APPENDIX 5 : HYDROLOGY ANALYSIS for preliminary LOW IMPACT DEVELOPMENT techniques

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March 2008

Appendix 5: Hydrology Analysis for Proposed Visalia Civic Center Expansion A5-1

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HYDROLOGY ANALYSIS FOR

PROPOSED VISALIA CIVIC CENTER EXPANSION

Introduction

The proposed Visalia Civic Center Expansion site is located north of East Center Avenue, south of East Goshen Avenue, east of North Santa Fe Ave. and west of North Ben Maddox Street within the City of Visalia, California.

This hydrology study is based on the City of Visalia Standards – Rational Method. The City of Visalia – *Storm Water Management Program* (November 2005) was used for determining Water Quality Volumes and Flows required for treatment.

The hydrology analysis was only within the area limited by East Center Ave., East Goshen Ave., North Santa Fe Ave. and North Ben Maddox St.. The proposed site was divided into two areas by Burke Street. Area 1 located west of Burke St. and Area 2 located east of Burke St.

The purpose of this study is to determine a hydrology analysis and design Low Impact Development (LID) Techniques to mimic existing hydrologic conditions through runoff volume control, peak runoff rate control, flow frequency/duration control and water quality control.

Existing Conditions

Currently, the exiting project consists of open land with Jennings Ditch running north to south and Mill Creek running east to west. Runoff from the site has a drainage pattern from west to east on Area 1 and a west to east pattern on Area 2, both discharging directly into Mill Creek and Jennings Ditch.

Table 1 and 2 below summarizes the rational method analysis for the project site. Per criteria set forth in the "City of Visalia Standards", a runoff coefficient of 0.15 and 0.65 was selected corresponding to Natural/Undeveloped area and existing developed area.

Table 1 – 2 & 10 Year Runoff Flow & Volume for Existing Conditions (Area 1 – West of Burke St.)

Location	Area (Acres)	2-Year Storm Event			10-Year Storm Event		
		Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)	Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)
North	4.9	0.5	18.1	0.09	0.8	18.1	0.12
South	3.4	0.4	16.5	0.06	0.7	15.2	0.09

Table 2 – 2 & 10 Year Runoff Flow & Volume for Existing Conditions (Area 2 – East of Burke St.)

Location	Area (Acres)	2-Year Storm Event			10-Year Storm Event		
		Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)	Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)
	34.6	4.8	17.6	0.8	7.7	17.6	1.1

Proposed Conditions

The proposed Visalia Civic Center Expansion will consists of a Civic Center, Business Center, Office Campus, Park and associated local streets, sidewalks, internal storm drain system and various entrances.

Onsite flow will be collected and conveyed via an internal storm drain system which ultimately discharges to proposed Detention basins, located along Mill Creek for Area 1 and Jennings Ditch for Area 2 (See Alternatives A & B Maps). Using the proposed detention basins, peak flows for the 10-year storm event will be attenuated down to existing conditions.

In order to maintain existing conditions of runoff volume, each block will have Bioretention basins located strategically to convey flow from rooftops, parking lots, and walkways between buildings.

The combination of using detention and bioretention basins will contribute to maintain time of concentration for proposed conditions below existing.

The hydrologic analysis in proposed conditions has been done for Alternatives A & B.

Table 3, 4, 5 and 6 below summarizes the rational method analysis for the project site (Alternatives A & B). Per criteria set forth in the "City of Visalia Standards", a runoff coefficient of 0.15 and 0.85 was selected corresponding to Natural/Undeveloped area and proposed developed area (Commercial, Parking Lots, etc.).

Table 3 – 2 & 10 Year Runoff Flow & Volume for Proposed Conditions – Alternative A (Area 1 – West of Burke St.)

Location	Area (Acres)	2-Year Storm Event			10-Year Storm Event		
		Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)	Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)
North	5.9	2.4	21.8	0.4	4	21.8	0.6
South	2.4	0.3	16.7	0.04	0.4	16.7	0.06

Table 4 – 2 & 10 Year Runoff Flow & Volume for Proposed Conditions – Alternative B (Area 1 – West of Burke St.)

Location	Area (Acres)	2-Year Storm Event			10-Year Storm Event		
		Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)	Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)
North	5.9	2.4	21.8	0.4	4	21.8	0.6
South	2.4	0.3	16.7	0.04	0.4	16.7	0.06

Table 5 – 2 & 10 Year Runoff Flow & Volume for Proposed Conditions - Alternative A (Area 2 – East of Burke St.)

Location	Area (Acres)	2-Year Storm Event			10-Year Storm Event		
		Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)	Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)
	34.6	12.6	23	2.4	20.6	23	3.5

Table 6 – 2 & 10 Year Runoff Flow & Volume for Proposed Conditions - Alternative B (Area 2 – East of Burke St.)

Location	Area (Acres)	2-Year Storm Event			10-Year Storm Event		
		Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)	Runoff Flow (cfs)	Tc (min)	Runoff Volume (Ac-ft)
	34.6	12.6	24.3	2.5	20.6	24.3	3.6

Summary of Results

Table 7, 8, 9 and 10 below summarizes the rational method analysis for the project site in existing and proposed (Alternatives A & B) conditions.

Table 7 – 2 & 10 Year Runoff Flow & Volume for Proposed Conditions - Alternative A (Area 1 – West of Burke St.)

				2-Year Storm Event			10-Year Storm Event		
		Area	Runoff Coefficient	Runoff Flow	Time of Concentration	Runoff Volume	Runoff Flow	Time of Concentration	Runoff Volume
		(Acres)		(cfs)	(min)	(Ac-ft)	(cfs)	(min)	(Ac-ft)
North	Existing Conditions	4.9	0.15	0.5	18.1	0.09	0.8	18.1	0.12
	Developed Conditions	5.9	0.65	2.4	21.8	0.4	4.0	21.8	0.6
	DIFFERENCE			*1.9*	*3.6*	*0.4*	*3.1*	*3.6*	*0.5*
South	Existing Conditions	3.4	0.15	0.4	16.5	0.06	0.7	15.2	0.09
	Developed Conditions	2.4	0.65	0.3	16.7	0.04	0.4	16.7	0.06
	DIFFERENCE			*-0.1*	*0.2*	*-0.02*	*-0.2*	*1.5*	*-0.03*

Table 8 – 2 & 10 Year Runoff Flow & Volume for Proposed Conditions - Alternative A (Area 2 – East of Burke St.)

			2-Year Storm Event			10-Year Storm Event		
	Area	Runoff Coefficient	Runoff Flow	Time of Concentration	Runoff Volume	Runoff Flow	Time of Concentration	Runoff Volume
	(Acres)		(cfs)	(min)	(Ac-ft)	(cfs)	(min)	(Ac-ft)
Existing Conditions	34.60	0.19	4.8	17.6	0.8	7.7	17.6	1.1
Developed Conditions	34.60	0.60	12.6	23.0	2.4	20.6	23.0	3.5
DIFFERENCE			*7.8*	*5.4*	*1.7*	*12.9*	*5.4*	*2.4*

Table 9 – 2 & 10 Year Runoff Flow & Volume for Proposed Conditions - Alternative B (Area 1 – West of Burke St.)

				2-Year Storm Event			10-Year Storm Event		
		Area	Runoff Coefficient	Runoff Flow	Time of Concentration	Runoff Volume	Runoff Flow	Time of Concentration	Runoff Volume
		(Acres)		(cfs)	(min)	(Ac-ft)	(cfs)	(min)	(Ac-ft)
North	Existing Conditions	4.9	0.15	0.5	18.1	0.09	0.8	18.1	0.12
	Developed Conditions	5.9	0.65	2.4	21.8	0.4	4.0	21.8	0.6
	DIFFERENCE			*1.9*	*3.6*	*0.4*	*3.1*	*3.6*	*0.5*
South	Existing Conditions	3.4	0.15	0.4	16.5	0.06	0.7	15.2	0.09
	Developed Conditions	2.4	0.65	0.3	16.7	0.04	0.4	16.7	0.06
	DIFFERENCE			*-0.1*	*0.2*	*-0.02*	*-0.2*	*1.5*	*-0.03*

Table 10 – 2 & 10 Year Runoff Flow & Volume for Proposed Conditions - Alternative B (Area 2 – East of Burke St.)

			2-Year Storm Event			10-Year Storm Event		
	Area	Runoff Coefficient	Runoff Flow	Time of Concentration	Runoff Volume	Runoff Flow	Time of Concentration	Runoff Volume
	(Acres)		(cfs)	(min)	(Ac-ft)	(cfs)	(min)	(Ac-ft)
Existing Conditions	34.60	0.19	4.8	17.6	0.8	7.7	17.6	1.1
Developed Conditions	34.60	0.62	12.6	24.3	2.5	20.6	24.3	3.6
DIFFERENCE			*7.8*	*6.7*	*1.7*	*12.9*	*6.7*	*2.5*

Proposed Detention and Bioretention basins have been designed to maintain existing conditions of runoff flow and runoff volume for each alternative analyzed (See Table 11).

Table 11 – Detention and Bioretention Basin Volumes Alternative A & B (Areas 1 & 2)

Location		Alternative	Detention Basin Volume (Acre-ft)	Bioretention Basin Volume (Acre-ft)
Area 1	West of Burke St. – Northern Portion	A	0.36	0.5
		B	0.36	0.5
Area 2	East of Burke St.	A	1.25	2.4
		B	1.29	2.5

Water Quality Analysis

The water quality analysis consisted in addressing the treatment of the 85th percentile runoff from the proposed Civic Center Expansion. The design will utilize a combination of Best Management Practices (BMP's) in order to provide maximum water quality treatment.

Flows tributary to the Detention Basins will receive primary treatment (85th Percentile) via curb inlet filters, such as FloGard units. Secondary treatment will be provided via Vortex Separators, such as CDS units. This combination will provide a dual BMP "Treatment Train".

Street runoff will receive partial treatment via Vegetated Swales located adjacent to the internal streets, each designed to treat the 85th percentile flow. The proposed vegetated swales will consist of a bottom width of 4 ft, side slope of 3:1, water depth of 0.33 ft and length of 150 ft. Each swale will treat 85th percentile flows of 0.41 cfs.

The proposed BMP's have been designed for both alternatives A & B.

Additional Source Controls can be implemented within the proposed project site, such as follows:

- Site Design and Landscape Planning
- Roof Runoff Controls
- Efficient Irrigation
- Storm Drain System Signs
- Pervious Pavements (Parking Lots and Entrance Locations)

References

City of Visalia Improvement Standards.

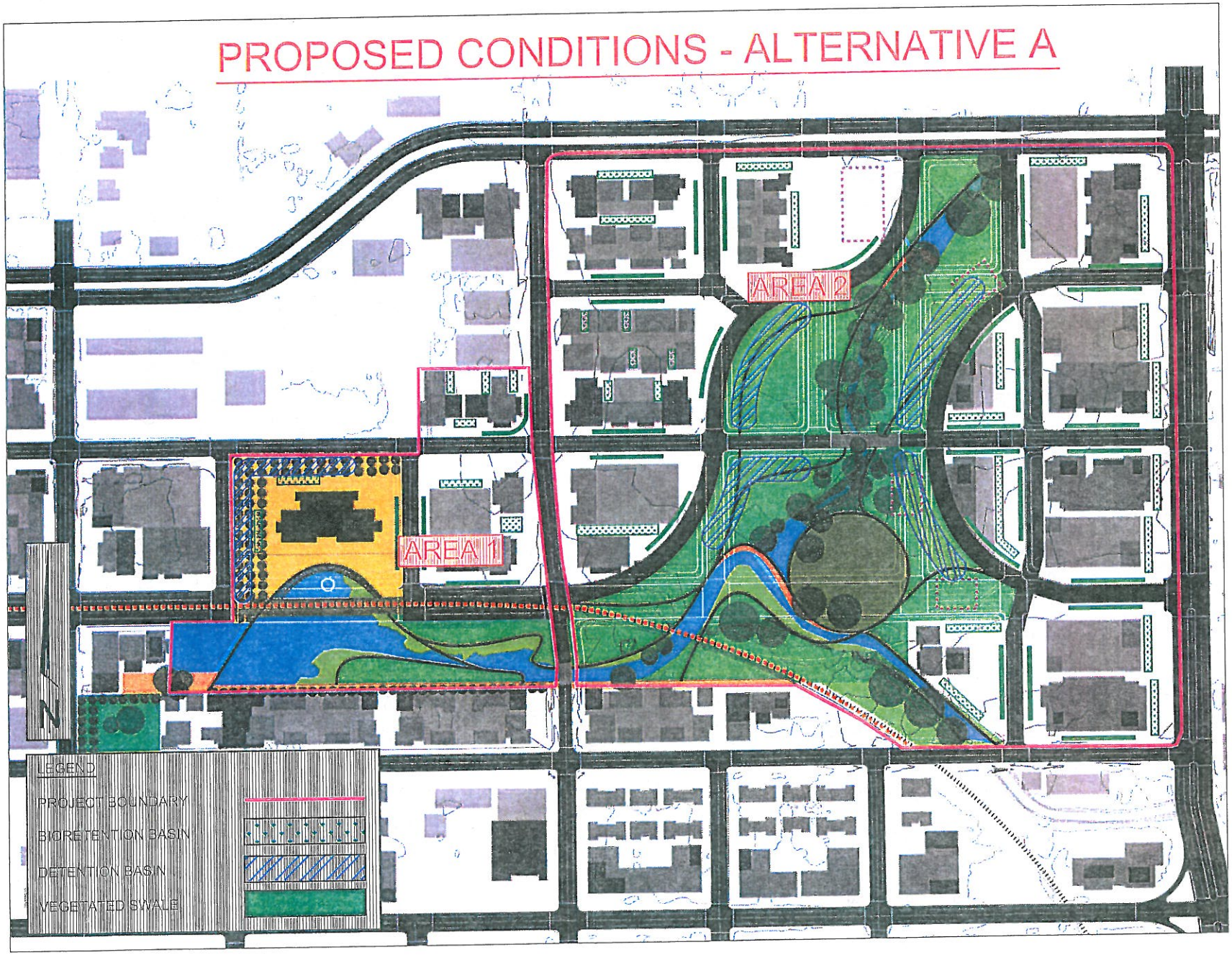
City of Visalia Storm Water Management Program (November 2005).

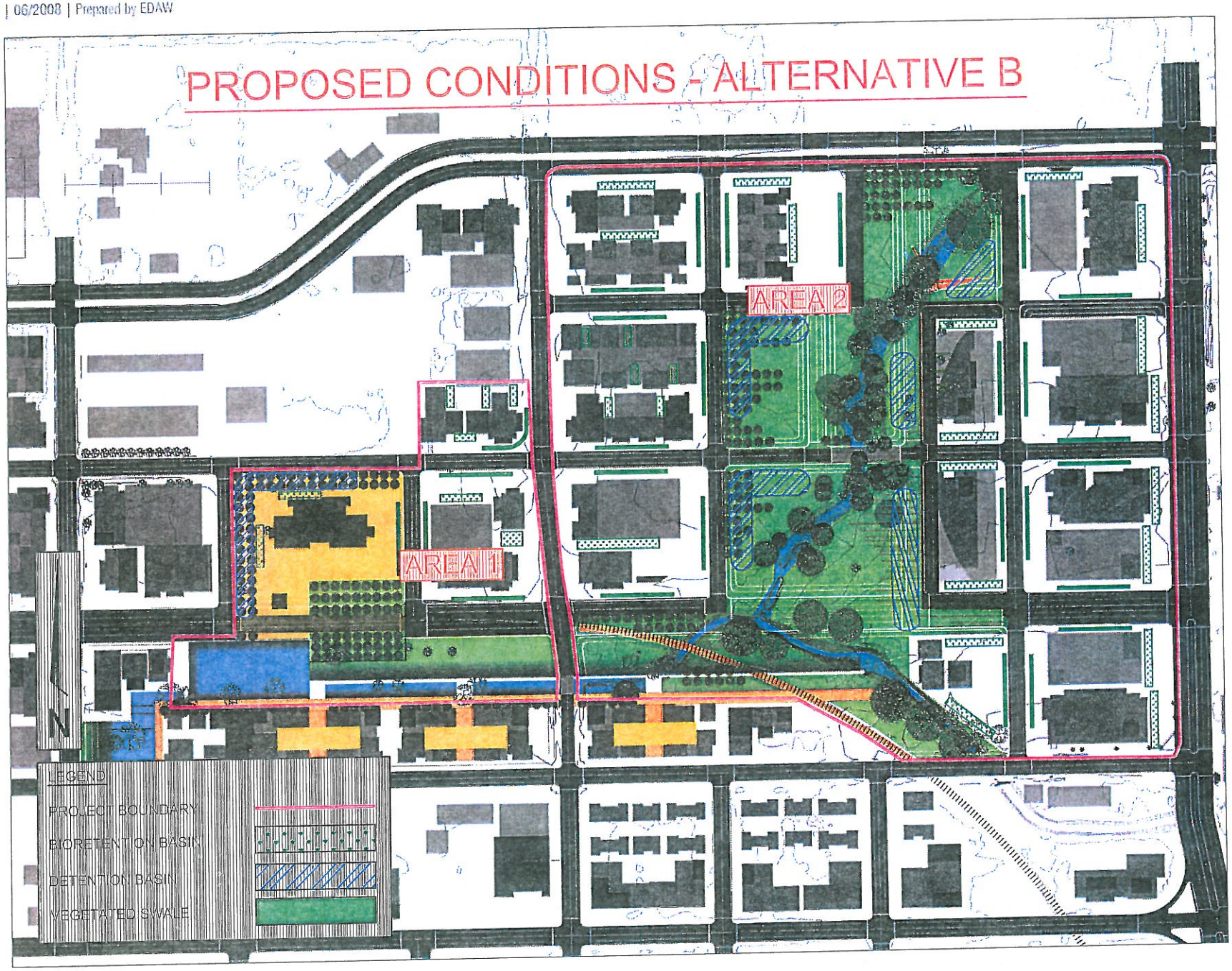
Stormwater Best Management Practice Handbook – New Development and Redevelopment (California Stormwater Quality Association - CASQA).

Low Impact Development Strategies – An Integrated Design Approach (July 1999). Prince George's County, Maryland (Department of Environmental Resources).

Integrated Stormwater Design: Using Runoff to Create Greate Site Ammenity. Stuart Echols, Penn State. (July 2007).

PROPOSED CONDITIONS - ALTERNATIVE A




PROPOSED CONDITIONS - ALTERNATIVE B
AREA 2
AREA 1
N
LEGEND
PROJECT BOUNDARY
BIORETENTION BASIN
DETENTION BASIN
VEGETATED SWALE

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WATER QUALITY ANALYSIS - ALTERNATIVE A

PROJECT: Visalia Civic Center Expansion COMP. BY: A.D. DATE: 9/17/2007
JOB NO: 180406V1 CHKD. BY: DATE:
DESCRIPTION: Water Quality Analysis (ALTERNATIVE A)

AREA 1 (WEST OF BURKE ST.) - NORTHERN & SOUTHERN PORTION

Volume Based Design: Northern Portion

Regression Constant - a (24Hr-1.582 48Hr-1.963):	1.582	
Runoff Coefficient - C:	0.55	
85th Percentile Rainfall - P (inches):	0.55	
Contributing Area - A (Acres):	5.9	
Total 85th Percentile Runoff Volume - V (Acre-ft):	3.3	V = aCPA
Number of Locations to Treat:	3	
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	*1.1*	

Flow Based Design: Northern & Southern Portion

Runoff Coefficient - C:	0.85	
85th Percentile Rainfall Intensity - I (in/hr):	0.2	* 0.2 in/hr per RWQCB
Contributing Area - A (Acres):	0.8	
Total 85th Percentile Runoff Flow - Q (cfs):	*0.1*	Q = CIA
Number of Locations to Treat:	3	
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	*0.05*	

AREA 2 (EAST OF BURKE ST.)

Volume Based Design:

Regression Constant - a (24Hr-1.582 48Hr-1.963):	1.582	
Runoff Coefficient - C:	0.60	
85th Percentile Rainfall - P (inches):	0.55	
Contributing Area - A (Acres):	34.6	
Total 85th Percentile Runoff Volume - V (Acre-ft):	18.1	V = aCPA
Number of Locations to Treat:	11	
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	*1.6*	

Flow Based Design:

Runoff Coefficient - C:	0.85	
85th Percentile Rainfall Intensity - I (in/hr):	0.2	* 0.2 in/hr per RWQCB
Contributing Area - A (Acres):	4.6	
Total 85th Percentile Runoff Flow - Q (cfs):	*0.8*	Q = CIA
Number of Locations to Treat:	11	
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	*0.07*	

Reference:
City of Visalia - Storm Water Management Program (November 2005)

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WATER QUALITY ANALYSIS - ALTERNATIVE B

PROJECT: Visalia Civic Center Expansion
JOB NO: 180406V1
DESCRIPTION: Water Quality Analysis (ALTERNATIVE B)

COMP. BY: A.D.
CHKD. BY:

DATE: 9/17/2007
DATE:

AREA 1 (WEST OF BURKE ST.) - NORTHERN & SOUTHERN PORTION

Volume Based Design: Northern Portion

Regression Constant - a (24Hr-1.582 48Hr-1.963):	1.582	
Runoff Coefficient - C:	0.65	
85th Percentile Rainfall - P (inches):	0.55	
Contributing Area - A (Acres):	5.9	
Total 85th Percentile Runoff Volume - V (Acre-ft):	3.3	V = aCPA
Number of Locations to Treat:	3	
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	*1.1*	

Flow Based Design: Northern & Southern Portion

Runoff Coefficient - C:	0.85	
85th Percentile Rainfall Intensity - I (in/hr):	0.2	* 0.2 in/hr per RWQCB
Contributing Area - A (Acres):	0.8	
Total 85th Percentile Runoff Flow - Q (cfs):	*0.1*	Q = CIA
Number of Locations to Treat:	3	
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	*0.05*	

AREA 2 (EAST OF BURKE ST.)

Volume Based Design:

Regression Constant - a (24Hr-1.582 48Hr-1.963):	1.582	
Runoff Coefficient - C:	0.62	
85th Percentile Rainfall - P (inches):	0.55	
Contributing Area - A (Acres):	34.6	
Total 85th Percentile Runoff Volume - V (Acre-ft):	18.7	V = aCPA
Number of Locations to Treat:	11	
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	*1.7*	

Flow Based Design:

Runoff Coefficient - C:	0.85	
85th Percentile Rainfall Intensity - I (in/hr):	0.2	* 0.2 in/hr per RWQCB
Contributing Area - A (Acres):	4.9	
Total 85th Percentile Runoff Flow - Q (cfs):	*0.8*	Q = CIA
Number of Locations to Treat:	11	
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	*0.07*	

Reference:
City of Visalia - Storm Water Management Program (November 2005)

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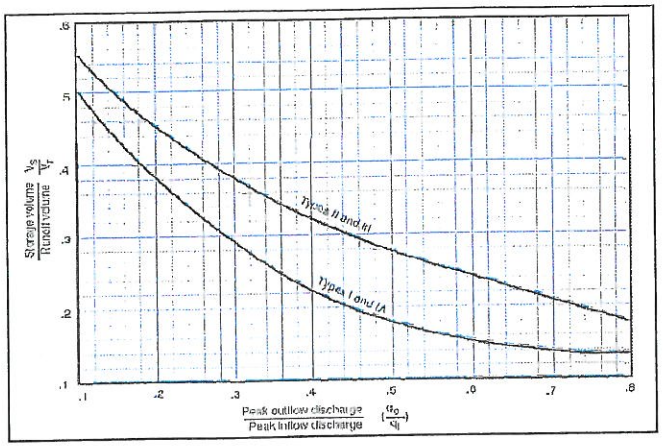
DETENTION UNITS SIZING - ALTERNATIVE A

PROJECT: Visalia Civic Center Expansion **COMP. BY:** A.D. **DATE:** 9/17/2007
JOB NO: 180406V1 **CHKD. BY:** **DATE:**
DESCRIPTION: Detention Units Sizing (ALTERNATIVE A)

AREA 1 (WEST OF BURKE ST.) - NORTHERN PORTION

Existing Condition Flow (cfs) - Qo	Developed Condition Flow (cfs) - Qi	Contributing Area (acres) - A	P (in)	Weigthed Runoff Coefficient (Cw)	Inflow Runoff Volume (acre-ft) - Vr	Ratio (Qo/Qi)	Ratio (Vs/Vr)	Storage Volume (acre-ft) - Vs	Security Factor	Final Storage Volume (acre-ft) - Vsf
0.8	4	5.9	2.0	0.65	0.64	0.20	0.38	0.24	1.5	0.36

Areas (acre) - Ai	Runoff Coefficient (Ci)
2.4	0.15
5.9	0.85
Total Area (acres)	8.3
Cw	0.65



DETENTION BASIN SIZING:

Detention Basin Water Depth (ft): 1
Detention Basin Freeboard (ft): 1.5
Detention Basin Side Slope - z: 2

	Elevation	Area	Length	Width	Inc. Volume	Total Volume
	(ft)	(acres)	(ft)	(ft)	(acre-ft.)	(acre-ft.)
Bottom of Basin	1000	0.335	148.0	98.7		0.00
					0.35	
W.S.E.	1001	0.363	154.0	102.7		0.35
					0.58	
Top of Basin	1002.5	0.407	163.0	108.7		0.93

* Detention Basin Dimension could vary due to Site Layout

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DETENTION UNITS SIZING - ALTERNATIVE A

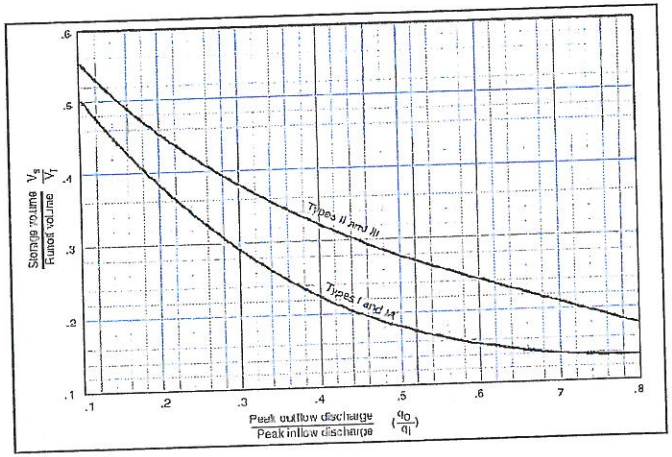
PROJECT: Visalia Civic Center Expansion
JOB NO: 180406V1
DESCRIPTION: Detention Units Sizing (ALTERNATIVE A)

COMP. BY: A.D. DATE: 9/17/2007
CHKD. BY: DATE:

AREA 2 (EAST OF BURKE ST.)

Existing Condition Flow (cfs) - Qo	Developed Condition Flow (cfs) - Qi	Contributing Area (acres) - A	P (in)	Weigthed Runoff Coefficient (Cw)	Inflow Runoff Volume (acre-ft) - Vr	Ratio (Qo/Qi)	Ratio (Vs/Vr)	Storage Volume (acre-ft) - Vs	Security Factor	Final Storage Volume (acre-ft) - Vsf
7.7	20.6	34.6	2.0	0.60	3.47	0.37	0.24	0.83	1.5	*1.25*

Areas (acre) - Ai	Runoff Coefficient (Ci)
12.3	0.15
22.3	0.85
Total Area (acres)	34.6
Cw	0.60



DETENTION BASIN SIZING:

Detention Basin Water Depth (ft): 1
Detention Basin Freeboard (ft): 1.5
Detention Basin Side Slope - z: 2

	Elevation	Area	Length	Width	Inc. Volume	Total Volume
	(ft)	(acres)	(ft)	(ft)	(acre-ft.)	(acre-ft.)
Bottom of Basin	1000	1.196	279.6	186.4		0.00
					1.22	
W.S.E.	1001	1.248	285.6	190.4		1.22
					1.93	
Top of Basin	1002.5	1.328	294.6	196.4		3.15

* Detention Basin Dimension could vary due to Site Layout

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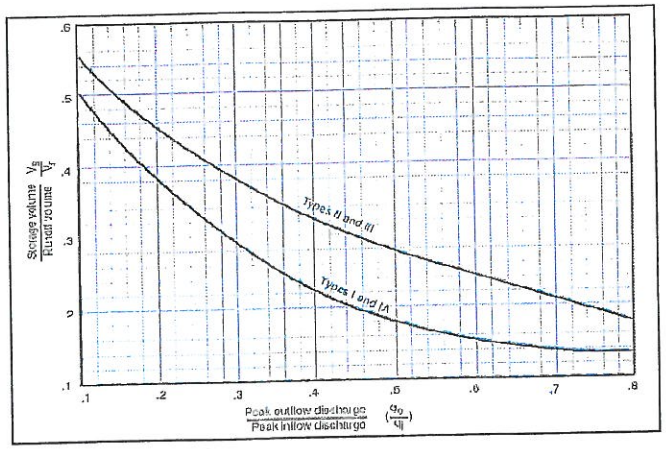
DETENTION UNITS SIZING - ALTERNATIVE B

PROJECT: Visalia Civic Center Expansion **COMP. BY:** A.D. **DATE:** 9/17/2007
JOB NO: 180406V1 **CHKD. BY:** **DATE:**
DESCRIPTION: Detention Units Sizing (ALTERNATIVE B)

AREA 1 (WEST OF BURKE ST.) - NORTHERN PORTION

Existing Condition Flow (cfs) - Qo	Developed Condition Flow (cfs) - Qi	Contributing Area (acres) - A	P (in)	Weigthed Runoff Coefficient (Cw)	Inflow Runoff Volume (acre-ft) - Vr	Ratio (Qo/Qi)	Ratio (Vs/Vr)	Storage Volume (acre-ft) - Vs	Security Factor	Final Storage Volume (acre-ft) - Vsf
0.8	4	5.9	2.0	0.65	0.64	0.20	0.38	0.24	1.5	*0.36*

Areas (acre) - Ai	Runoff Coefficient (Ci)
2.4	0.15
5.9	0.85
Total Area (acres)	8.3
Cw	0.65



DETENTION BASIN SIZING:

Detention Basin Water Depth (ft): 1
Detention Basin Freeboard (ft): 1.5
Detention Basin Side Slope - z: 2

	Elevation	Area	Length	Width	Inc. Volume	Total Volume
	(ft)	(acres)	(ft)	(ft)	(acre-ft.)	(acre-ft.)
Bottom of Basin	1000	0.335	148.0	98.7		0.00
					0.35	
W.S.E.	1001	0.363	154.0	102.7		0.35
					0.58	
Top of Basin	1002.5	0.407	163.0	108.7		0.93

* Detention Basin Dimension could vary due to Site Layout

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DETENTION UNITS SIZING - ALTERNATIVE B

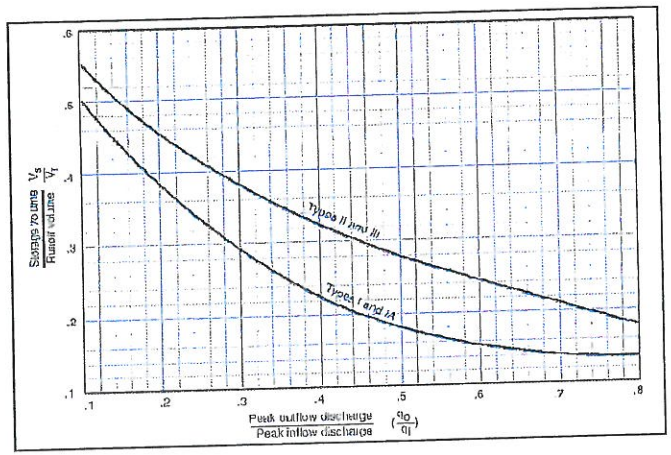
PROJECT: Visalia Civic Center Expansion
JOB NO: 180406V1
DESCRIPTION: Detention Units Sizing (ALTERNATIVE B)

COMP. BY: A.D. **DATE:** 9/17/2007
CHKD. BY: **DATE:**

AREA 2 (EAST OF BURKE ST.)

Existing Condition Flow (cfs) - Qo	Developed Condition Flow (cfs) - Qi	Contributing Area (acres) - A	P (in)	Weigthed Runoff Coefficient (Cw)	Inflow Runoff Volume (acre-ft) - Vr	Ratio (Qo/Qi)	Ratio (Vs/Vr)	Storage Volume (acre-ft) - Vs	Security Factor	Final Storage Volume (acre-ft) - Vsf
7.7	20.6	34.6	2.0	0.62	3.58	0.37	0.24	0.86	1.5	1.29

Areas (acre) - Ai	Runoff Coefficient (Ci)
11.3	0.15
23.3	0.85
Total Area (acres)	34.6
Cw	0.62



DETENTION BASIN SIZING:

Detention Basin Water Depth (ft): 1
Detention Basin Freeboard (ft): 1.5
Detention Basin Side Slope - z: 2

	Elevation	Area	Length	Width	Inc. Volume	Total Volume
	(ft)	(acres)	(ft)	(ft)	(acre-ft.)	(acre-ft.)
Bottom of Basin	1000	1.237	284.3	189.6		0.00
					1.26	
W.S.E.	1001	1.290	290.3	193.6		1.26
					2.00	
Top of Basin	1002.5	1.371	299.3	199.6		3.26

* Detention Basin Dimension could vary due to Site Layout

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BIORETENTION UNITS SIZING - ALTERNATIVE A

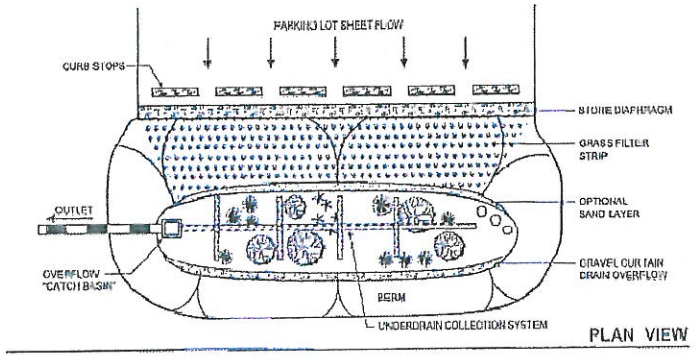
PROJECT:	Visalia Civic Center Expansion	**COMP. BY:**	A.D.	**DATE:**	9/17/2007
JOB NO:	180406V1	**CHKD. BY:**		**DATE:**	
DESCRIPTION:	Detention Units Sizing (ALTERNATIVE A)				

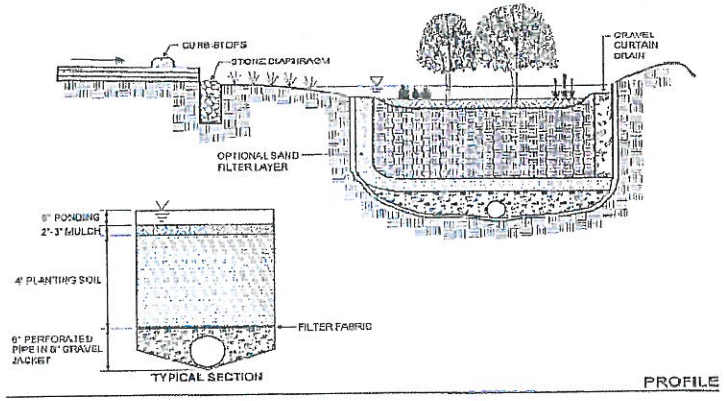
AREA 1 (WEST OF BURKE ST.) - NORTHERN PORTION

Total Design Runoff Volume (Acre-ft - ft^3):	0.5	21,780	
Number of Locations to be Installed:	3		* Number of Bioretention Unit per Developed Block
Design Runoff Volume per Unit (ft^3/Location):	7,260		
Ponding Water Depth (in - ft):	6.0	0.50	* 6 inchs Maximum Ponding Depth
Mulch Depth (in - ft):	2.5	0.21	* 2 - 3 inches
Planting Soil Depth (ft):	4.0		* 2.5 ft Minimum Soil Depth - 4 ft Maximum Soil Depth
Soil Infiltration Rate (in/hr):	0.50		* 0.5 in/hr Minimum Soil Infiltration Rate (Sand - 1.75 in/hr) - If Lower, Need to Install Underdrain
Dewatering Time (hr):	60.0		* Dewatering Time between 48 & 72 Hours
Bioretention Surface Area (ft^2):	2,596		
Bioretention Design Width (ft):	36		* 15 ft Minimum Width
Bioretention Design Length (ft):	72		* 40 ft Minimum Length (L =+/- 2*W)
Approximate Number of Trees & Shrubs:	60		

* Bioretention Dimension could vary due to Site Layout

Total Number of Trees: 17
Total Number of Shrubs: 43





Reference:
California Stormwater Quality Association - Stormwater Best Management Practice Handbook (New Development and Redevelopment)

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EST. 1968 PROVOST & PRITCHARD ENGINEERING GROUP An Employee Owned Company

BIORETENTION UNITS SIZING - ALTERNATIVE A

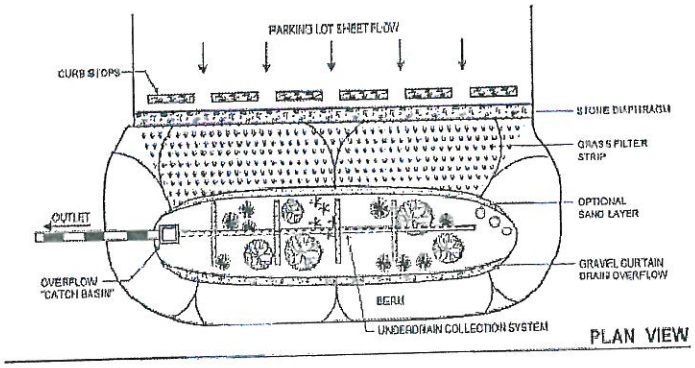
PROJECT: Visalia Civic Center Expansion
JOB NO: 180406V1
DESCRIPTION: Detention Units Sizing (ALTERNATIVE A)

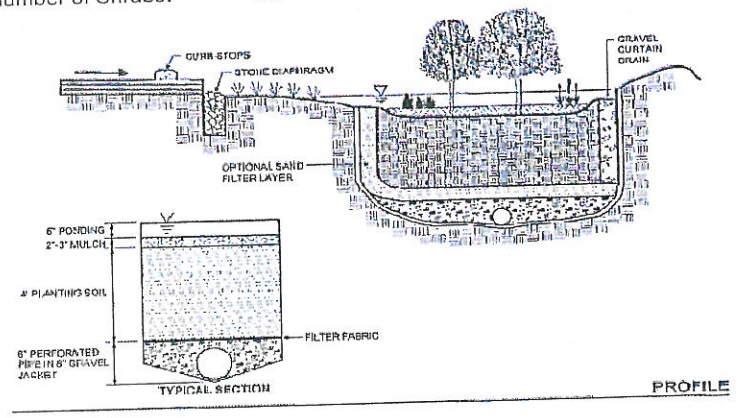
COMP. BY: A.D. DATE: 9/17/2007
CHKD. BY: DATE:

AREA 2 (EAST OF BURKE ST.)

Total Design Runoff Volume (Acre-ft - ft^3):	2.4	104,544	
Number of Locations to be Installed:	11		* Number of Bioretention Unit per Developed Block
Design Runoff Volume per Unit (ft^3/Location):	9,504		
Ponding Water Depth (in - ft):	6.0	0.50	* 6 inchs Maximum Ponding Depth
Mulch Depth (in - ft):	2.5	0.21	* 2 - 3 inches
Planting Soil Depth (ft):	4.0		* 2.5 ft Minimum Soil Depth - 4 ft Maximum Soil Depth
Soil Infiltration Rate (in/hr):	0.50		* 0.5 in/hr Minimum Soil Infiltration Rate (Sand - 1.75 in/hr) - If Lower, Need to Install Underdrain
Dewatering Time (hr):	60.0		* Dewatering Time between 48 & 72 Hours
Bioretention Surface Area (ft^2):	3,398		
Bioretention Design Width (ft):	41		* 15 ft Minimum Width
Bioretention Design Length (ft):	82		* 40 ft Minimum Length (L =+/- 2*W)
Approximate Number of Trees & Shrubs:	78		Total Number of Trees: 22 Total Number of Shrubs: 56

* Bioretention Dimension could vary due to Site Layout





Reference:
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BIORETENTION UNITS SIZING - ALTERNATIVE B

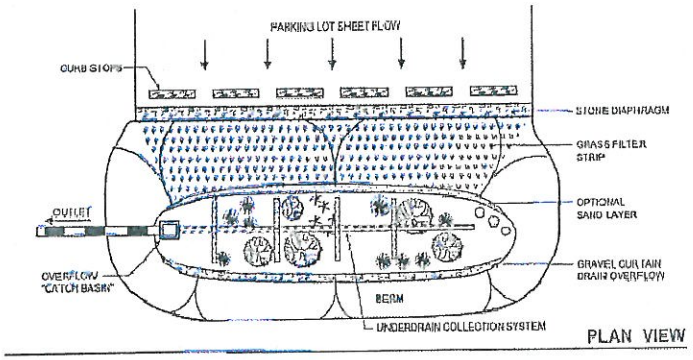
PROJECT: Visalia Civic Center Expansion **COMP. BY:** A.D. **DATE:** 9/17/2007
JOB NO: 180406V1 **CHKD. BY:** **DATE:**
DESCRIPTION: Detention Units Sizing (ALTERNATIVE B)

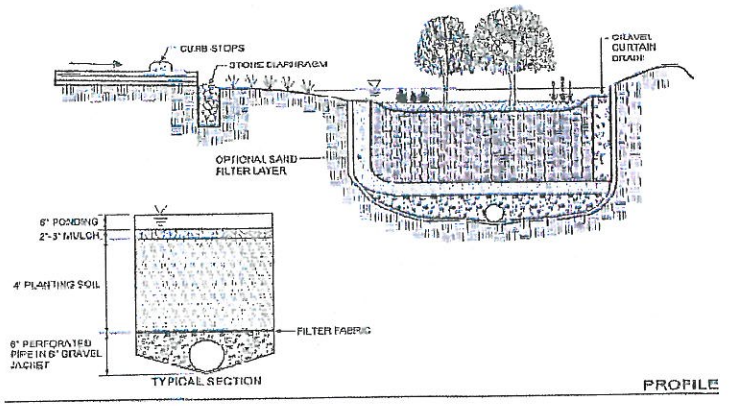
AREA 1 (WEST OF BURKE ST.) - NORTHERN PORTION

Total Design Runoff Volume (Acre-ft - ft^3):	0.5	21,780	
Number of Locations to be Installed:	3		* Number of Bioretention Unit per Developed Block
Design Runoff Volume per Unit (ft^3/Location):	7,260		
Ponding Water Depth (in - ft):	6.0	0.50	* 6 inchs Maximum Ponding Depth
Mulch Depth (in - ft):	2.5	0.21	* 2 - 3 inches
Planting Soil Depth (ft):	4.0		* 2.5 ft Minimum Soil Depth - 4 ft Maximum Soil Depth
Soil Infiltration Rate (in/hr):	0.50		* 0.5 in/hr Minimum Soil Infiltration Rate (Sand - 1.75 in/hr) - If Lower, Need to Install Underdrain
Dewatering Time (hr):	60.0		* Dewatering Time between 48 & 72 Hours
Bioretention Surface Area (ft^2):	2,596		
Bioretention Design Width (ft):	36		* 15 ft Minimum Width
Bioretention Design Length (ft):	72		* 40 ft Minimum Length (L =+/- 2*W)
Approximate Number of Trees & Shrubs:	60		

* Bioretention Dimension could vary due to Site Layout

Total Number of Trees: 17
Total Number of Shrubs: 43





Reference:
California Stormwater Quality Association - Stormwater Best Management Practice Handbook (New Development and Redevelopment)

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PROVOST & PRITCHARD INC ENGINEERING GROUP
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BIORETENTION UNITS SIZING - ALTERNATIVE B

PROJECT: Visalia Civic Center Expansion
JOB NO: 180406V1
DESCRIPTION: Detention Units Sizing (ALTERNATIVE B)

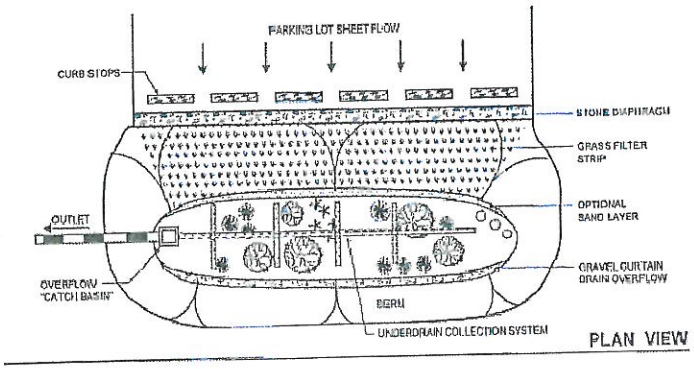
COMP. BY: A.D. DATE: 9/17/2007
CHKD. BY: DATE:

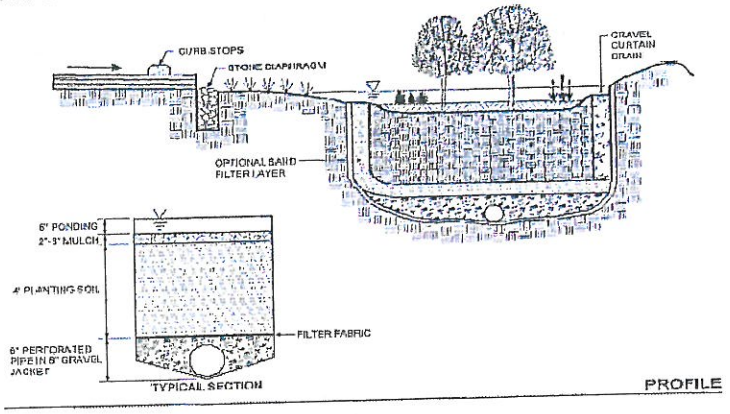
AREA 2 (EAST OF BURKE ST.)

Total Design Runoff Volume (Acre-ft - ft^3):	2.5	108,900	
Number of Locations to be Installed:	11		* Number of Bioretention Unit per Developed Block
Design Runoff Volume per Unit (ft^3/Location):	9,900		
Ponding Water Depth (in - ft):	6.0	0.50	* 6 inchs Maximum Ponding Depth
Mulch Depth (in - ft):	2.5	0.21	* 2 - 3 inches
Planting Soil Depth (ft):	4.0		* 2.5 ft Minimum Soil Depth - 4 ft Maximum Soil Depth
Soil Infiltration Rate (in/hr):	0.50		* 0.5 in/hr Minimum Soil Infiltration Rate (Sand - 1.75 in/hr) - If Lower, Need to Install Underdrain
Dewatering Time (hr):	60.0		* Dewatering Time between 48 & 72 Hours
Bioretention Surface Area (ft^2):	3,539		
Bioretention Design Width (ft):	42		* 15 ft Minimum Width
Bioretention Design Length (ft):	84		* 40 ft Minimum Length (L =+/- 2*W)
Approximate Number of Trees & Shrubs:	81		

* Bioretention Dimension could vary due to Site Layout

Total Number of Trees: 23
Total Number of Shrubs: 58





Reference:
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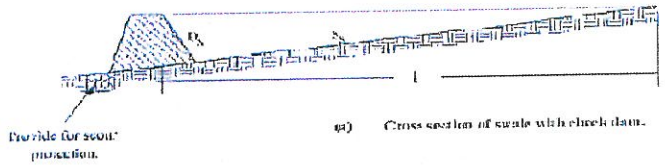
GRASSY SWALE DESIGN - ALTERNATIVE A

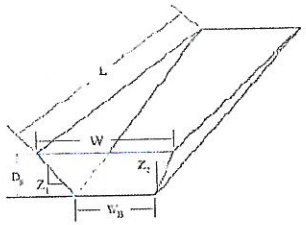
PROJECT:	Visalia Civic Center Expansion	**COMP. BY:** A.D.	**DATE:** 9/17/2007
JOB NO:	180406V1	**CHKD. BY:**	**DATE:**
DESCRIPTION:	Grassy Swale Design (ALTERNATIVE A)		

AREA 1 (WEST OF BURKE ST.) - NORTHERN & SOUTHERN PORTION

Manning's - n:	0.25	* Manning "n" value of 0.25 is typical for grass 6" high
Bottom Width (ft):	4.0	* 4 feet Minimum Bottom Width
Side Slope - z:	3.0	* Minimum Side Slope, z=3
Longitudinal Slope - S (ft/ft):	0.01	* Maximum Slope of 0.025
Water Depth - h (ft):	0.33	* Maximum Design Depth, 0.33 ft
Length of Swale - L (ft):	150	
Design Flow - Q (cfs):	0.05	
Calculated Flow - Q (cfs):	*0.41*	
Flow Area - A (ft^2)	1.65	
Wetted Perimeter - P (ft):	6.09	
Top Width - W (ft):	5.98	
Velocity - V (ft/s):	0.25	
Hydraulic Residence Time - t (min):	10.06	* Minimum Residence Time, 10 min



(a) Cross section of swale with check dam.



(b) Dimensional view of swale impoundment area.

Notation:
L = Length of swale impoundment area per check dam (ft)
D_s = Depth of check dam (ft)
S_o = Bottom slope of swale (ft/ft)
W = Top width of check dam (ft)
W_B = Bottom width of check dam (ft)
$Z_{1&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

Reference:

California Stormwater Quality Association - Stormwater Best Management Practice Handbook (New Development and Redevelopment)

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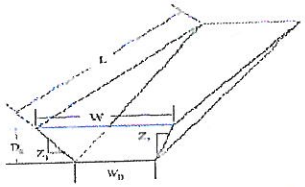
GRASSY SWALE DESIGN - ALTERNATIVE A

PROJECT:	Visalia Civic Center Expansion	**COMP. BY:**	A.D.	**DATE:**	9/17/2007
JOB NO:	180406V1	**CHKD. BY:**		**DATE:**	
DESCRIPTION:	Grassy Swale Design (ALTERNATIVE A)				

AREA 2 (EAST OF BURKE ST.)

Manning's - n:	0.25	* Manning "n" value of 0.25 is typical for grass 6" high
Bottom Width (ft):	4.0	* 4 feet Minimum Bottom Width
Side Slope - z:	3.0	* Minimum Side Slope, z=3
Longitudinal Slope - S (ft/ft):	0.01	* Maximum Slope of 0.025
Water Depth - h (ft):	0.33	* Maximum Design Depth, 0.33 ft
Length of Swale - L (ft):	150	
Design Flow - Q (cfs):	0.07	
Calculated Flow - Q (cfs):	*0.41*	
Flow Area - A (ft^2)	1.65	
Wetted Perimeter - P (ft):	6.09	
Top Width - W (ft):	5.98	
Velocity - V (ft/s):	0.25	
Hydraulic Residence Time - t (min):	10.06	* Minimum Residence Time, 10 min

(a) Cross section of swale with check dam.



(b) Dimensional view of swale impoundment area.

Notation:
L = Length of swale impoundment area per check dam (ft)
D_b = Depth of check dam (ft)
S_o = Bottom slope of swale (ft/ft)
W = Top width of check dam (ft)
W_b = Bottom width of check dam (ft)
$Z_{1,2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

Reference:

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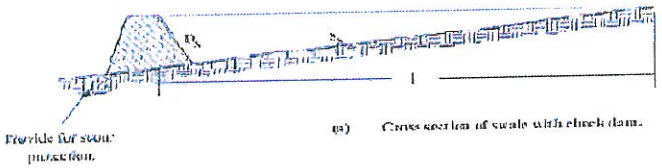
GRASSY SWALE DESIGN - ALTERNATIVE B

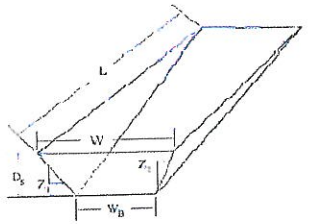
PROJECT:	Visalia Civic Center Expansion	COMP. BY: A.D.	DATE: 9/17/2007
JOB NO:	180406V1	CHKD. BY:	DATE:
DESCRIPTION:	Grassy Swale Design (ALTERNATIVE B)		

AREA 1 (WEST OF BURKE ST.) - NORTHERN & SOUTHERN PORTION

Manning's - n:	0.25	* Manning "n" value of 0.25 is typical for grass 6" high
Bottom Width (ft):	4.0	* 4 feet Minimum Bottom Width
Side Slope - z:	3.0	* Minimum Side Slope, z=3
Longitudinal Slope - S (ft/ft):	0.01	* Maximum Slope of 0.025
Water Depth - h (ft):	0.33	* Maximum Design Depth, 0.33 ft
Length of Swale - L (ft):	150	
Design Flow - Q (cfs):	0.05	
Calculated Flow - Q (cfs):	*0.41*	
Flow Area - A (ft^2)	1.65	
Wetted Perimeter - P (ft):	6.09	
Top Width - W (ft):	5.98	
Velocity - V (ft/s):	0.25	
Hydraulic Residence Time - t (min):	10.06	* Minimum Residence Time, 10 min



(a) Cross section of swale with check dam.



(b) Dimensional view of swale impoundment area.

Notation:
L = Length of swale impoundment area per check dam (ft)
D_s = Depth of check dam (ft)
S_0 = Bottom slope of swale (ft/ft)
W = Top width of check dam (ft)
W_B = Bottom width of check dam (ft)
Z_{12} = Ratio of horizontal to vertical change in swale side slope (ft/ft)

Reference:

California Stormwater Quality Association - Stormwater Best Management Practice Handbook (New Development and Redevelopment)

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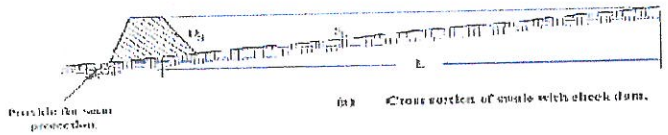
GRASSY SWALE DESIGN - ALTERNATIVE B

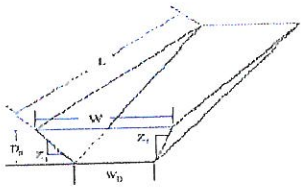
PROJECT:	Visalia Civic Center Expansion	COMP. BY:	A.D.	DATE:	9/17/2007
JOB NO:	180406V1	CHKD. BY:		DATE:	
DESCRIPTION:	Grassy Swale Design (ALTERNATIVE B)				

AREA 2 (EAST OF BURKE ST.)

Manning's - n:	0.25	* Manning "n" value of 0.25 is typical for grass 6" high
Bottom Width (ft):	4.0	* 4 feet Minimum Bottom Width
Side Slope - z:	3.0	* Minimum Side Slope, z=3
Longitudinal Slope - S (ft/ft):	0.01	* Maximum Slope of 0.025
Water Depth - h (ft):	0.33	* Maximum Design Depth, 0.33 ft
Length of Swale - L (ft):	150	
Design Flow - Q (cfs):	0.07	
Calculated Flow - Q (cfs):	*0.41*	
Flow Area - A (ft^2)	1.65	
Wetted Perimeter - P (ft):	6.09	
Top Width - W (ft):	5.98	
Velocity - V (ft/s):	0.25	
Hydraulic Residence Time - t (min):	10.06	* Minimum Residence Time, 10 min



(a) Cross section of swale with check dam.



(b) Dimensional view of swale impoundment area.

Notation:
L = Length of swale impoundment area per check dam (ft)
D_s = Depth of check dam (ft)
S_b = Bottom slope of swale (ft/ft)
W = Top width of check dam (ft)
W_b = Bottom width of check dam (ft)
Z_{ss} = Ratio of horizontal to vertical change in swale side slope (ft/ft)

Reference:

California Stormwater Quality Association - Stormwater Best Management Practice Handbook (New Development and Redevelopment)

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LID DESIGN SUMMARY (ALTERNATIVE A)

PROJECT: Visalia Civic Center Expansion
JOB NO: 180406V1
DESCRIPTION: LID Design Summary (ALTERNATIVE A)

COMP. BY: A.D. DATE: 9/17/2007
CHKD. BY: DATE:

AREA 1 (WEST OF BURKE ST.) - NORTHERN & SOUTHERN PORTION

Water Quality - Volume Based (Northern Portion):

Total 85th Percentile Runoff Volume - V (Acre-ft):	3.3
Number of Locations to Treat:	3
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	1.1

Bioretention Basin:

Volume of Bioretention Basin (Acre-ft):	0.5
Number of Locations to be Installed:	3
Volume of Bioretention Basin per Location (ft^3/Location):	7,260
Dewatering Time (hr):	60
Bioretention Design Width (ft):	36
Bioretention Design Length (ft):	72
Total Number of Trees:	17
Total Number of Shrubs:	43

Detention Basin:

Flow to Detain (cfs):	3.2
Volume of Detention Basin (Acre-ft):	0.36
Heigth of Basin (ft):	1
Freeboard (ft):	1.5
Side Slopes:	2

Water Quality - Flow Based (Northern & Southern Portion):

Total 85th Percentile Runoff Flow - Q (cfs):	0.1
Number of Locations to Treat:	3
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	0.05

Grassy Swale:

Bottom Width (ft):	4
Side Slope - z:	3
Longitudinal Slope - S (ft/ft):	0.01
Water Depth - h (ft):	0.33
Length of Swale - L (ft):	150
Design Flow - Q (cfs):	0.05
Calculated Flow - Q (cfs):	0.41
Hydraulic Residence Time - t (min):	10.06

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LID DESIGN SUMMARY (ALTERNATIVE A)

PROJECT: Visalia Civic Center Expansion
JOB NO: 180406V1
DESCRIPTION: LID Design Summary (ALTERNATIVE A)

COMP. BY: A.D. DATE: 9/17/2007
CHKD. BY: DATE:

AREA 2 (EAST OF BURKE ST.)

Water Quality - Volume Based:

Total 85th Percentile Runoff Volume - V (Acre-ft):	18.1
Number of Locations to Treat:	11
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	1.6

Bioretention Basin:

Volume of Bioretention Basin (Acre-ft):	2.4
Number of Locations to be Installed:	11
Volume of Bioretention Basin per Location (ft^3/Location):	9,504
Dewatering Time (hr):	60
Bioretention Design Width (ft):	41
Bioretention Design Length (ft):	82
Total Number of Trees:	22
Total Number of Shrubs:	56

Detention Basin:

Flow to Detain (cfs):	12.9
Volume of Detention Basin (Acre-ft):	1.25
Heigth of Basin (ft):	1
Freeboard (ft):	1.5
Side Slopes:	2

Water Quality - Flow Based:

Total 85th Percentile Runoff Flow - Q (cfs):	0.8
Number of Locations to Treat:	11
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	0.07

Grassy Swale:

Bottom Width (ft):	4
Side Slope - z:	3
Longitudinal Slope - S (ft/ft):	0.01
Water Depth - h (ft):	0.33
Length of Swale - L (ft):	150
Design Flow - Q (cfs):	0.05
Calculated Flow - Q (cfs):	0.41
Hydraulic Residence Time - t (min):	10.06

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LID DESIGN SUMMARY (ALTERNATIVE B)

PROJECT: Visalia Civic Center Expansion
JOB NO: 180406V1
DESCRIPTION: LID Design Summary (ALTERNATIVE B)

COMP. BY: A.D. DATE: 9/17/2007
CHKD. BY: DATE:

AREA 1 (WEST OF BURKE ST.) - NORTHERN & SOUTHERN PORTION

Water Quality - Volume Based (Northern Portion):

Total 85th Percentile Runoff Volume - V (Acre-ft):	3.3
Number of Locations to Treat:	3
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	1.1

Bioretention Basin:

Volume of Bioretention Basin (Acre-ft):	0.5
Number of Locations to be Installed:	3
Volume of Bioretention Basin per Location (ft^3/Location):	7,260
Dewatering Time (hr):	60
Bioretention Design Width (ft):	36
Bioretention Design Length (ft):	72
Total Number of Trees:	17
Total Number of Shrubs:	43

Detention Basin:

Flow to Detain (cfs):	3.2
Volume of Detention Basin (Acre-ft):	0.36
Heigth of Basin (ft):	1
Freeboard (ft):	1.5
Side Slopes:	2

Water Quality - Flow Based (Northern & Southern Portion):

Total 85th Percentile Runoff Flow - Q (cfs):	0.1
Number of Locations to Treat:	3
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	0.05

Grassy Swale:

Bottom Width (ft):	4
Side Slope - z:	3
Longitudinal Slope - S (ft/ft):	0.01
Water Depth - h (ft):	0.33
Length of Swale - L (ft):	150
Design Flow - Q (cfs):	0.05
Calculated Flow - Q (cfs):	0.41
Hydraulic Residence Time - t (min):	10.06

V:\Clients\EDAW-1804\180406V1 Visalia Civic Center Expansion\Calculations\180406V1 - Water Quality & LID Design.xlsx

PROVOST & PRITCHARD ENGINEERING GROUP
EST. 1956
An Employee Owned Company

LID DESIGN SUMMARY (ALTERNATIVE B)

PROJECT: Visalia Civic Center Expansion
JOB NO: 180406V1
DESCRIPTION: LID Design Summary (ALTERNATIVE B)
COMP. BY: A.D. DATE: 9/17/2007
CHKD. BY: DATE:

AREA 2 (EAST OF BURKE ST.)

Water Quality - Volume Based:

Total 85th Percentile Runoff Volume - V (Acre-ft):	18.7
Number of Locations to Treat:	11
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	1.7

Water Quality - Flow Based:

Total 85th Percentile Runoff Flow - Q (cfs):	0.8
Number of Locations to Treat:	11
Design 85th Percentile Runoff Volume - V (Acre-ft/Location):	0.07

Bioretention Basin:

Volume of Bioretention Basin (Acre-ft):	2.5
Number of Locations to be Installed:	11
Volume of Bioretention Basin per Location (ft^3/Location):	9,900
Dewatering Time (hr):	60
Bioretention Design Width (ft):	42
Bioretention Design Length (ft):	84
Total Number of Trees:	23
Total Number of Shrubs:	58

Grassy Swale:

Bottom Width (ft):	4
Side Slope - z:	3
Longitudinal Slope - S (ft/ft):	0.01
Water Depth - h (ft):	0.33
Length of Swale - L (ft):	150
Design Flow - Q (cfs):	0.05
Calculated Flow - Q (cfs):	0.41
Hydraulic Residence Time - t (min):	10.06

Detention Basin:

Flow to Detain (cfs):	12.9
Volume of Detention Basin (Acre-ft):	1.29
Heigth of Basin (ft):	1
Freeboard (ft):	1.5
Side Slopes:	2