, 1993

$$Q_{100} = 1.95 \times A^{0.83} \times P^{1.87}$$

Area (A) = 2.81 square miles

Mean Annual Precipitation (P) = 21.5 inches

$$Q_{100} = 1.95 \times 2.81^{0.83} \times 21.5^{1.87}$$

$$Q_{100} = 1.95 \times 2.36 \times 310.21$$

$$Q_{100} = \underline{1,428 \text{ cfs}}$$

$$1,427.59 \times 1.5 \text{ (bulk factor)} = \underline{2,142 \text{ cfs}}$$

Partial Method

Source: Memo from Jim Stubchaer, Santa Barbara County Flood Control

$$Q_{\text{partial}} = Q_{\text{total}} (\text{Area Partial}/\text{Area Total})^{0.7}$$

$Q_{\text{total}} = 1,600 \text{ cfs}$ (per South Coast Watershed Map)

Area Partial = 1799 acres (measured)

Area Total = 1890 acres (per South Coast Watershed Map)

$$Q_{\text{partial}} = 1600 (1799/1890)^{0.7}$$

$$Q_{\text{partial}} = 1600 \times .9661$$

$$Q_{\text{partial}} = \underline{1,546 \text{ cfs}}$$

Program CHANNEL.EXE SBCFCD Flow= 2,142cfs,
Base= 16.0ft, Side Slope= 1.50, n=0.035, Btm Slope=0.05000 Dn= 4.55 ft, Vn=20.62
ft/sec, P+M= 1,585 cu ft, Fr= 1.94, Dc= 6.64 ft

Flow in TRAPEZOIDAL Channel

Normal Depth = 4.55 ft

$V \cdot V/2G = 6.60$ ft

P + M = 1,585 cu-ft

Critical Depth = 6.64 ft

Steep Slope, 'S' Profiles

Hit Any Key for Menu

Normal Vel = 20.62 ft/sec

$V \cdot V/2G + \text{Depth} = 11.16$ ft

Froude Nr. = 1.94

Program CHANNEL.EXE SBCFCD Flow= 2,142cfs,
Base= 16.0ft, Side Slope= 1.50, n=0.075, Btm Slope=0.05000 Dn= 6.84 ft, Vn=11.92
ft/sec, P+M= 1,328 cu ft, Fr= 0.95, Dc= 6.64 ft

Flow in TRAPEZOIDAL Channel

Normal Depth = 6.84 ft

$V \cdot V/2G = 2.21$ ft

P + M = 1,328 cu-ft

Critical Depth = 6.64 ft

Mild Slope, 'M' Profiles

S(O)/S(C) = 0.89

Hit Any Key for Menu

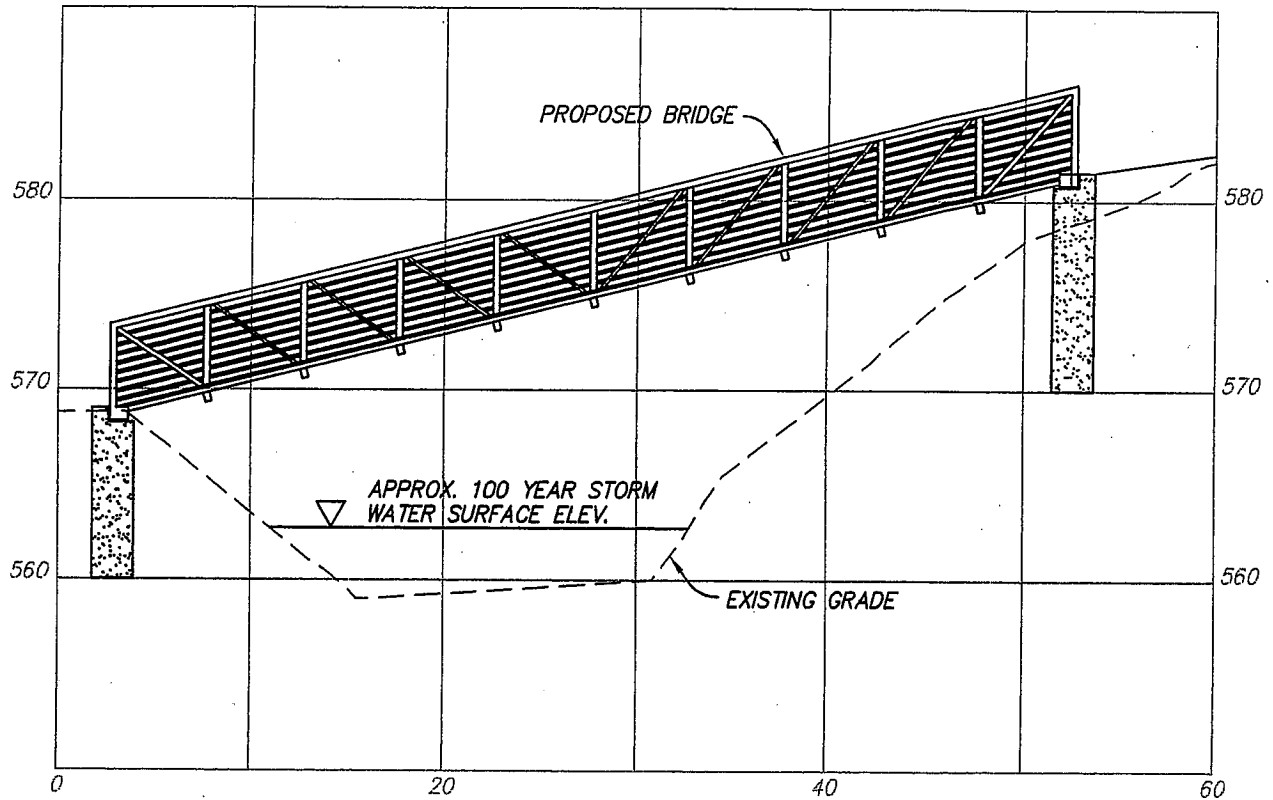
Normal Vel = 11.92 ft/sec

$V \cdot V/2G + \text{Depth} = 9.05$ ft

Froude Nr. = 0.95

Flow is in Unstable Zone.

Wave Height = 1.44 ft, D(n)+Wave = 8.28 ft



SCALE : 1" = 10' H. & V.

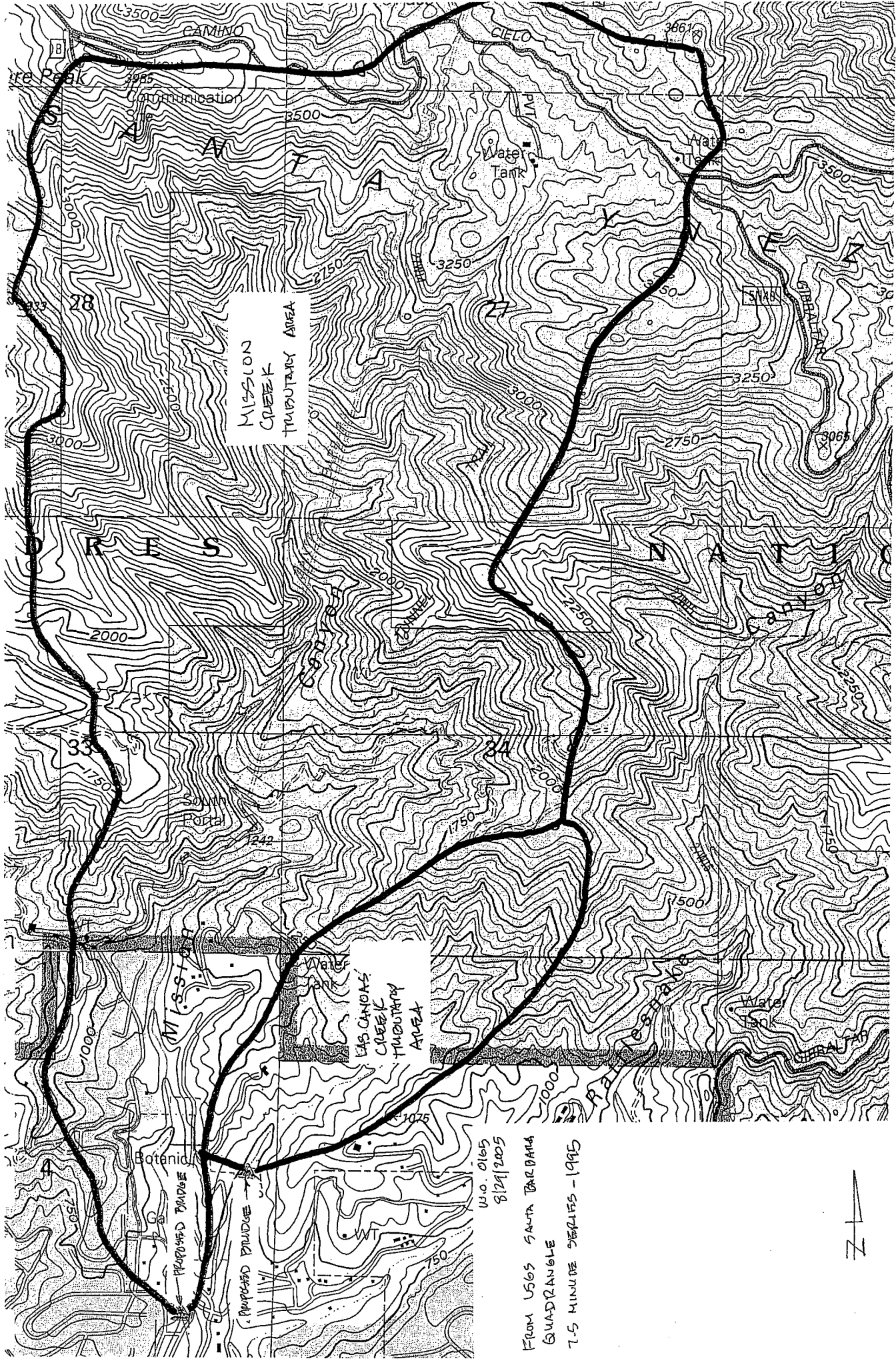
MISSION CREEK BRIDGE
 FOR
SANTA BARBARA BOTANIC GARDENS
 AUGUST 30, 2005

FLOWERS & ASSOCIATES, INC.

CIVIL ENGINEERS

500 East Montecito Street

Santa Barbara, California 9310



MISSION CREEK TRIBUTARY AREA

LAS CANOAS CREEK TRIBUTARY AREA

W.O. 0165
8/21/2005
FROM USGS SANTA BARBARA
QUADRANGLE
7.5 MINUTE SHEETS - 1995



APPENDIX "B"

DRAINAGE STUDY AREAS MAP

**Map Available at County of Santa Barbara Planning
and Development Department**

APPENDIX "C"

**GUILD STUDIO AREA
DRAINAGE CALCULATIONS**

**Map Available at County of Santa Barbara Planning
and Development Department**

APPENDIX "D"
HANSON SITE
DRAINAGE CALCULATIONS

Hydrology

Time of Concentration

$$\begin{aligned} \text{Assume 5 ft. / sec in paved road:} \\ 900 \text{ l.f. / 5 ft./sec / 60} = 3 \end{aligned}$$

$$\begin{aligned} \text{Assume 12 minute Lot Time:} \\ \underline{12} \\ 15 \text{ minutes} \end{aligned}$$

Run-off Coefficient Calculations:

Rainfall Intensities:

$$I_{25} = 2.9 \text{ in. / hr}$$

$$I_{100} = 3.7 \text{ in. / hr}$$

	<u>Existing</u>				<u>Proposed</u>			
	Area		"C"		Area		"C"	
Roof Area	0.20	x	0.90	= 0.18	0.36	x	0.90	= 0.32
Paving	0.13	x	0.85	= 0.11	0.43	x	0.85	= 0.37
Landscaping	<u>2.10</u>	x	0.25	= <u>0.53</u>	<u>1.64</u>	x	0.25	= <u>0.41</u>
	2.43 AC			0.82	2.43 AC			1.10

Weighted "C" = $0.82 / 2.43 = 0.34$ Weighted "C" = $1.10 / 2.43 = 0.45$

Run-off Calculations:

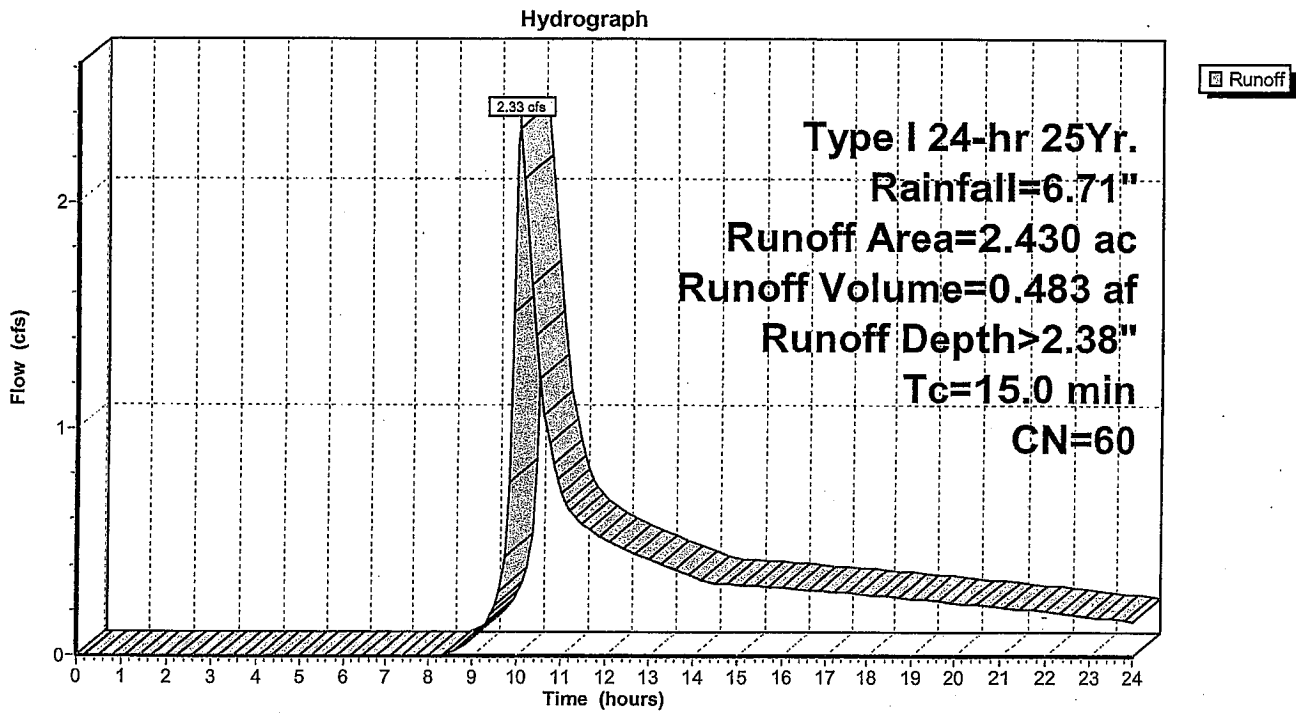
	<u>Existing</u>	<u>Proposed</u>
$Q_{25} =$	$(0.34)(2.9)(2.43) = 2.4 \text{ cfs}$	$(0.45)(2.9)(2.43) = 3.2 \text{ cfs}$
$Q_{100} =$	$(3.7/2.9)(2.5) = 3.1 \text{ cfs}$	$(3.8/3.0)(3.3) = 4.1 \text{ cfs}$

Run-off comparison for Q_{25} : $(3.2-2.4) / 3.2 = 25\%$ increase – Detention Required

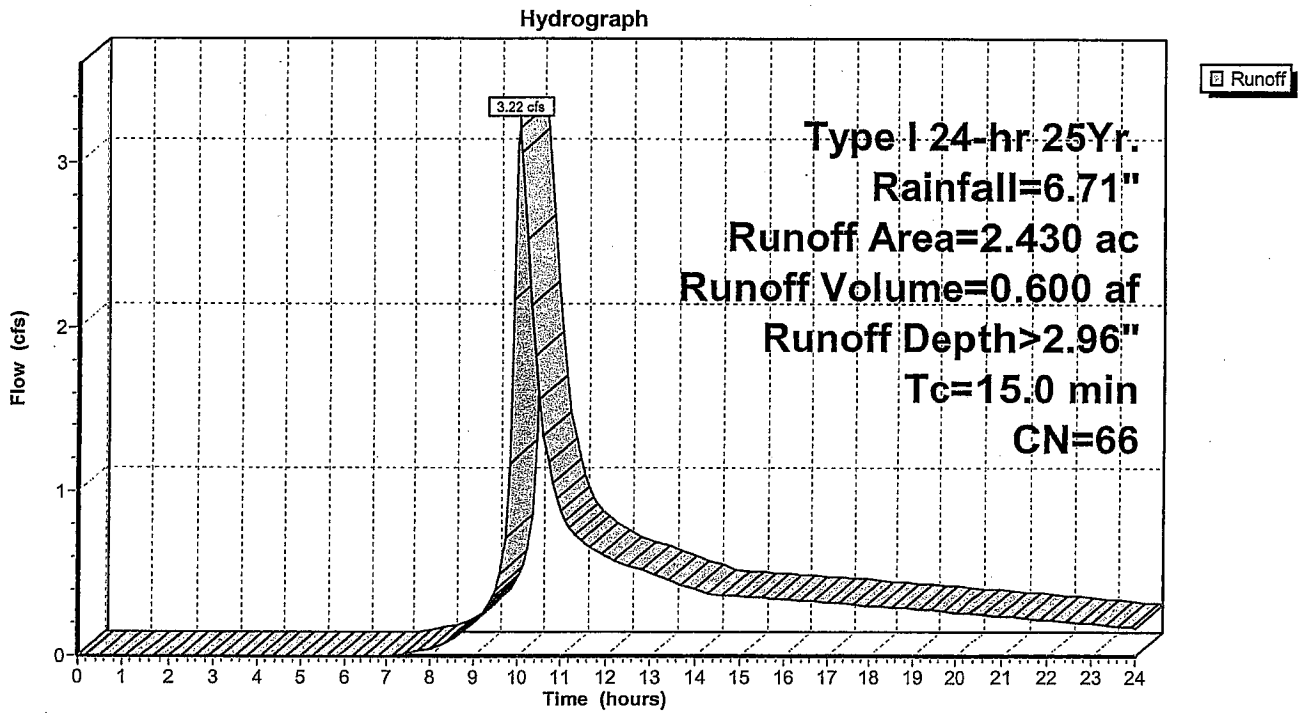
Table 27. Values of Coefficient of Runoff – "C". [25]

Land Use	Surface Condition	"C"	Example Computation
IMPROVED	Roof Surfaces	.90	20 acre tract
	A.C. or P.C.C. Pavement, patios, driveways, streets, sidewalks	.85	3 acres roof @ .90 10 acres A.C. Pave. @ .85 7 acres landscaped @ .25
	Landscaped areas	.25	
	Gravel walks, roadways	.30	$C = \frac{3 \times .90 + 10 \times .85 + 7 \times .25}{20} = 0.65$
UNIMPROVED	SLOPE	Above 30%	.32
		10% - 30%	.24
		5% - 10%	.17
		0 - 5%	.11
	SUB-DRAINAGE	Bare rock or very thin soil	.14
		Impervious clays, shallow soils	.10
		Well drained soils	.07
		Deep sand, volcanic ash	.05
	VEGETATIVE COVER	None or very sparse	.14
		Less than 20% covered with substantial growth	.10
		About 50% covered with heavy growth	.07
		90% covered with heavy growth, deep humus layer	.05
	DRAIN-AGE CONDITION	Smooth soil, slick rock, drainage flow continuous	.11
		Roughened soil or rocks	.05
		Drainage flow arrested, large lakes, ponds, marshes	.07
		Drainage flow interrupted, many ponds, lakes, marshes	.05
			20% Slope .24 Well drained soil .07 Fair cover .07 No ponds .00 $C = .45$

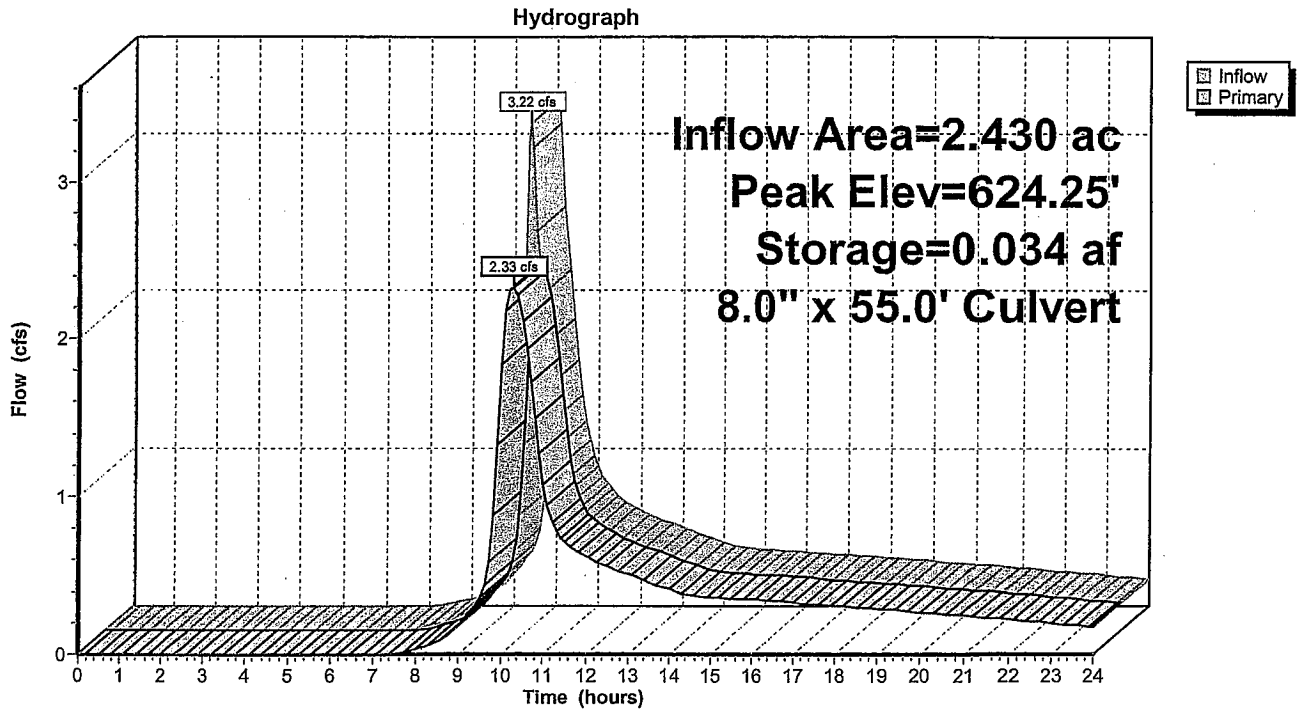
Subcatchment 3S: Existing Hanson



Subcatchment 4S: Proposed Hanson



Pond 5P: Hanson Detention



APPENDIX "E"

**HORTICULTURAL SITE
DRAINAGE CALCULATIONS**

Hydrology

Time of Concentration

Assume 5 ft. / sec in paved road:
600 l.f. / 5 ft./sec / 60 = 2 minutes

Assume 12 minutes Lot Time: 12
14 minutes

Rainfall Intensities:

$I_{25} = 3.0$

$I_{100} = 3.8$

	<u>Existing</u>				<u>Proposed</u>		
	Area	"C"		Area	"C"		
Roof Area	0.12	x 0.90	= 0.108	0.29	x 0.90	= 0.26	
Paving	0.25	x 0.85	= 0.213	0.56	x 0.85	= 0.48	
Landscaping	<u>0.89</u>	x 0.25	= <u>0.223</u>	<u>0.41</u>	x 0.25	= <u>0.10</u>	
	1.26 AC		0.54	1.26 AC		0.84	

Weighted "C" = $0.54 / 1.26 = 0.43$

Weighted "C" = $0.84 / 1.26 = 0.67$

Run-off Calculations:

Existing
 $Q_{25} = (0.43)(3.0)(1.26) = 1.6 \text{ cfs}$

Proposed
 $Q_{25} = (0.67)(3.0)(1.26) = 2.5 \text{ cfs}$

$Q_{100} = (3.8/3.0)(1.62) = 2.1 \text{ cfs}$

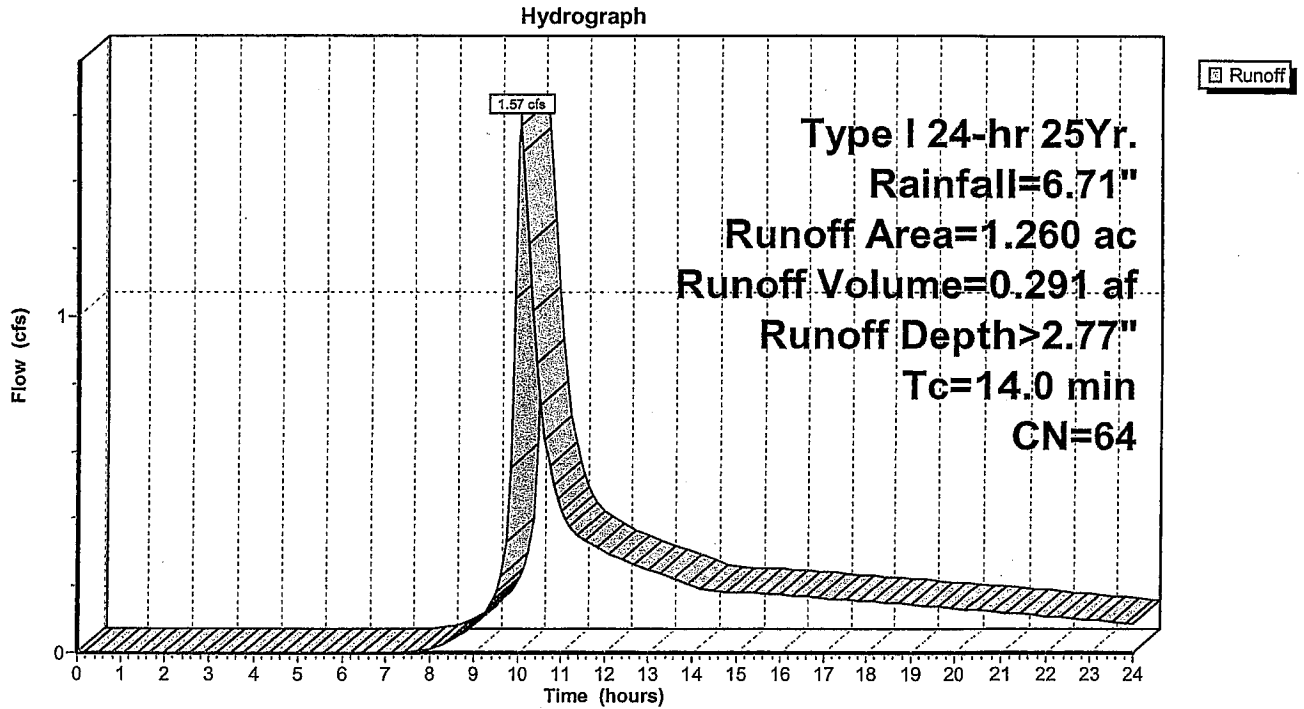
$Q_{100} = (3.8/3.0)(2.5) = 3.2 \text{ cfs}$

Run-off comparison for Q_{25} : $(2.5-1.6) / 2.5 = 36\%$ increase – Detention Required

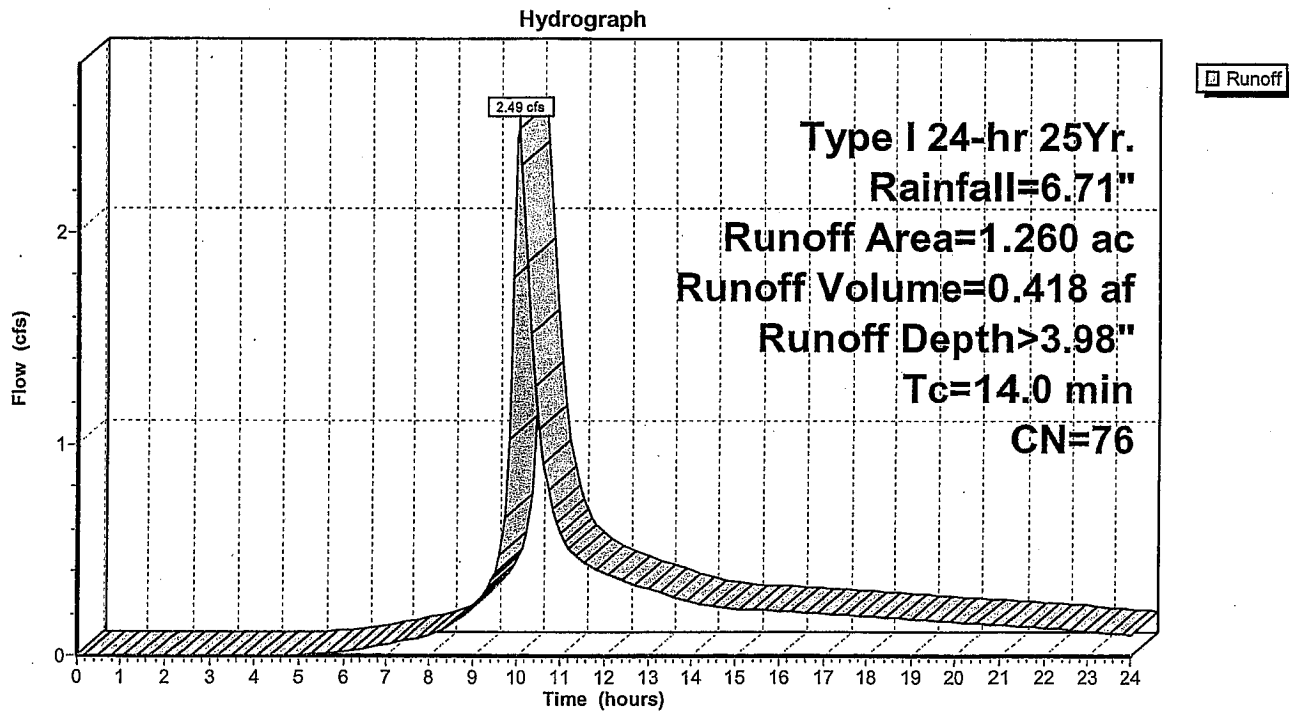
Table 27. Values of Coefficient of Runoff – “C”. [25]

Land Use	Surface Condition	“C”	Example Computation
IMPROVED	Roof Surfaces	.90	20 acre tract
	A.C. or P.C.C. Pavement, patios, driveways, streets, sidewalks	.85	3 acres roof @ .90 10 acres A.C. Pave. @ .85 7 acres landscaped @ .25
	Landscaped areas	.25	
	Gravel walks, roadways	.30	$C = \frac{3 \times .90 + 10 \times .85 + 7 \times .25}{20} = 0.65$
UNIMPROVED	SLOPE	Above 30%	.32
		10% - 30%	.24
		5% - 10%	.17
		0 - 5%	.11
	SUB-DRAINAGE	Bare rock or very thin soil	.14
		Impervious clays, shallow soils	.10
		Well drained soils	.07
		Deep sand, volcanic ash	.05
	VEGETATIVE COVER	None or very sparse	.14
		Less than 20% covered with substantial growth	.10
		About 50% covered with heavy growth	.07
		90% covered with heavy growth, deep humus layer	.05
	DRAINAGE	Smooth soil, slick rock, drainage flow continuous	.11
		Roughened soil or rocks	.05
	CONDI-TION	Drainage flow arrested, large lakes, ponds, marshes	.07
		Drainage flow interrupted, many ponds, lakes, marshes	.05
			20% Slope .24 Well drained soil .07 Fair cover .07 No ponds <u>.00</u> C= .45

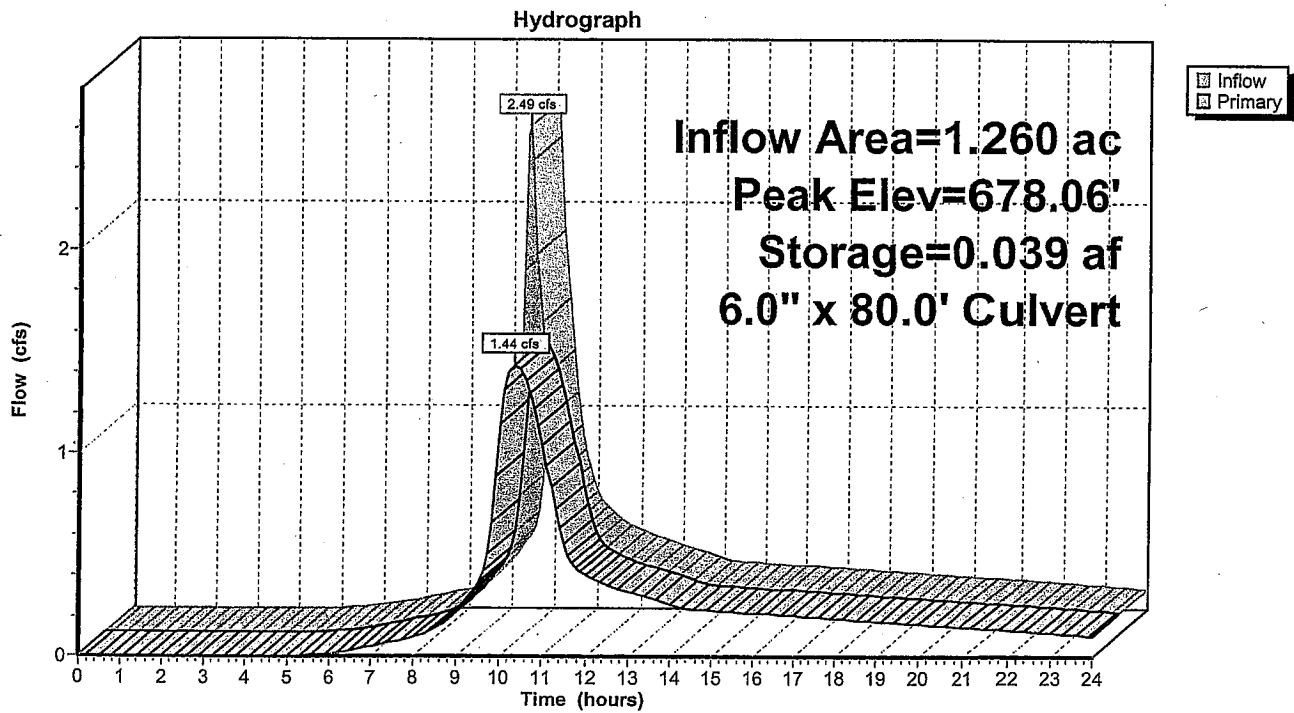
Subcatchment 6S: Existing Hort.



Subcatchment 7S: Proposed Hort.



Pond 8P: Hort. Pond



APPENDIX "F"

**CAVALLI PATH
DRAINAGE CALCULATIONS**

Main Site

Hydrology

Time of Concentration – overland flow:

$$\begin{array}{rcl} H = 857' - 645' = 212' & L = 600' & T_c = 1.5 \times 2 = 3.0 \\ & + \text{ Lot Time} & \underline{12.0} \\ \text{Total} = & & 15 \text{ minutes} \end{array}$$

Run-off Coefficient Calculations:

Undeveloped Area	"C"
Slope Range 10-30%	0.24
Shallow Clay Soil	0.10
Heavy Growth	0.05
Rough Soil	<u>0.09</u>
"C"	0.48

	<u>Existing</u>				<u>Proposed</u>					
	Area		"C"		Area		"C"			
Roof Area	0	x	0.90	=	0	0.014	x	0.90	=	0.26
Paving	0	x	0.85	=	0	0.59	x	0.85	=	0.48
Landscaping	0	x	0.25	=	0	0	x	0.25	=	0
Undeveloped	<u>8.85</u>	x	0.48	=	<u>4.25</u>	<u>7.73</u>	x	0.48	=	<u>3.71</u>
	8.85 AC				4.25	8.85 AC				4.23

Weighted "C" = $4.25 / 8.85 = 0.48$

Weighted "C" = $4.23 / 8.85 = 0.48$

Rainfall Intensities:

$I_{25} = 2.9 \text{ in / hr}$

$I_{100} = 3.7 \text{ in / hr}$

Run-off Calculations:

Existing
 $Q_{25} = (0.48)(2.9)(8.85) = 12.3 \text{ cfs}$

Proposed
 $Q_{25} = (0.48)(2.9)(8.85) = 12.3 \text{ cfs}$

Run-off comparison for Q_{25} : $(12.3 - 12.3) / 12.3 = 0\% \text{ increase} - \text{Detention Not Required}$

Las Canoas Creek foot / cart bridge clearance calculation

Hydrology

Using USGS methodology (See Guild Studio Calculations):

$$Q_{100} = 1.95 \times A^{.83} P^{1.87}$$

Area A = 231/640 = 0.36 square miles

Mean Annual Precipitation, P = 21.5 inches

$$Q_{100} = 1.95(0.36)^{.83}(21.5)^{1.87} = 259 \text{ cfs}$$
$$259 \times 1.5 \text{ (bulk factor)} = 389 \text{ cfs}$$

Hydraulics

See attached print out from SBCFCD channel.exe program showing a maximum water depth of approximately 3-feet for the 100 year storm flow.

The attached creek section at the proposed foot / cart bridge shows the bridge / water level relationship.

Table 27. Values of Coefficient of Runoff – "C". [25]

Land Use	Surface Condition	"C"	Example Computation	
IMPROVED	Roof Surfaces	.90	20 acre tract 3 acres roof @ .90 10 acres A.C. Pave. @ .85 7 acres landscaped @ .25 $C = \frac{3 \times .90 + 10 \times .85 + 7 \times .25}{20} = 0.65$	
	A.C. or P.C.C. Pavement, patios, driveways, streets, sidewalks	.85		
	Landscaped areas	.25		
	Gravel walks, roadways	.30		
UNIMPROVED	SLOPE	Above 30%	.32	20% Slope .24 Well drained soil .07 Fair cover .07 No ponds .00 $C = .45$
		10% - 30%	.24	
		5% - 10%	.17	
		0 - 5%	.11	
	SUB-DRAINAGE	Bare rock or very thin soil	.14	
		Impervious clays, shallow soils	.10	
		Well drained soils	.07	
		Deep sand, volcanic ash	.05	
	VEGETATIVE COVER	None or very sparse	.14	
		Less than 20% covered with substantial growth	.10	
		About 50% covered with heavy growth	.07	
		90% covered with heavy growth, deep humus layer	.05	
	DRAINAGE	Smooth soil, slick rock, drainage flow continuous	.11	
		Roughened soil or rocks	.05	
	CONDITION	Drainage flow arrested, large lakes, ponds, marshes	.07	
		Drainage flow interrupted, many ponds, lakes, marshes	.05	

Program CHANNEL.EXE SBCFCD Flow= 389cfs,
Base= 7.0ft, Side Slope= 1.50, n=0.045, Btm Slope=0.06000 Dn= 2.84 ft, Vn=12.19
ft/sec, P+M= 187 cu ft, Fr= 1.50, Dc= 3.54 ft

Flow in TRAPEZOIDAL Channel

Normal Depth = 2.84 ft

$V \cdot V/2G = 2.31$ ft

P + M = 187 cu-ft

Critical Depth = 3.54 ft

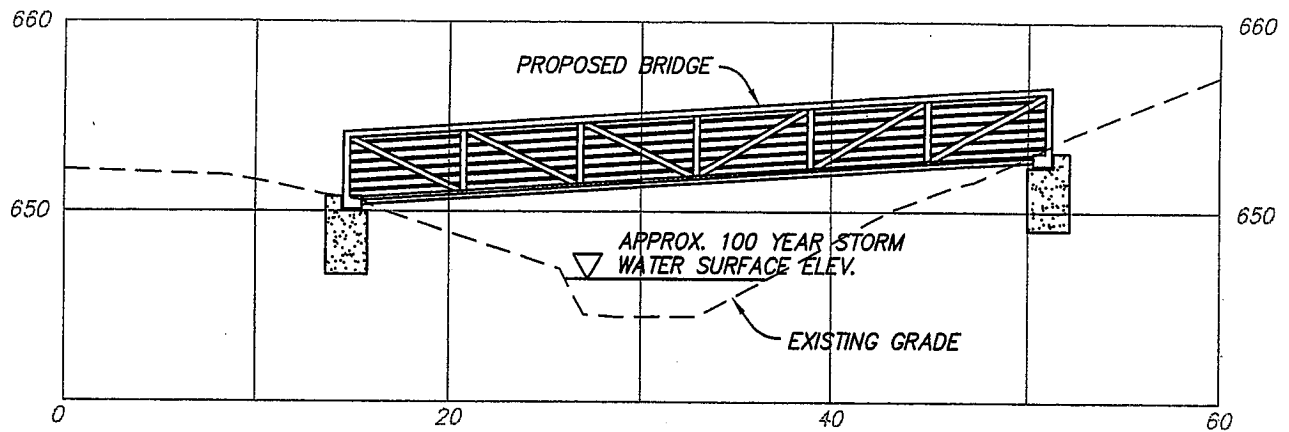
Steep Slope. 'S' Profiles

Hit Any Key for Menu

Normal Vel = 12.19 ft/sec

$V \cdot V/2G + \text{Depth} = 5.14$ ft

Froude Nr. = 1.50



SCALE : 1" = 10' H. & V.

CAVALLI PATH CREEK BRIDGE

FOR

SANTA BARBARA BOTANIC GARDENS

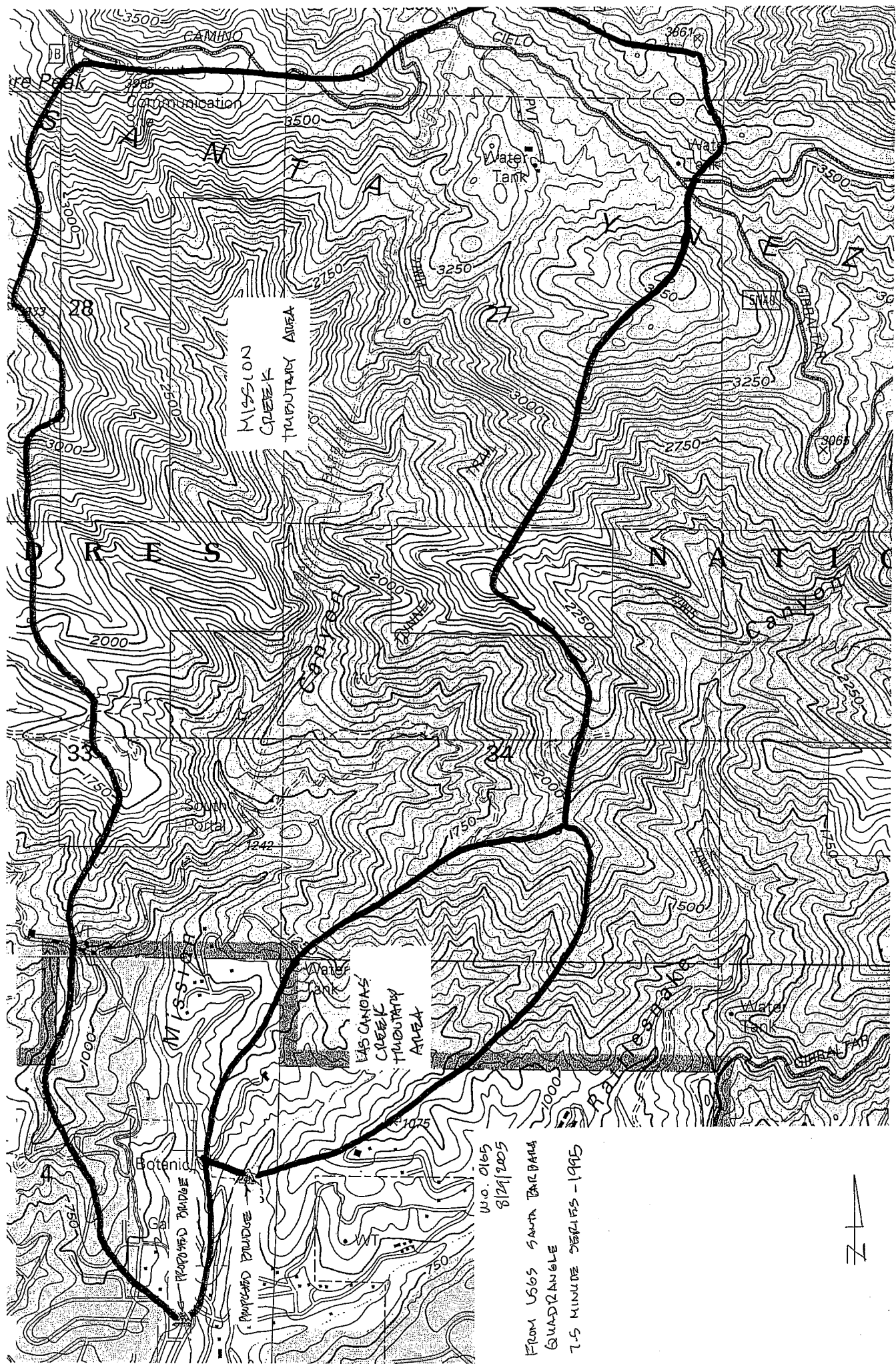
AUGUST 30, 2005

FLOWERS & ASSOCIATES, INC.

CIVIL ENGINEERS

500 East Montecito Street

Santa Barbara, California 9310



MISSION
CREEK
TRIBUTARY AREA

EAS CANYONS
CREEK
TRIBUTARY
AREA

W.O. 0165
8/29/2005
FROM USGS SANTA BARBARA
QUADRANGLE
7.5 MINUTE SERIES - 1965



APPENDIX "G"

**CAVALLI RESIDENTIAL SITE
DRAINAGE CALCULATIONS**

Hydrology

Time of Concentration – overland flow:

H= 1006' – 656'= 350'	L=2000'	T _c = 5 x 2 =	10
	+ Lot Time		<u>12.0</u>
		Total=	22 minutes

Run-off Coefficient Calculations:

Undeveloped Area	"C"
Slope Range 10-30%	0.24
Shallow Clay Soil	0.10
Heavy Growth	0.05
Rough Soil	<u>0.09</u>
"C"	0.48

Existing

Proposed

	Area		"C"	=		Area		"C"	=	
Roof Area	.01	x	0.90	=	0.009	0.11	x	0.90	=	0.10
Paving	0	x	0.85	=	0	0.14	x	0.85	=	0.12
Landscaping	0	x	0.25	=	0	0.10	x	0.25	=	0.03
Undeveloped	<u>22.72</u>	x	0.48	=	<u>10.91</u>	<u>22.38</u>	x	0.48	=	<u>10.74</u>
	22.73 AC				10.92	22.73 AC				10.98

Weighted "C" = 10.92 / 22.73 = 0.48

Weighted "C" = 10.98 / 22.73 = 0.48

Rainfall Intensities:

I₂₅= 2.5 in / hr

I₁₀₀= 3.1 in / hr

Run-off Calculations:

Existing

Proposed

Q₂₅= 27.3 cfs

Q₂₅= 27.3 cfs

Q₁₀₀= 33.8 cfs

Q₁₀₀= 33.8 cfs

Run-off comparison for Q₂₅: (27.3-27.3) / 27.3 = 0% increase – Detention Not Required

Table 27. Values of Coefficient of Runoff – “C”. [25]

Land Use	Surface Condition	“C”	Example Computation	
IMPROVED	Roof Surfaces	.90	20 acre tract	
	A.C. or P.C.C. Pavement, patios, driveways, streets, sidewalks	.85	3 acres roof @ .90 10 acres A.C. Pave. @ .85 7 acres landscaped @ .25	
	Landscaped areas	.25		
	Gravel walks, roadways	.30	$C = \frac{3 \times .90 + 10 \times .85 + 7 \times .25}{20} = 0.65$	
UNIMPROVED	SLOPE	Above 30%	.32	
		10% - 30%	.24	
		5% - 10%	.17	
		0 - 5%	.11	
	SUB-DRAINAGE	Bare rock or very thin soil	.14	
		Impervious clays, shallow soils	.10	
		Well drained soils	.07	
		Deep sand, volcanic ash	.05	
	VEGETATIVE COVER	None or very sparse	.14	20% Slope .24 Well drained soil .07 Fair cover .07 No ponds <u>.00</u>
		Less than 20% covered with substantial growth	.10	C= .45
		About 50% covered with heavy growth	.07	
		90% covered with heavy growth, deep humus layer	.05	
	DRAINAGE	Smooth soil, slick rock, drainage flow continuous	.11	
		Roughened soil or rocks	.05	
	CONDITION	Drainage flow arrested, large lakes, ponds, marshes	.07	
		Drainage flow interrupted, many ponds, lakes, marshes	.05	

Table 27. Values of Coefficient of Runoff – “C”. [25]

Land Use	Surface Condition	“C”	Example Computation
IMPROVED	Roof Surfaces	.90	20 acre tract 3 acres roof @ .90 10 acres A.C. Pave. @ .85 7 acres landscaped @ .25 $C = \frac{3 \times .90 + 10 \times .85 + 7 \times .25}{20} = 0.65$
	A.C. or P.C.C. Pavement, patios, driveways, streets, sidewalks	.85	
	Landscaped areas	.25	
	Gravel walks, roadways	.30	
UNIMPROVED	SLOPE	Above 30%	.32
		10% - 30%	.24
		5% - 10%	.17
		0 - 5%	.11
	SUB-DRAINAGE	Bare rock or very thin soil	.14
		Impervious clays, shallow soils	.10
		Well drained soils	.07
		Deep sand, volcanic ash	.05
	VEGETATIVE COVER	None or very sparse	.14
		Less than 20% covered with substantial growth	.10
		About 50% covered with heavy growth	.07
		90% covered with heavy growth, deep humus layer	.05
	DRAINAGE CONDITION	Smooth soil, slick rock, drainage flow continuous	.11
		Roughened soil or rocks	.05
		Drainage flow arrested, large lakes, ponds, marshes	.07
		Drainage flow interrupted, many ponds, lakes, marshes	.05
			20% Slope .24 Well drained soil .07 Fair cover .07 No ponds <u>.00</u> $C = .45$

APPENDIX "H"

**WEST CAMPUS
DRAINAGE CALCULATIONS**

Hydrology

Time of Concentration:

$$\begin{array}{rcl} H = 790' - 690' = 100' & L = 1000' & T_c = 4 \times 1 = 4 \\ & + \text{Lot Time} & \underline{12} \\ & & \text{Total} = 16 \text{ minutes} \end{array}$$

Run-off Coefficient Calculations:

	<u>Existing</u>			<u>Proposed</u>		
	Area	"C"	=	Area	"C"	=
Roof Area	0.23	x 0.90	=	0.29	x 0.90	= 0.26
Paving	1.08	x 0.85	=	1.21	x 0.85	= 1.03
Landscaping	<u>3.79</u>	x 0.25	=	<u>3.60</u>	x 0.25	= <u>0.90</u>
	5.10 AC			5.10 AC		2.18

$$\text{Weighted "C"} = 2.07 / 5.10 = 0.41$$

$$\text{Weighted "C"} = 2.18 / 5.10 = 0.43$$

Rainfall Intensities:

$$I_{25} = 2.8 \text{ in / hr}$$

$$I_{100} = 3.5 \text{ in / hr}$$

Run-off Calculations:

<u>Existing</u>	<u>Proposed</u>
$Q_{25} = 5.9 \text{ cfs}$	$Q_{25} = 6.1 \text{ cfs}$
$Q_{100} = 7.3 \text{ cfs}$	$Q_{100} = 7.7 \text{ cfs}$

Run-off comparison for Q_{25} : $(6.1 - 5.9) / 5.9 = 3.3\%$ increase – Detention Not Required