DRAINAGE REPORT

NEVADA COUNTY HABITAT FOR HUMANITY – JOYCE DRIVE DEVELOPMENT (SOUTH SIDE)

Grass Valley, CA1

Prepared for:

NEVADA COUNTY HABITAT FOR HUMANITY

P.O. BOX 2997
Grass Valley, CA 95945
T (530) 274-1951

Prepared by:

SCO PLANNING & ENGINEERING, INC.

140 Litton Drive, Suite 240
Grass Valley, CA 95945
T (530) 272-5841

NOVEMBER, 2019

DRAINAGE REPORT
Habitat for Humanity Development
Joyce Drive (South Side)
TABLE OF CONTENTS

PAGE

SECTION 1: SUMMARY

A. PURPOSE 1
B. INTRODUCTION 1
   1. Existing Site Conditions 1
   2. Proposed Site Drainage System 1
   3. Water Quality Treatment Methods 2
C. METHODOLOGY 3
   1. Hydrology 3
   2. Hydraulics 3
D. RESULTS AND CONCLUSIONS 3
E. REFERENCES 4

SECTION 2: HYDROLOGY CALCULATIONS

SECTION 3: WATER QUALITY TREATMENT

EXHIBITS

EXHIBIT 1: VICINITY MAP

APPENDICES

APPENDIX A: HYDROLOGY MAPS

SECTION 1: SUMMARY

A. PURPOSE

The purpose of this report is:

- Describe the existing watershed characteristic within the project area;
- Provide a hydrologic drainage analysis per City standards
- Describe the proposed storm drainage and water quality treatment system.

B. INTRODUCTION

The Habitat for Humanity, Joyce Drive Development is located southwesterly of Whiting street and is composed of two parcels totaling 3.74 acres. (APN.29-280-16 & 29-270-33)

Existing Site Conditions:

The property consists of grass covered pasture type areas with natural slopes of varying gradients of 4-15%. Generally, offsite and onsite storm runoff consists of sheet flow and concentrated flow in undefined drainage ditches that convey flow to a natural drainage course located within the westerly ½ of the site. Stormwater gradually channelizes in a southerly direction, combining with runoff from the undeveloped site and Joyce drive. Stormwater then passes through an existing 12" culvert under existing Joyce drive and continues offsite towards the Highway 29 and ultimately to Wolf Creek located westerly.

The overall watershed area is 9.9 acres which is sloping southeasterly towards the existing wetland and Joyce Drive culvert crossing.

Proposed Site Drainage System:

On-site drainage will be collected in a new drainage system containing drainage inlets, storm drain, manholes etc. Runoff from the proposed residences will exit roof downspouts into small infiltration trenches prior to discharge to the existing natural drainage course. Runoff from pavement area is conveyed along curb and gutter to one of two storm drain inlets with deepened sumps for retention and infiltration. Storm water is further conveyed through new storm drain and ultimately will enter a "Stormceptor" manhole for removal of potential pollutants prior to discharge into a new Bio-Swale, then conveyed to a new retention pond allowing infiltration and removal of potential pollutants prior to discharge to the adjacent natural drainage course. The existing 12" culvert crossing Joyce Dr. presently will be removed and replaced with a new 24" culvert to improve the hydraulic capacity of the culvert crossing. Stormwater runoff from the portion of Joyce Drive on the south side of centerline, or "crown" of Joyce Drive will sheet flow through a vegetative buffer strip, reducing velocities, allowing infiltration and removal of potential pollutants prior to discharge to the adjacent natural drainage course. All drainage facilities are designed to accommodate the required storm events in accordance with City of Grass Valley requirements.

Water Quality Treatment Methods:

Storm drainage from impervious areas (roads, walks, roofs) is collected and routed through water quality treatment facilities for removal of potential pollutants. A matrix of treatment facilities being used for this project is provided in Section 4. This consists of a Multiple Treatment System which includes the following Best Management Practices (BMP's) in series prior to discharge of flow to existing drainage facilities.

BMP #

TC-10 Infiltration trenches will be installed at roof downspouts for both retention of storm water runoff and for capturing pollutants prior to entering the natural drainage course. Runoff is stored in the void space between the stones and infiltrates into surrounding soil.

TC-11 Infiltration basins will be installed at the end of the biofiltration swales for stormwater runoff storage and exfiltration into the underlying soil. Pollutant removal occurs through the infiltration of runoff and the absorption of pollutants into the soil and vegetation.

TC-30 Vegetated biofiltration swales will be provided at the discharge of the underground storm water piping. The swale will trap particulate pollutants, promote infiltration, reduce flow velocity, and increase time of concentration of stormwater runoff.

TC-31 A vegetated buffer strip will be provided southerly of the Joyce Drive roadway. The fill slope and area up to the right of way will have amended soils and be seeded to create a vegetated buffer strip that will filter sheet flow from the roadway crown southerly. The strip will reduce runoff velocities allowing stormwater infiltration and filtration of potential pollutants.

TC-50 Water Quality Inlets consists of a 1' deep sump at bottom of all storm drain inlets that collects sand and sediment and allows infiltration. At the downstream manhole, there will be an in-line Stormceptor manhole to remove trash and debris and larger suspended solids using radial flow prior to discharge.

During construction, additional BMP's including temporary erosion control facilities shall be implemented to control pollutants that have a potential to affect the quality of storm water discharges from the construction site. Implementation of BMP's for Construction Activities will be in accordance with California State Water Resources Control Board (SWRCB) requirements.

C. METHODOLOGY

Hydrology

Hydrology calculations for the project site are provided herein per the City of Grass Valley Storm Drainage Master Plan. Pre- and post-development hydrology analyses include calculations of impervious surfaces for the purpose of determining impacts of the proposed development. Peak flows were determined for 10- 25- and 100-year storm events.

The post-development rate and volume will be reduced below the pre-development rate and volume with the retention facilities and BMPS's identified herein. Onsite retention facilities will reduce the post-development flow by attenuating the peak flow. Post-Mitigated (after retention) Flow calculation is based on Federal Highway Administration Hydraulic Design of Highway Culverts, Hydraulic Design Series No. 5 (HDS-5).

The Pre- and Post-development hydrology maps are provided herein for reference (see Appendix A, Hydrology Maps).

Hydraulics

No hydraulic calculations are provided due to the oversized storm drain piping for a 100-year event in accordance with City standards.

D. RESULTS AND CONCLUSIONS

We have determined the difference between pre- and post-development flows, as required by the City, and we have designed all culverts, storm drain, and outlet structures in conformance with City Standards. A summary of flows is included in Section 2, Hydrology Calculations. The Post-Mitigated flow is reduced to pre-project rates and quantities for the 10-yr, 25-yr and 100-yr storm events as required by the project conditions of approval. Analysis of pre- and post-development hydrology indicates that downstream facilities will not be affected by the development.

This project includes Water Quality Treatment facilities in accordance with State Regional Water Quality Control Board and City requirements. The retention facilities provide water quality treatment, recharge natural groundwater and attenuate peak flows thus reducing runoff volume and rate of discharge.

E. REFERENCES

- *City of Grass Valley Storm Water Master Plan & Criteria*, dated March 1986.
- *City of Grass Valley Improvement Standards,* dated March 2009.
- *Improvement Plans for Habitat for Humanity Development, Joyce Drive, prepared by SCO Planning & Engineering, Inc.,* dated July 2010.

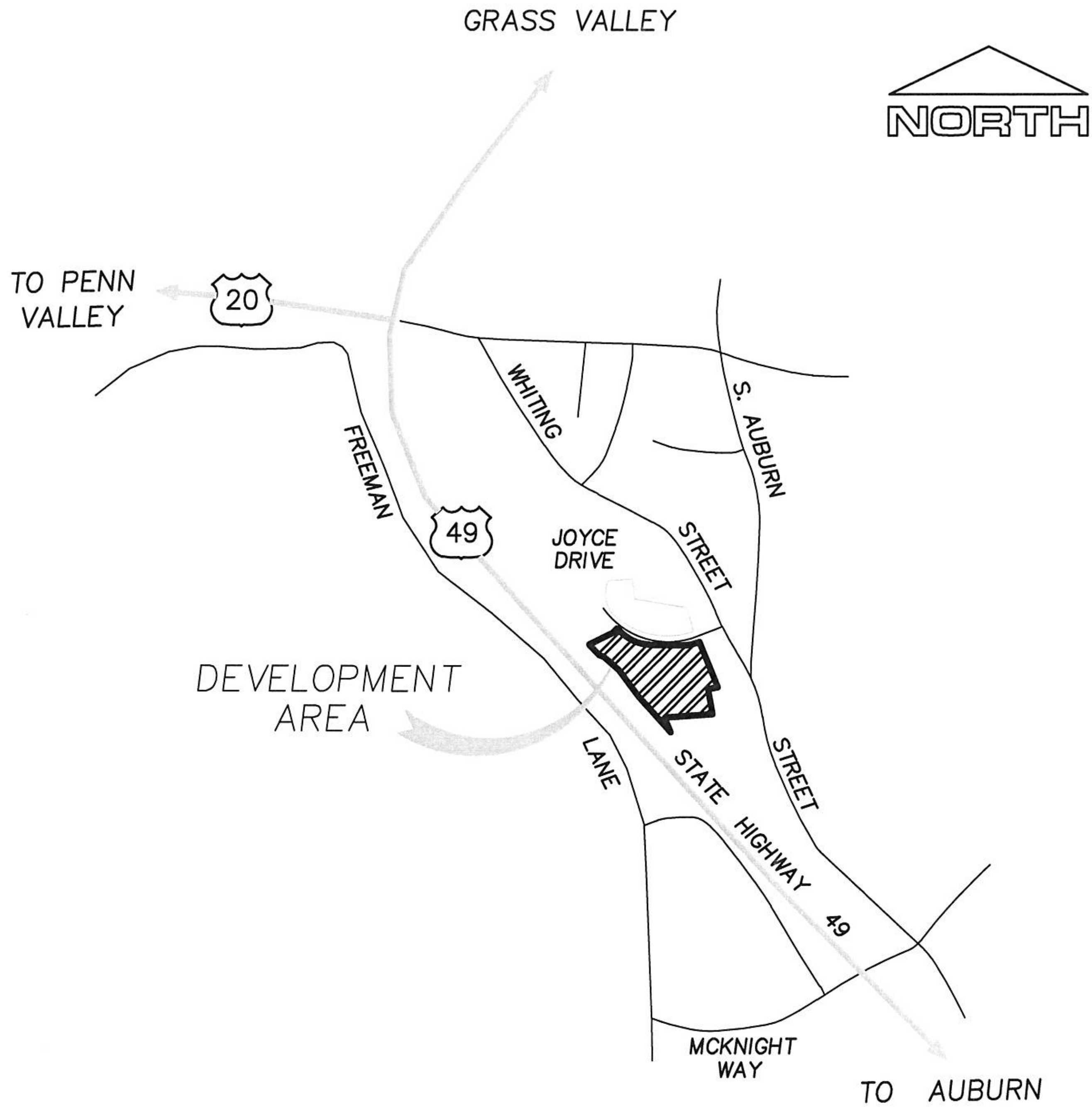
As always please feel free to contact our office at (530) 272-5841 with any questions.

SCO PLANNING & ENGINEERING, INC.

Steven Kline, P.E.
Senior Design Engineer

EXHIBIT 1

VICINITY MAP



LOCATION MAP

SCALE: N.T.S

GRASS VALLEY
530·272-5841
TRUCKEE
530·582-4043
FAX: 530·272-5880

SCO
PLANNING
ENGINEERING
& SURVEYING

CALIFORNIA

DESIGNED:

DATE:

SECTION 2:

HYDROLOGY CALCULATIONS

SUMMARY OF PEAK FLOWS (RATIONAL METHOD)

	Drainage Basin	Area (AC)	Response Time (min)	10-YR (cfs)	25-YR (cfs)	100-YR (cfs)	Onsite Retention (cf)
Pre-Development	A-2	0.74	14.00	0.38	0.42	0.72	-
	A-3	1.63	14.30	0.84	0.92	1.59	-
	Total	2.37		1.23	1.34	2.31	
Post-Dev Q's (not including onsite retention*)							
Post-Development	A-2	0.74	10.00	0.80	0.87	1.19	360.00
	A-3	1.63	14.68	1.63	1.77	2.37	900.00
	Total	2.37		2.43	2.64	3.55	
Post-Dev Q's (including onsite retention**)							
Post-Mitigated Flow	O-2 + A-2			0.35	0.42	0.74	
Post-Mitigated Flow	O-3 + A-3			0.86	1.00	1.60	
	Total Post-Mitigated Flow			1.21	1.42	2.34	

Notes:
* The post-development flow is more than pre-development flow as a result of an increase in impervious surfaces.
**The Post-Mitigated Flow includes the effect of attenuation from onsite retention facilities.
Retention facilities for this project is a vegetative buffer strip, drainage inlet sumps and roof downspout infiltration trenches

Post-Mitigated Flow calculation is based on Federal Highway Administration Hydraulic Design of Highway Culverts, Hydraulic Design Series No. 5 (HDS-5). Storage Routing Calculation is based on available storage and this equation:

Qr = Qp - S / 80tp

Qp - Peak Flow (cfs) without onsite retention
S - Available Onsite Storage/Retention
tp - Time to Peak (min)

As described in FHWA's HDS-5, this calculation method is a 'quick, direct solution for the reduced outflow'. If further confirmatic or analysis is needed, the full routing calculation with Stage-Storage calculations and Inflow/Outflow Hydrographs should be use

Joyce Drive **Grass Valley, CA**

PRE-DEV. HYDROLOGY **Project No:** 201808

"A" : **AREA** A-2 **=** 0.735 **AC**

"C" : RUNOFF COEFFICIENT

				C
ROOF	=	0.00	AC	0.95
PAVEMENT	=	0.00	AC	0.90
GRAVEL	=	0.00	AC	0.30
LANDSCAPED	=	0.00	AC	0.25
NATURAL	=	**0.74**	AC	0.29
Total	=	0.74	AC	

C for Unimproved Area

Slope	0.12
Permeability	0.05
Vegetation	0.06
Surface	0.06
Natural C	0.29

COMPOSITE "C"

C (10/25yr)	**=**	0.29
C (100yr)	**=**	0.43

"I" : INTENSITY

Sheet Flow	L	=	220.00	ft
	S	=	5.20	%
Channel Flow	L	=	0.00	ft
	S	=	6.50	%
	V	=	6.00	fps
Ti (Sheet)		=	14.0	min
Tt (Channel)		=	**0.0**	min
Ti+Tt		=	**14.0**	min
Tc		**=**	**14.0**	**min**

For Tc<=70min $I = 1.8.2(6.02T)^X$

I (10yr)	**=**	1.81	**in/hr**
I (25yr)	**=**	1.96	**in/hr**
I (100yr)	**=**	2.27	**in/hr**

Q = C I A			
Q (10yr)	**=**	0.38	**cfs**
Q (25yr)	**=**	0.42	**cfs**
Q (100yr)	**=**	0.72	**cfs**

Joyce Drive **Grass Valley, CA**

PRE-DEV. HYDROLOGY **Project No:** 201808

"A" : **AREA** A-3 **=** 1.63 **AC**

"C" : RUNOFF COEFFICIENT

				C
ROOF	=	0.00	AC	0.95
PAVEMENT	=	0.00	AC	0.90
GRAVEL	=	0.00	AC	0.30
LANDSCAPED	=	0.00	AC	0.25
NATURAL	=	1.63	AC	0.29
Total	=	1.63	AC	

C for Unimproved Area

Slope	0.12
Permeability	0.05
Vegetation	0.06
Surface	0.06
Natural C	0.29

COMPOSITE "C"

C (10/25yr)	**=**	0.29
C (100yr)	**=**	0.43

"I" : INTENSITY

Sheet Flow	L	=	260.00	ft
	S	=	7.50	%
Channel Flow	L	=	0.00	ft
	S	=	6.50	%
	V	=	6.00	fps
Ti (Sheet)		=	14.3	min
Tt (Channel)		=	0.0	min
Ti+Tt		=	14.3	min
Tc		**=**	**14.3**	**min**

For Tc<=70min $I = 1.8.2(6.02T)^X$

I (10yr)	**=**	1.79	**in/hr**
I (25yr)	**=**	1.94	**in/hr**
I (100yr)	**=**	2.25	**in/hr**

Q = C I A			
Q (10yr)	**=**	0.84	**cfs**
Q (25yr)	**=**	0.92	**cfs**
Q (100yr)	**=**	1.59	**cfs**

Joyce Drive — **Grass Valley, CA**

POST-DEV. HYDROLOGY — **Project No:** 201808

"A" : **AREA** A-2 = 0.735 AC

"C" : RUNOFF COEFFICIENT

				C
ROOF	=	0.07	AC	0.95
PAVEMENT	=	0.19	AC	0.90
GRAVEL	=	0.00	AC	0.30
LANDSCAPED	=	0.07	AC	0.25
NATURAL	=	0.40	AC	0.29
Total	=	0.74	AC	

C for Unimproved Area

Slope	0.12
Permeability	0.05
Vegetation	0.06
Surface	0.06
Natural C	0.29

COMPOSITE "C"

C (10/25yr)	=	0.51
C (100yr)	=	0.61

"I" : INTENSITY

Sheet Flow	L	=	111.00	ft
	S	=	0.05	%
Channel Flow	L	=	140.00	ft
	S	=	0.04	%
	V	=	2.00	fps
Ti (Sheet)		=	7.8	min
Tt (Channel)		=	1.2	min
Ti+Tt		=	9.0	min
Tc		=	10.0	**min**

For Tc<=70min $I = 1.8.2(6.02T)^X$

I (10yr)	=	2.15	**in/hr**
I (25yr)	=	2.33	**in/hr**
I (100yr)	=	2.66	**in/hr**

Q = C I A			
Q (10yr)	=	0.80	cfs
Q (25yr)	=	0.87	cfs
Q (100yr)	=	1.19	cfs

Joyce Drive	**Grass Valley, CA**
POST-DEV. HYDROLOGY	**Project No:** 201808

"A" : **AREA** A-3 **=** 1.63 **AC**

"C" : RUNOFF COEFFICIENT

				C
ROOF	=	0.43	AC	0.95
PAVEMENT	=	0.30	AC	0.90
GRAVEL	=	0.00	AC	0.30
LANDSCAPED	=	0.40	AC	0.25
NATURAL	=	0.50	AC	0.29
Total	=	1.63	AC	

C for Unimproved Area	
Slope	0.12
Permeability	0.05
Vegetation	0.06
Surface	0.06
Natural C	0.29

COMPOSITE "C"

C (10/25yr)	**=**	0.57
C (100yr)	**=**	0.65

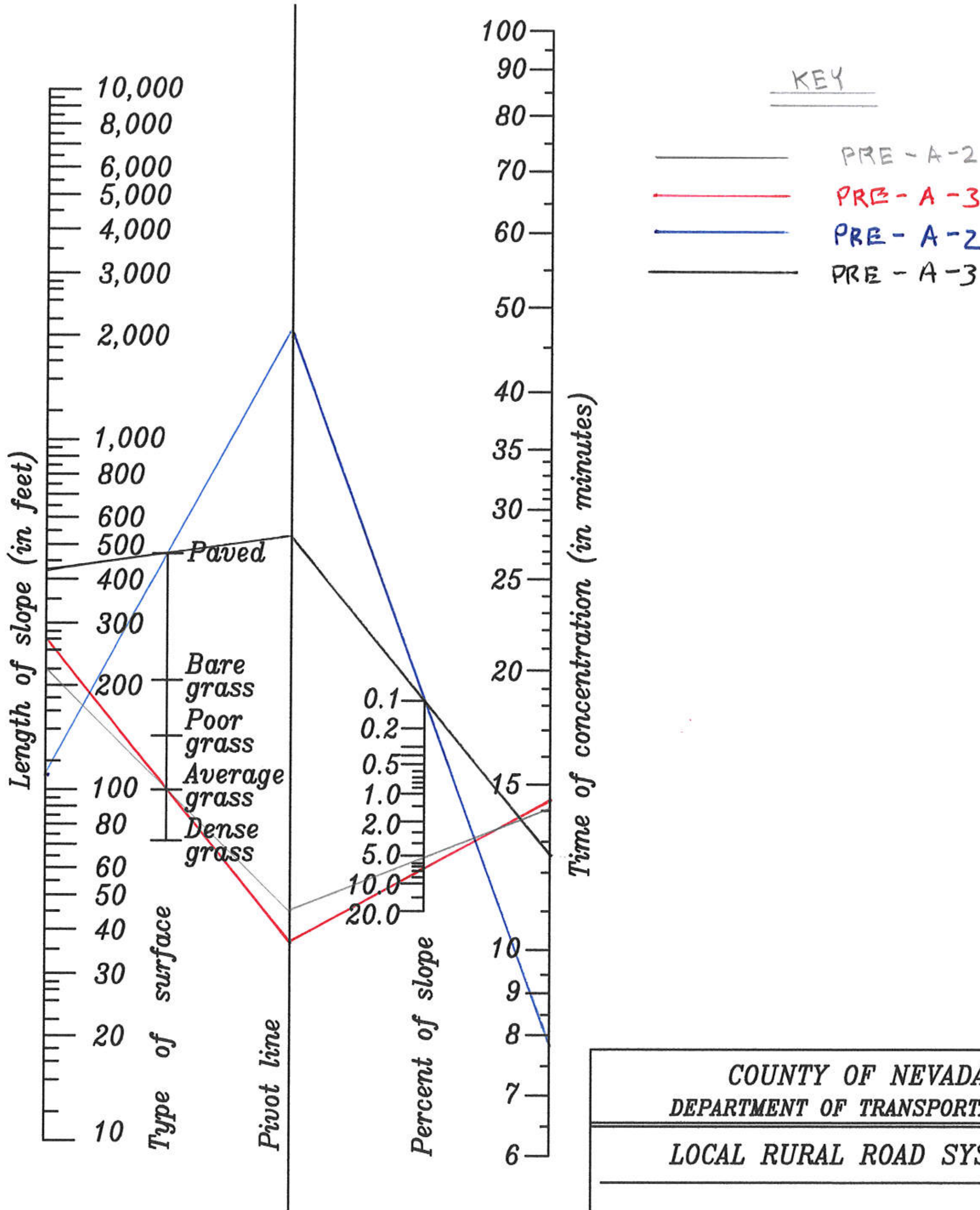
"I" : INTENSITY

Sheet Flow	L	=	425.00	ft
	S	=	0.04	%
Channel Flow	L	=	125.00	ft
	S	=	0.01	%
	V	=	1.00	fps
Ti (Sheet)		=	12.6	min
Tt (Channel)		=	2.1	min
Ti+Tt		=	14.7	min
Tc		**=**	14.7	**min**

For Tc<=70min $I = 1.8.2(6.02T)^X$

I (10yr)	**=**	1.76	**in/hr**
I (25yr)	**=**	1.92	**in/hr**
I (100yr)	**=**	2.22	**in/hr**

Q = C I A			
Q (10yr)	**=**	1.63	**cfs**
Q (25yr)	**=**	1.77	**cfs**
Q (100yr)	**=**	2.37	**cfs**



COUNTY OF NEVADA
DEPARTMENT OF TRANSPORTATION

LOCAL RURAL ROAD SYSTEM

TIME OF CONCENTRATION SHEET FLOW

REGISTERED PROFESSIONAL ENGINEER
JOHN W. RUMSEY, III
No. 40386
Exp. 3-31-99
CIVIL
STATE OF CALIFORNIA

Approved by:
John W. Rumsey 5-10-95
Senior Civil Engineer Date

STANDARD DRAWING
D-8

Rev.5-10-95

VELOCITIES IN GUTTERS, CHANNELS & EXISTING DRAINAGE CHANNELS FOR GIVEN SLOPE

Slope	Velocity	Slope	Velocity
0.5%	= 1.7'/Sec	8.0	= 6.6
1.0	= 2.3	.5	= 6.9
1.5	= 3.0	9.0	= 7.2
2.0	= 3.4	.5	= 7.5
2.5	= 3.8	10.0	= 7.8
3.0	= 4.2	.5	= 8.0
3.5	= 4.4	11.0	= 8.2
4.0	= 4.6	.5	= 8.5
.5	= 4.8	12.0	= 8.7
5.0	= 5.0	.5	= 8.9
.5	= 5.2	13.0	= 9.1
6.0	= 5.4	.5	= 9.3
.5	= 5.7	14.0	= 9.6
7.0	= 6.0	.5	= 9.8
.5	= 6.3	15.0	= 10.0

NOTE: The velocities shown hereon are to be used only for the purpose of calculating Tc, Time of Concentration.

REGISTERED PROFESSIONAL ENGINEER
JOHN W. RUMSEY, III
No. 40386
Exp. 3-31-99
CIVIL
STATE OF CALIFORNIA

COUNTY OF NEVADA
DEPARTMENT OF TRANSPORTATION

LOCAL RURAL ROAD SYSTEM

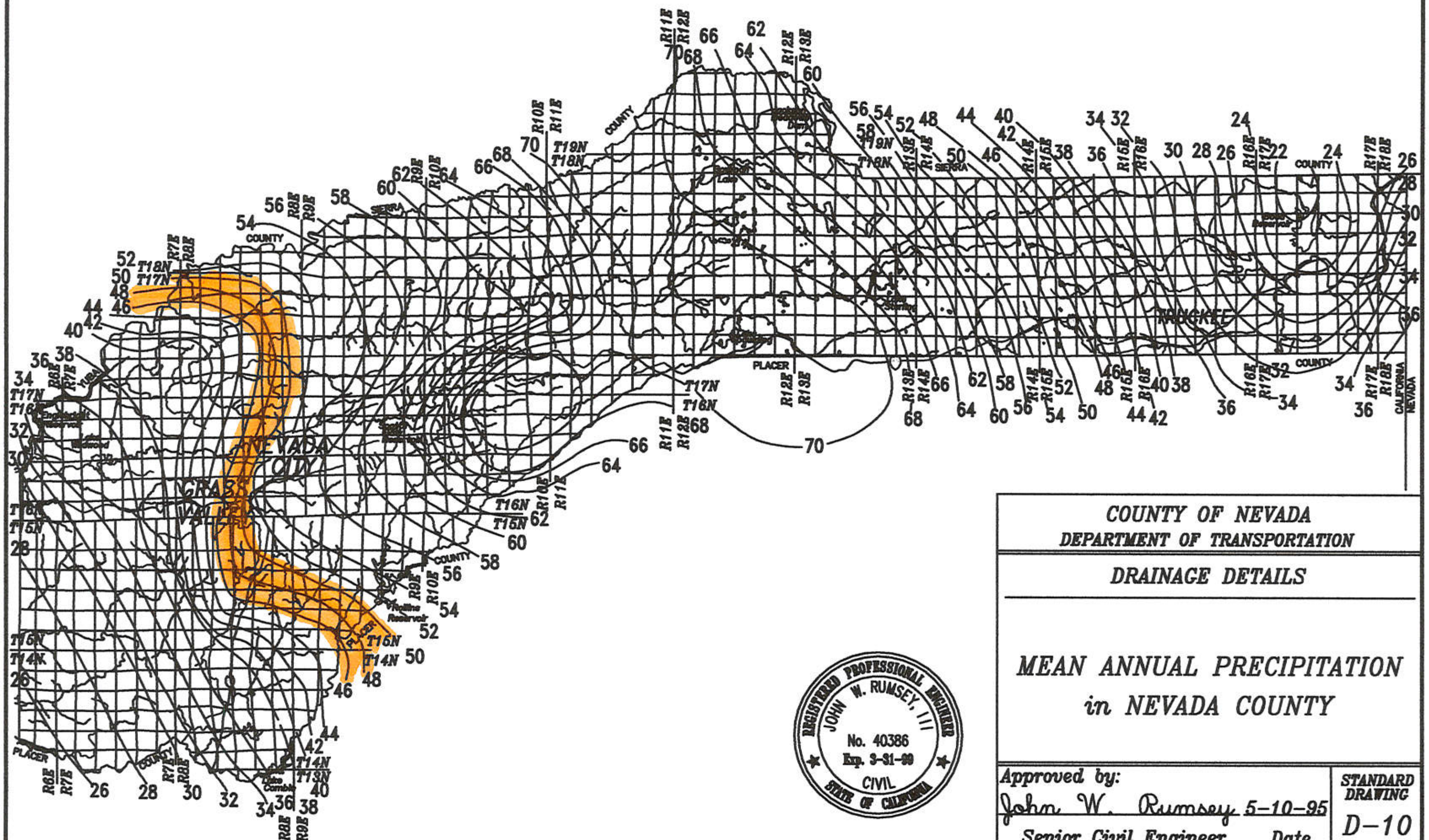
VELOCITIES IN GUTTERS & CHANNELS

Approved by:
John W. Rumsey 5-10-95
Senior Civil Engineer Date

STANDARD DRAWING
D-9

Rev.5-10-95

NEVADA COUNTY



COUNTY OF NEVADA
DEPARTMENT OF TRANSPORTATION

DRAINAGE DETAILS

MEAN ANNUAL PRECIPITATION
in NEVADA COUNTY

Approved by:
John W. Rumsey 5-10-95
Senior Civil Engineer Date

STANDARD DRAWING
D-10

Rev.5-10-95

REMARKS

NEVADA COUNTY DESIGN STORM (INTENSITY)

10 YEAR STORM DURATION IN MINUTES FOR NEVADA COUNTY

Mean Annual Precipitation Inches	5	10	15	30	60 1hr	120 2Hr	180 3Hr	360 6Hr	720 12Hr	1440 24Hr
	Intensity in inches per hour									
20	1.57	1.15	.96	.70	.51	.38	.31	.23	.17	.12
22	1.68	1.23	1.03	.75	.55	.40	.34	.25	.18	.13
24	1.80	1.31	1.10	.80	.59	.43	.36	.26	.19	.14
26	1.91	1.40	1.17	.85	.62	.46	.38	.28	.20	.15
28	2.02	1.48	1.23	.90	.66	.48	.40	.30	.22	.16
30	2.14	1.57	1.30	.95	.70	.51	.43	.31	.23	.17
32	2.25	1.65	1.37	1.01	.74	.54	.45	.33	.24	.18
34	2.37	1.73	1.44	1.06	.77	.57	.47	.35	.25	.19
36	2.48	1.82	1.51	1.11	.81	.59	.49	.36	.27	.19
38	2.59	1.90	1.58	1.16	.85	.62	.52	.38	.28	.20
40	2.71	1.98	1.65	1.21	.89	.65	.54	.40	.29	.21
42	2.82	2.07	1.72	1.26	.92	.68	.56	.41	.30	.22
44	2.94	2.15	1.79	1.31	.96	.70	.59	.43	.31	.23
46	3.05	2.23	1.86	1.36	1.00	.73	.61	.45	.33	.24
48	3.17	2.32	1.93	1.41	1.03	.76	.63	.46	.34	.25
50	3.28	2.40	2.00	1.46	1.07	.78	.65	.48	.35	.26
52	3.39	2.48	2.07	1.52	1.11	.81	.68	.50	.36	.27
54	3.51	2.57	2.14	1.57	1.15	.84	.70	.51	.37	.27
56	3.62	2.65	2.21	1.62	1.18	.87	.72	.53	.39	.28
58	3.74	2.73	2.28	1.67	1.22	.89	.74	.55	.40	.29
60	3.85	2.82	2.35	1.72	1.26	.92	.77	.56	.41	.30
62	3.96	2.90	2.42	1.77	1.30	.95	.79	.58	.42	.31
64	4.08	2.98	2.49	1.82	1.33	.98	.81	.60	.44	.32
66	4.19	3.07	2.56	1.87	1.37	1.00	.84	.61	.45	.33
68	4.31	3.15	2.63	1.92	1.41	1.03	.86	.63	.46	.34
70	4.42	3.24	2.70	1.97	1.44	1.06	.88	.65	.47	.35
72	4.53	3.32	2.77	2.02	1.48	1.08	.90	.66	.48	.35
74	4.65	3.40	2.84	2.08	1.52	1.11	.93	.68	.50	.36
76	4.76	3.49	2.90	2.13	1.56	1.14	.95	.70	.51	.37
78	4.88	3.57	2.97	2.18	1.59	1.17	.97	.71	.52	.38
80	4.99	3.65	3.04	2.23	1.63	1.19	.99	.73	.53	.39

COUNTY OF NEVADA
DEPARTMENT OF TRANSPORTATION

DRAINAGE DETAIL

10 YEAR STORM DURATION IN MINUTES FOR NEVADA COUNTY

Approved by:

John W. Rumsey 5-11-95

Senior Civil Engineer Date

STANDARD DRAWING

D-11

Rev.5-11-95

NEVADA COUNTY DESIGN STORM (INTENSITY)

100 YEAR STORM DURATION IN MINUTES FOR NEVADA COUNTY

Mean Annual Precipitation Inches	5	10	15	30	60 1hr	120 2hr	180 3hr	360 6hr	720 12hr	1440 24hr
	Intensity in inches per hour									
20	2.22	1.63	1.36	.99	.73	.53	.44	.32	.24	.17
22	2.39	1.75	1.46	1.07	.78	.57	.48	.35	.25	.19
24	2.55	1.86	1.55	1.14	.83	.61	.51	.37	.27	.20
26	2.71	1.98	1.65	1.21	.89	.65	.54	.40	.29	.21
28	2.87	2.10	1.75	1.28	.94	.69	.57	.42	.31	.22
30	3.03	2.22	1.85	1.35	.99	.73	.60	.44	.32	.24
32	3.19	2.34	1.95	1.43	1.04	.76	.64	.47	.34	.25
34	3.36	2.46	2.05	1.50	1.10	.80	.67	.49	.36	.26
36	3.52	2.58	2.15	1.57	1.15	.84	.70	.51	.38	.28
38	3.68	2.69	2.24	1.64	1.20	.88	.73	.54	.39	.29
40	3.84	2.81	2.34	1.72	1.26	.92	.77	.56	.41	.30
42	4.00	2.93	2.44	1.79	1.31	.96	.80	.58	.43	.31
44	4.17	3.05	2.54	1.86	1.36	1.00	.83	.61	.45	.33
46	4.33	3.17	2.64	1.93	1.41	1.04	.86	.63	.46	.34
48	4.49	3.29	2.74	2.00	1.47	1.07	.89	.66	.48	.35
50	4.65	3.40	2.84	2.08	1.52	1.11	.93	.68	.50	.36
52	4.81	3.52	2.94	2.15	1.57	1.15	.96	.70	.51	.38
54	4.97	3.64	3.03	2.22	1.63	1.19	.99	.73	.53	.39
56	5.14	3.76	3.13	2.29	1.68	1.23	1.02	.75	.55	.40
58	5.30	3.88	3.23	2.37	1.73	1.27	1.06	.77	.57	.41
60	5.46	4.00	3.33	2.44	1.78	1.31	1.09	.80	.58	.43
62	5.62	4.12	3.43	2.51	1.84	1.35	1.12	.82	.60	.44
64	5.78	4.23	3.53	2.58	1.89	1.38	1.15	.84	.62	.45
66	5.94	4.35	3.63	2.65	1.94	1.42	1.19	.87	.64	.46
68	6.11	4.47	3.72	2.73	2.00	1.46	1.22	.89	.65	.48
70	6.27	4.59	3.82	2.80	2.05	1.50	1.25	.91	.67	.49
72	6.43	4.71	3.92	2.87	2.10	1.54	1.28	.94	.69	.50
74	6.59	4.83	4.02	2.94	2.15	1.58	1.31	.96	.70	.52
76	6.75	4.94	4.12	3.02	2.21	1.62	1.35	.99	.72	.53
78	6.92	5.06	4.22	3.09	2.26	1.65	1.38	1.01	.74	.54
80	7.08	5.18	4.32	3.16	2.31	1.69	1.41	1.03	.76	.55

REGISTERED PROFESSIONAL ENGINEER
JOHN W. RUMSEY, III
No. 40386
Exp. 3-31-99
CIVIL
STATE OF CALIFORNIA

COUNTY OF NEVADA
DEPARTMENT OF TRANSPORTATION

DRAINAGE DETAIL

100 YEAR STORM DURATION IN MINUTES FOR NEVADA COUNTY

Approved by:

John W. Rumsey 5-11-95

Senior Civil Engineer Date

STANDARD DRAWING

D-12

Rev.5-11-95

NEVADA COUNTY DESIGN STORM (DEPTH)

10 YEAR STORM DURATION IN MINUTES FOR NEVADA COUNTY

Mean Annual Precipitation Inches	5	10	15	30	60 1hr	120 2Hr	180 3Hr	360 6Hr	720 12Hr	1440 24Hr
	Design Storm Depth in inches									
20	.13	.19	.24	.35	.51	.75	.94	1.37	2.01	2.94
22	.14	.21	.26	.38	.55	.81	1.01	1.47	2.16	3.16
24	.15	.22	.27	.40	.59	.86	1.07	1.57	2.30	3.37
26	.16	.23	.29	.43	.62	.91	1.14	1.67	2.45	3.59
28	.17	.25	.31	.45	.66	.97	1.21	1.77	2.60	3.80
30	.18	.26	.33	.48	.70	1.02	1.28	1.87	2.74	4.01
32	.19	.27	.34	.50	.74	1.08	1.35	1.97	2.89	4.23
34	.20	.29	.36	.53	.77	1.13	1.42	2.07	3.03	4.44
36	.21	.30	.38	.55	.81	1.19	1.48	2.17	3.18	4.66
38	.22	.32	.40	.58	.85	1.24	1.55	2.27	3.33	4.87
40	.23	.33	.41	.60	.89	1.30	1.62	2.37	3.47	5.08
42	.24	.34	.43	.63	.92	1.35	1.69	2.47	3.62	5.30
44	.24	.36	.45	.66	.96	1.41	1.76	2.57	3.77	5.51
46	.25	.37	.47	.68	1.00	1.46	1.82	2.67	3.91	5.73
48	.26	.39	.48	.71	1.03	1.51	1.89	2.77	4.06	5.94
50	.27	.40	.50	.73	1.07	1.57	1.96	2.87	4.20	6.16
52	.28	.41	.52	.76	1.11	1.62	2.03	2.97	4.35	6.37
54	.29	.43	.53	.78	1.15	1.68	2.10	3.07	4.50	6.58
56	.30	.44	.55	.81	1.18	1.73	2.17	3.17	4.64	6.80
58	.31	.46	.57	.83	1.22	1.79	2.23	3.27	4.79	7.01
60	.32	.47	.59	.86	1.26	1.84	2.30	3.37	4.94	7.23
62	.33	.48	.60	.88	1.30	1.90	2.37	3.47	5.08	7.44
64	.34	.50	.62	.91	1.33	1.95	2.44	3.57	5.23	7.65
66	.35	.51	.64	.94	1.37	2.01	2.51	3.67	5.37	7.87
68	.36	.53	.66	.96	1.41	2.06	2.58	3.77	5.52	8.08
70	.37	.54	.67	.99	1.44	2.12	2.64	3.87	5.67	8.30
72	.38	.55	.69	1.01	1.48	2.17	2.71	3.97	5.81	8.51
74	.39	.57	.71	1.04	1.52	2.22	2.78	4.07	5.96	8.72
76	.40	.58	.73	1.06	1.56	2.28	2.85	4.17	6.11	8.94
78	.41	.59	.74	1.09	1.59	2.33	2.92	4.27	6.25	9.15
80	.42	.61	.76	1.11	1.63	2.39	2.98	4.37	6.40	9.37

REGISTERED PROFESSIONAL ENGINEER
JOHN W. RUMSEY, III
No. 40386
Exp. 3-31-99
CIVIL
STATE OF CALIFORNIA

COUNTY OF NEVADA
DEPARTMENT OF TRANSPORTATION

DRAINAGE DETAIL

10 YEAR STORM DURATION IN MINUTES FOR NEVADA COUNTY

Approved by:
John W. Rumsey 5-11-95
Senior Civil Engineer Date

STANDARD DRAWING
D-13

Rev.5-11-95

NEVADA COUNTY DESIGN STORM (DEPTH)

100 YEAR STORM DURATION IN MINUTES FOR NEVADA COUNTY

Mean Annual Precipitation Inches	5	10	15	30	60 1hr	120 2hr	180 3hr	360 6hr	720 12hr	1440 24hr
	Design Storm depth in inches									
20	.19	.27	.34	.50	.73	1.06	1.33	1.95	2.85	4.17
22	.20	.29	.36	.53	.78	1.14	1.43	2.09	3.06	4.48
24	.21	.31	.39	.57	.83	1.22	1.52	2.23	3.27	4.78
26	.23	.33	.41	.60	.89	1.30	1.62	2.37	3.47	5.09
28	.24	.35	.44	.64	.94	1.37	1.72	2.51	3.68	5.39
30	.25	.37	.46	.68	.99	1.45	1.81	2.66	3.89	5.69
32	.27	.39	.49	.71	1.04	1.53	1.91	2.80	4.10	6.00
34	.28	.41	.51	.75	1.10	1.61	2.01	2.94	4.30	6.30
36	.29	.43	.54	.79	1.15	1.68	2.10	3.08	4.51	6.60
38	.31	.45	.56	.82	1.20	1.76	2.20	3.22	4.72	6.91
40	.32	.47	.59	.86	1.26	1.84	2.30	3.36	4.93	7.21
42	.33	.49	.61	.89	1.31	1.92	2.39	3.51	5.13	7.51
44	.35	.51	.64	.93	1.36	1.99	2.49	3.65	5.34	7.82
46	.36	.53	.66	.97	1.41	2.07	2.59	3.79	5.55	8.12
48	.37	.55	.68	1.00	1.47	2.15	2.68	3.93	5.76	8.43
50	.39	.57	.71	1.04	1.52	2.23	2.78	4.07	5.96	8.73
52	.40	.59	.73	1.07	1.57	2.30	2.88	4.21	6.17	9.03
54	.41	.61	.76	1.11	1.63	2.38	2.98	4.36	6.38	9.34
56	.43	.63	.78	1.15	1.68	2.46	3.07	4.50	6.58	9.64
58	.44	.65	.81	1.18	1.73	2.54	3.17	4.64	6.79	9.94
60	.45	.67	.83	1.22	1.78	2.61	3.27	4.78	7.00	10.25
62	.47	.69	.86	1.25	1.84	2.69	3.36	4.92	7.21	10.55
64	.48	.71	.88	1.29	1.89	2.77	3.46	5.06	7.41	10.86
66	.50	.73	.91	1.33	1.94	2.84	3.56	5.21	7.62	11.16
68	.51	.75	.93	1.36	2.00	2.92	3.65	5.35	7.83	11.46
70	.52	.76	.96	1.40	2.05	3.00	3.75	5.49	8.04	11.77
72	.54	.78	.98	1.44	2.10	3.08	3.85	5.63	8.24	12.07
74	.55	.80	1.01	1.47	2.15	3.15	3.94	5.77	8.45	12.37
76	.56	.82	1.03	1.51	2.21	3.23	4.04	5.91	8.66	12.68
78	.58	.84	1.05	1.54	2.26	3.31	4.14	6.06	8.87	12.98
80	.59	.86	1.08	1.58	2.31	3.39	4.23	6.20	9.07	13.28

COUNTY OF NEVADA
DEPARTMENT OF TRANSPORTATION

DRAINAGE DETAIL

100 YEAR STORM DURATION IN MINUTES FOR NEVADA COUNTY

Approved by:

John W. Rumsey 5-11-95

Senior Civil engineer Date

STANDARD DRAWING

D-14

Rev.5-11-95

TABLE FOR ESTIMATING "C" IN RATIONAL FORMULA

UNIMPROVED AREAS

CONDITION	EXTREME	HIGH	MODERATE	LOW
Slope	.36 – .28 Above 30%	.28 – .15 30% – 10%	.15 – .10 10% – 5%	.10 – .05 5% – 0
Surface permeability	.20 – .15 Bare rock or very thin soil	.15 – .07 Impervious clays shallow soils	.07 – .04 Deep pervious loam, sandy loam	.03 Deep sand, volcanic ash
Vegetation	.20 – .15 None or very sparse	.15 – .07 Less than 20% covered with substantial growth	.07 – .04 About 50% covered with heavy growth	.03 90% covered with heavy growth, deep hummus layer
Surface	.20 – .15 Smooth soil, slick rock drainage flow continous	.15 – .07 Roughened soil or rocks	.07 – .04 Drainage flow interrupted many ponds, lakes & marshes	.03 Drainage flow arrested many ponds, lakes & marshes

IMPROVED AREAS

Surface	C
Roof surfaces	.95
A.C. or P.C.C. pavement, patios, driveways, streets, sidewalks	.90
Landscaped areas	.25
Gravel walks, roadways	.30

EXAMPLE: Unimproved

20% slope.................... .22
Well drained soil........ .05
Fair cover.................. .07
No ponds.................... .08

C= .42

EXAMPLE: Improved

100 acre tract
15 ac........................@.95
50 ac. A.C.pave........@.90
35 ac. landscaped...@.25

$$C=\frac{(15 \times .95)+(50 \times .90)+(35 \times .25)}{100 \text{ acres}}= 0.68 \quad C= 0.68$$

REGISTERED PROFESSIONAL ENGINEER
JOHN W. RUMSEY, III
No. 40386
Exp. 3-31-99
CIVIL
STATE OF CALIFORNIA

COUNTY OF NEVADA
DEPARTMENT OF TRANSPORTATION

DRAINAGE DETAILS

VALUES FOR ESTIMATING COEFFICIENT OF RUNOFF "C"

Approved by: John W. Rumsey 5-11-95
Senior Civil Engineer Date

STANDARD DRAWING D-15

Rev.5-11-95

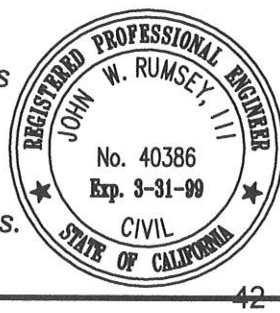
LAND USE DESCRIPTION	HYDROLOGIC SOIL GROUP			
	A	B	C	D
Cultivated land:① without conservation treatment	72	81	88	91
with conservation treatment	62	71	78	81
Pasture or range land: poor condition	68	79	86	89
good condition	39	61	74	80
Meadow: good condition	30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch	45	66	77	83
good cover②	25	55	70	77
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:③				
Average lot size — Average % Impervious④				
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 National Engineering Handbook, Section 4, Hydrology, Chapter 9, August 1972.

② Good cover is protected from grazing and litter and brush cover soil.

③ 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.

④ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.



COUNTY OF NEVADA

DEPARTMENT OF TRANSPORTATION

RUNOFF CURVE NUMBERS

Approved by:

John W. Rumsey — 5-11-95

Senior Civil Engineer — Date

STANDARD DRAWING

D-16

SECTION 3:

WATER QUALITY TREATMENT

RETENTION CALCULATIONS

JOYCE DRIVE (SOUTH) - HABITAT FOR HUMANITY

Grass Valley, CA

Prepared by: SCO Planning & Engineering

Prepared on: 11/11/2019

				Recommended							*Actual*
	Developed Areas		Total	0.5"	Vegitation Buffer		Water	Infiltration Trench		Retention	Retention
AREA	Asph/Conc (sf)	Roof (sf)	Imp. Area (sf)	Retention (cf)	Area (sf)	Storage (cf)	Inlets (cf)	Length (lf)	Storage (cf)	Pond (cf)	Provided (cf)
A-2	8392	3008	11400	475	3237	259	12	84	420	360	1051
A-3	13250	18528	31778	1324	17278	1382	12	95	475	900	2769
TOTAL	21642	21536	43178	1799							

Typical Infiltration Trench			
Depth	Width	Vol Factor	Volume (cf/lf)
2	5	0.50	5.00

Habitat for Humanity - Water Quality BMP's

MULTIPLE TREATMENT SYSTEM					
Source	BMP #	BMP Description	Treatment Description	TSS % Removal	Filtration of Other Pollutants?
Pre-Treatment					
Roof Runoff	SD-11 TC-10	Roof Runoff Controls - Dry Wells or Infiltration Trenches	Roof downspouts are directed to dry wells or infiltration trenches. Reduces total volume and rate of runoff from individual lots. Retains pollutants from roofing materials and atmospheric deposition.	n/a	Yes
curb and storm drain collects runoff from pavement areas	TC-50	Water Quality Inlet	1' deep sump at bottom of inlet collects sand and sediment and allows infiltration.	20-30%	No
sheet flow from sidewalk and roof areas	TC-31	Vegetated Buffer Strip	Sheet Flow from sidewalk and roof areas is directed across adjacent landscape areas which includes soil amendments and vegetation. Provides filtration of pollutants and allows infiltration.	30-50%	Yes
Primary Treatment					
all impervious areas and snow storage areas	TC-50	StormCeptor Filter	Removes trash and debris and larger suspended solids using radial flow through StormCeptor in-line manhole. Also includes an oil separator.	70-90%	Yes
Post Filter	TC-30	Biofiltration Swale	Traps particulate pollutants, promotes infiltration, reduces flow velocity and increases time of concentration	90-95%	Yes
Retention	TC-11	Retention Pond	Storage of stormwater runoff and exfiltration. Absorption and Infiltration	95-100%	Yes
			Combined Total	**95-100%**	**Yes**

References:

Design Criteria and effectiveness of BPM's was obtained from the following sources:

1.) California Stormwater Quality Association (CASQA), Storm Water Best Management Practice Handbooks, January 2003 available at: http://www.cabmphandbooks.com/Construction.asp

2.) California Department of Transportation (CALTRANS), Storm Water Quality Handbook, May 2007 available at: http://www.dot.ca.gov/hq/oppd/stormwtr/Final-PPDG_Master_Document-6-04-07.pdf

3.) U.S. Environmental Protection Agency, Stormwater Best Management Practice Design Guide, EPA/600/R.04/121B, September 2004 available at: http://www.epa.gov/nrmrl/pubs/600r04121/600r04121.htm

4.) U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development & Redevelopment BMP Factsheets, available at: http://cfpub.epa.gov/npdes/stormwater/menuofbmps

5.) The Stormwater Manager's Resource Center (SMRC), available at: http://www.stormwatercenter.net/

Roof Runoff Controls

Rain Garden

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- Collect and Convey

Description

Various roof runoff controls are available to address stormwater that drains off rooftops. The objective is to reduce the total volume and rate of runoff from individual lots, and retain the pollutants on site that may be picked up from roofing materials and atmospheric deposition. Roof runoff controls consist of directing the roof runoff away from paved areas and mitigating flow to the storm drain system through one of several general approaches: cisterns or rain barrels; dry wells or infiltration trenches; pop-up emitters, and foundation planting. The first three approaches require the roof runoff to be contained in a gutter and downspout system. Foundation planting provides a vegetated strip under the drip line of the roof.

Approach

Design of individual lots for single-family homes as well as lots for higher density residential and commercial structures should consider site design provisions for containing and infiltrating roof runoff or directing roof runoff to vegetative swales or buffer areas. Retained water can be reused for watering gardens, lawns, and trees. Benefits to the environment include reduced demand for potable water used for irrigation, improved stormwater quality, increased groundwater recharge, decreased runoff volume and peak flows, and decreased flooding potential.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Designing New Installations

Cisterns or Rain Barrels

One method of addressing roof runoff is to direct roof downspouts to cisterns or rain barrels. A cistern is an above ground storage vessel with either a manually operated valve or a permanently open outlet. Roof runoff is temporarily stored and then released for irrigation or infiltration between storms. The number of rain

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

barrels needed is a function of the rooftop area. Some low impact developers recommend that every house have at least 2 rain barrels, with a minimum storage capacity of 1000 liters. Roof barrels serve several purposes including mitigating the first flush from the roof which has a high volume, amount of contaminants, and thermal load. Several types of rain barrels are commercially available. Consideration must be given to selecting rain barrels that are vector proof and childproof. In addition, some barrels are designed with a bypass valve that filters out grit and other contaminants and routes overflow to a soak-away pit or rain garden.

If the cistern has an operable valve, the valve can be closed to store stormwater for irrigation or infiltration between storms. This system requires continual monitoring by the resident or grounds crews, but provides greater flexibility in water storage and metering. If a cistern is provided with an operable valve and water is stored inside for long periods, the cistern must be covered to prevent mosquitoes from breeding.

A cistern system with a permanently open outlet can also provide for metering stormwater runoff. If the cistern outlet is significantly smaller than the size of the downspout inlet (say ¼ to ½ inch diameter), runoff will build up inside the cistern during storms, and will empty out slowly after peak intensities subside. This is a feasible way to mitigate the peak flow increases caused by rooftop impervious land coverage, especially for the frequent, small storms.

Dry wells and Infiltration Trenches

Roof downspouts can be directed to dry wells or infiltration trenches. A dry well is constructed by excavating a hole in the ground and filling it with an open graded aggregate, and allowing the water to fill the dry well and infiltrate after the storm event. An underground connection from the downspout conveys water into the dry well, allowing it to be stored in the voids. To minimize sedimentation from lateral soil movement, the sides and top of the stone storage matrix can be wrapped in a permeable filter fabric, though the bottom may remain open. A perforated observation pipe can be inserted vertically into the dry well to allow for inspection and maintenance.

In practice, dry wells receiving runoff from single roof downspouts have been successful over long periods because they contain very little sediment. They must be sized according to the amount of rooftop runoff received, but are typically 4 to 5 feet square, and 2 to 3 feet deep, with a minimum of 1-foot soil cover over the top (maximum depth of 10 feet).

To protect the foundation, dry wells must be set away from the building at least 10 feet. They must be installed in solids that accommodate infiltration. In poorly drained soils, dry wells have very limited feasibility.

Infiltration trenches function in a similar manner and would be particularly effective for larger roof areas. An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. These are described under Treatment Controls.

Pop-up Drainage Emitter

Roof downspouts can be directed to an underground pipe that daylights some distance from the building foundation, releasing the roof runoff through a pop-up emitter. Similar to a pop-up irrigation head, the emitter only opens when there is flow from the roof. The emitter remains flush to the ground during dry periods, for ease of lawn or landscape maintenance.

Foundation Planting

Landscape planting can be provided around the base to allow increased opportunities for stormwater infiltration and protect the soil from erosion caused by concentrated sheet flow coming off the roof. Foundation plantings can reduce the physical impact of water on the soil and provide a subsurface matrix of roots that encourage infiltration. These plantings must be sturdy enough to tolerate the heavy runoff sheet flows, and periodic soil saturation.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Supplemental Information

Examples

- City of Ottawa's Water Links Surface –Water Quality Protection Program
- City of Toronto Downspout Disconnection Program
- City of Boston, MA, Rain Barrel Demonstration Program

Other Resources

Hager, Marty Catherine, Stormwater, "Low-Impact Development", January/February 2003. www.stormh2o.com

Low Impact Urban Design Tools, Low Impact Development Design Center, Beltsville, MD. www.lid-stormwater.net

Start at the Source, Bay Area Stormwater Management Agencies Association, 1999 Edition

Design Considerations

- Accumulation of Metals
- Clogged Soil Outlet Structures
- Vegetation/Landscape Maintenance

Description

An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches perform well for removal of fine sediment and associated pollutants. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment entering the trench which can clog and render the trench ineffective.

California Experience

Caltrans constructed two infiltration trenches at highway maintenance stations in Southern California. Of these, one failed to operate to the design standard because of average soil infiltration rates lower than that measured in the single infiltration test. This highlights the critical need for appropriate evaluation of the site. Once in operation, little maintenance was required at either site.

Advantages

- Provides 100% reduction in the load discharged to surface waters.
- An important benefit of infiltration trenches is the approximation of pre-development hydrology during which a significant portion of the average annual rainfall runoff is infiltrated rather than flushed directly to creeks.
- If the water quality volume is adequately sized, infiltration trenches can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

- As an underground BMP, trenches are unobtrusive and have little impact of site aesthetics.

Limitations

- Have a high failure rate if soil and subsurface conditions are not suitable.
- May not be appropriate for industrial sites or locations where spills may occur.
- The maximum contributing area to an individual infiltration practice should generally be less than 5 acres.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration trenches once clogged.

Design and Sizing Guidelines

- Provide pretreatment for infiltration trenches in order to reduce the sediment load. Pretreatment refers to design features that provide settling of large particles before runoff reaches a management practice, easing the long-term maintenance burden. Pretreatment is important for all structural stormwater management practices, but it is particularly important for infiltration practices. To ensure that pretreatment mechanisms are effective, designers should incorporate practices such as grassed swales, vegetated filter strips, detention, or a plunge pool in series.
- Specify locally available trench rock that is 1.5 to 2.5 inches in diameter.
- Determine the trench volume by assuming the WQV will fill the void space based on the computed porosity of the rock matrix (normally about 35%).
- Determine the bottom surface area needed to drain the trench within 72 hr by dividing the WQV by the infiltration rate.

$$d = \frac{WQV + RFV}{SA}$$

- Calculate trench depth using the following equation:

where:

D = Trench depth

WQV	=	Water quality volume
RFV	=	Rock fill volume
SA	=	Surface area of the trench bottom

- The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).
- Provide observation well to allow observation of drain time.
- May include a horizontal layer of filter fabric just below the surface of the trench to retain sediment and reduce the potential for clogging.

Construction/Inspection Considerations

Stabilize the entire area draining to the facility before construction begins. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction. Stabilize the entire contributing drainage area before allowing any runoff to enter once construction is complete.

Performance

Infiltration trenches eliminate the discharge of the water quality volume to surface receiving waters and consequently can be considered to have 100% removal of all pollutants within this volume. Transport of some of these constituents to groundwater is likely, although the attenuation in the soil and subsurface layers will be substantial for many constituents.

Infiltration trenches can be expected to remove up to 90 percent of sediments, metals, coliform bacteria and organic matter, and up to 60 percent of phosphorus and nitrogen in the infiltrated runoff (Schueler, 1992). Biochemical oxygen demand (BOD) removal is estimated to be between 70 to 80 percent. Lower removal rates for nitrate, chlorides and soluble metals should be expected, especially in sandy soils (Schueler, 1992). Pollutant removal efficiencies may be improved by using washed aggregate and adding organic matter and loam to the subsoil. The stone aggregate should be washed to remove dirt and fines before placement in the trench. The addition of organic material and loam to the trench subsoil may enhance metals removal through adsorption.

Siting Criteria

The use of infiltration trenches may be limited by a number of factors, including type of native soils, climate, and location of groundwater table. Site characteristics, such as excessive slope of the drainage area, fine-grained soil types, and proximate location of the water table and bedrock, may preclude the use of infiltration trenches. Generally, infiltration trenches are not suitable for areas with relatively impermeable soils containing clay and silt or in areas with fill.

As with any infiltration BMP, the potential for groundwater contamination must be carefully considered, especially if the groundwater is used for human consumption or agricultural purposes. The infiltration trench is not suitable for sites that use or store chemicals or hazardous materials unless hazardous and toxic materials are prevented from entering the trench. In these areas, other BMPs that do not allow interaction with the groundwater should be considered.

The potential for spills can be minimized by aggressive pollution prevention measures. Many municipalities and industries have developed comprehensive spill prevention control and countermeasure (SPCC) plans. These plans should be modified to include the infiltration trench and the contributing drainage area. For example, diversion structures can be used to prevent spills from entering the infiltration trench. Because of the potential to contaminate groundwater, extensive site investigation must be undertaken early in the site planning process to establish site suitability for the installation of an infiltration trench.

Longevity can be increased by careful geotechnical evaluation prior to construction and by designing and implementing an inspection and maintenance plan. Soil infiltration rates and the water table depth should be evaluated to ensure that conditions are satisfactory for proper operation of an infiltration trench. Pretreatment structures, such as a vegetated buffer strip or water quality inlet, can increase longevity by removing sediments, hydrocarbons, and other materials that may clog the trench. Regular maintenance, including the replacement of clogged aggregate, will also increase the effectiveness and life of the trench.

Evaluation of the viability of a particular site is the same as for infiltration basins and includes:

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30 percent clay or more than 40 percent of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15 percent should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

Secondary Screening Based on Site Geotechnical Investigation

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.
- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Maintenance

Infiltration trenches required the least maintenance of any of the BMPs evaluated in the Caltrans study, with approximately 17 field hours spent on the operation and maintenance of each site. Inspection of the infiltration trench was the largest field activity, requiring approximately 8 hr/yr.

In addition to reduced water quality performance, clogged infiltration trenches with surface standing water can become a nuisance due to mosquito breeding. If the trench takes more than 72 hours to drain, then the rock fill should be removed and all dimensions of the trench should be increased by 2 inches to provide a fresh surface for infiltration.

Cost

Construction Cost

Infiltration trenches are somewhat expensive, when compared to other stormwater practices, in terms of cost per area treated. Typical construction costs, including contingency and design costs, are about \$5 per ft^3 of stormwater treated (SWRPC, 1991; Brown and Schueler, 1997). Actual construction costs may be much higher. The average construction cost of two infiltration trenches installed by Caltrans in southern California was about \$50/ft^3; however, these were constructed as retrofit installations.

Infiltration trenches typically consume about 2 to 3 percent of the site draining to them, which is relatively small. In addition, infiltration trenches can fit into thin, linear areas. Thus, they can generally fit into relatively unusable portions of a site.

Maintenance Cost

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly sited or maintained, infiltration trenches have a high failure rate. In general, maintenance costs for infiltration trenches are estimated at between 5 percent and 20 percent of the construction cost. More realistic values are probably closer to the 20-percent range, to ensure long-term functionality of the practice.

References and Sources of Additional Information

Caltrans, 2002, BMP Retrofit Pilot Program Proposed Final Report, Rpt. CTSW-RT-01-050, California Dept. of Transportation, Sacramento, CA.

Brown, W., and T. Schueler. 1997. *The Economics of Stormwater BMPs in the Mid-Atlantic Region.* Prepared for the Chesapeake Research Consortium, Edgewater, MD, by the Center for Watershed Protection, Ellicott City, MD.

Galli, J. 1992. *Analysis of Urban BMP Performance and Longevity in Prince George's County, Maryland.* Metropolitan Washington Council of Governments, Washington, DC.

Maryland Department of the Environment (MDE). 2000. *Maryland Stormwater Design Manual.* http://www.mde.state.md.us/environment/wma/stormwatermanual. Accessed May 22, 2001.

Metzger, M. E., D. F. Messer, C. L. Beitia, C. M. Myers, and V. L. Kramer. 2002. The Dark Side Of Stormwater Runoff Management: Disease Vectors Associated With Structural BMPs. Stormwater 3(2): 24-39.

Schueler, T. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Metropolitan Washington Council of Governments, Washington, DC.

Southeastern Wisconsin Regional Planning Commission (SWRPC). 1991. *Costs of Urban Nonpoint Source Water Pollution Control Measures.* Southeastern Wisconsin Regional Planning Commission, Waukesha, WI.

Watershed Management Institute (WMI). 1997. *Operation, Maintenance, and Management of Stormwater Management Systems.* Prepared for U.S. Environmental Protection Agency, Office of Water, Washington, DC.

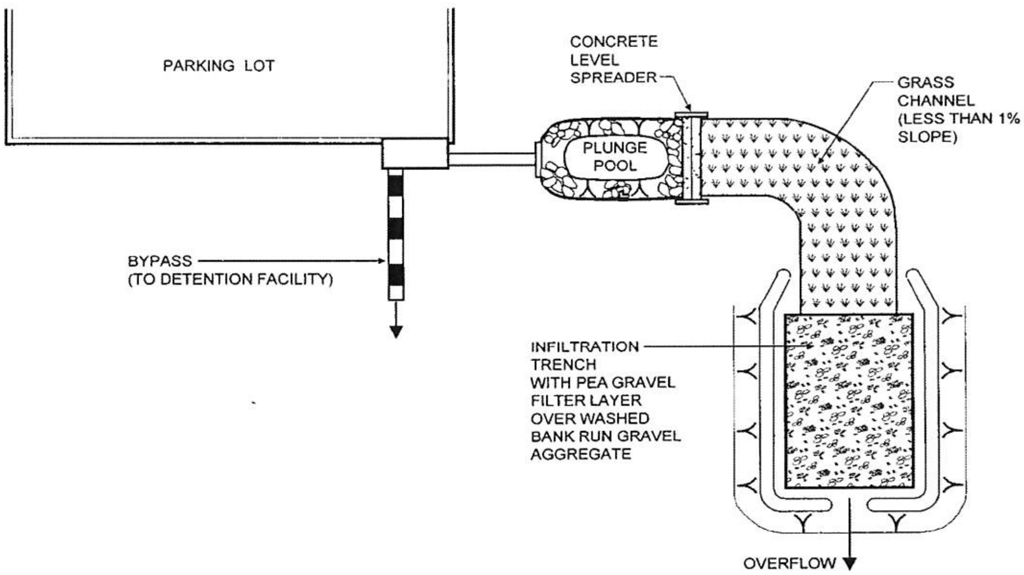
Information Resources

Center for Watershed Protection (CWP). 1997. *Stormwater BMP Design Supplement for Cold Climates.* Prepared for the U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington, DC, by the Center for Watershed Protection, Ellicott City, MD.

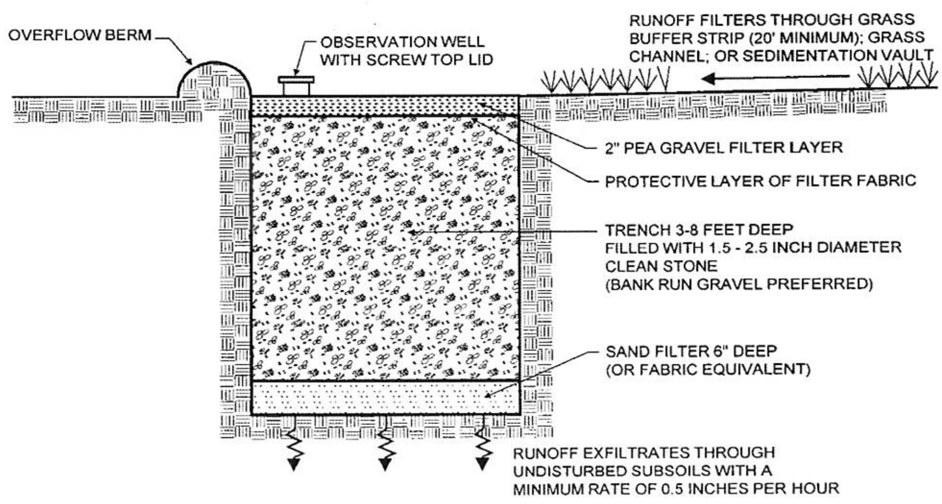
Ferguson, B.K. 1994. *Stormwater Infiltration.* CRC Press, Ann Arbor, MI.

Minnesota Pollution Control Agency. 1989. *Protecting Water Quality in Urban Areas: Best Management Practices.* Minnesota Pollution Control Agency, Minneapolis, MN.

USEPA. 1993. *Guidance to Specify Management Measures for Sources of Nonpoint Pollution in Coastal Waters.* EPA-840-B-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.



PLAN VIEW



SECTION

Water Quality Inlet TC-50

General Description

Water quality inlets (WQIs), also typically called trapping catch basins, oil/grit separators or oil/water separators, consist of one or more chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from stormwater. Some WQIs also contain screens to help retain larger or floating debris, and many of the newer designs also include a coalescing unit that helps promote oil/water separation.

These devices are appropriate for capturing hydrocarbon spills, but provide very marginal sediment removal and are not very effective for treatment of stormwater runoff. WQIs typically capture only the first portion of runoff for treatment and are generally used for pretreatment before discharging to other best management practices (BMPs).

Inspection/Maintenance Considerations

High sediment loads can interfere with the ability of the WQI to effectively separate oil and grease from the runoff. During periods of high flow, sediment can be re-suspended and released from the WQI into surface waters if this in the only BMP on site prior to discharge. Maintenance of WQIs can be easily neglected because they are underground. Establishment of a maintenance schedule is helpful for ensuring proper maintenance occurs. The required maintenance effort will be site-specific due to variations in sediment and hydrocarbon loading. Since WQI residuals contain hydrocarbon by-products, they may require disposal as hazardous waste. Many WQI owners coordinate with waste haulers to collect and dispose of these residuals.

Advanced BMPs Covered

Treatment Control

Maintenance Concerns

- *High Sediment Loads*
- *Hazardous Waste*
- *Vector Control*
- *Pollutant Release*

Targeted Constituents

Sediment	●
Nutrients	●
Trash	▲
Metals	●
Bacteria	●
Oil and Grease	▲
Organics	●

Legend (Removal Effectiveness)

● Low ▲ Medium ■ High

✱ Requires Pretreatment

Note: The removal effectiveness ratings shown in the table are for properly designed, sited, and maintained BMPs; some configurations will have variations in pollutant effectiveness.

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION®

Inspection Activities	Suggested Frequency
☐ Inspect regularly to determine if maintenance is required.	Monthly during the wet season, or after significant rain events
☐ Contact the local mosquito and vector control agency if mosquito breeding is observed or suspected.	As needed

Maintenance Activities	Suggested Frequency
☐ Clean out and dispose of accumulated oil, grease, and sediments. Remove accumulated trash and debris. The clean out and disposal techniques should be environmentally acceptable and in accordance with local regulations.	Annual, before the wet season, or more frequent as needed

Additional Information

Water quality inlets are most effective for drainage areas of 1 acre or less. They are often used in industrial applications such as airport runways, equipment washdown areas, and gas station parking lots. WQIs can be situated at the ground surface or underground, and they are available as pre-manufactured or cast-in-place units, typically constructed with reinforced concrete. They should be water-tight to prevent possible groundwater contamination, and should be sited such that vactor trucks can easily access and remove sediment and pollutants.

Since WQIs can be relatively deep, they may be designated as confined spaces. Caution should be exercised to comply with confined space entry safety regulations if it is required.

References

California Department of Transportation. *Treatment BMP Technology Report (CTSW-RT-09-239.06),* 2010. Available online at: http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-09-239-06.pdf.

California Stormwater Quality Association. *Stormwater Best Management Practice Handbook, New Development and Redevelopment*, 2003. Available online at: https://www.casqa.org/resources/bmp-handbooks/new-development-redevelopment-bmp-handbook.

San Francisco Public Utilities Commission, et al. San Francisco Stormwater Design Guidelines. Appendix A, Stormwater BMP Fact Sheets, 2010. Available online at: http://www.sfwater.org/modules/showdocument.aspx?documentid=2778.

Tahoe Regional Planning Agency. Best Management Practices Handbook, 2012. Available online at: http://www.tahoebmp.org/Documents/2012%20BMP%20Handbook.pdf.

Stormceptor® STC

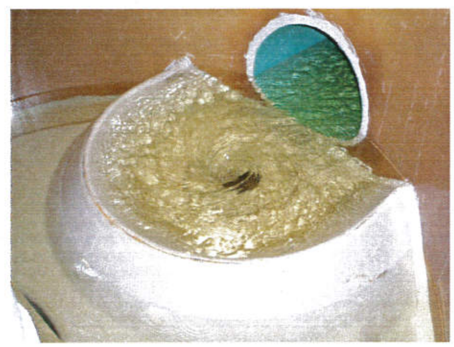
The calm *during* the storm

When it rains, oils, sediment and other contaminants are washed from paved surfaces directly into our storm drains and waterways. Non-point source pollution such as stormwater now accounts for 80% of water pollution in North America and governments are responding with demanding regulations to protect our water resources.

Removing more pollutants

Stormceptor removes more pollutants from stormwater than any other separator.

- Maintains continuous positive treatment of total suspended solids (TSS) year-round, regardless of flow rate
- Designed to remove a wide range of particle sizes, as well as free oils, heavy metals and nutrients that attach to fine sediment
- Can be designed to remove a specific particle size distribution (PSD)



A calm treatment environment

- Stormceptor slows incoming stormwater to create a non-turbulent treatment environment, allowing free oils and debris to rise, and sediment to settle
- Scour prevention technology ensures pollutants are captured and contained during all rainfall events, even extreme storms

Proven performance

With more than 20 years of industry experience, Stormceptor has been performance tested and verified by some of the most stringent technology evaluation programs in North America. Stormceptor has been performance verified through numerous verification programs, including;

- NJCAT
- Washington ECOLOGY
- EN858 Class 2

PCSWMM for Stormceptor – *Advanced online sizing & design software*

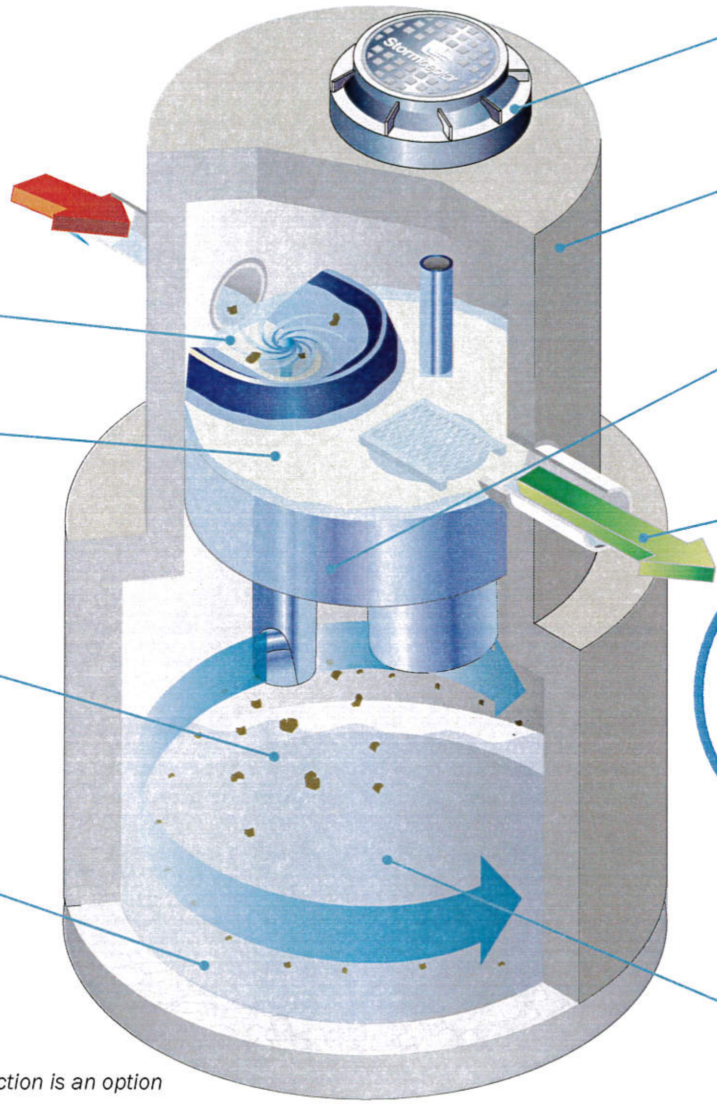
The most accurate, easy to use design tool available.

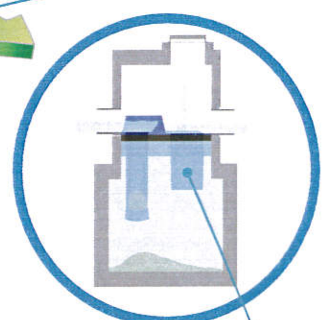
- This continuous simulation modeling software combines localized rainfall data from over 1,900 weather stations across North America allowing for region-specific design with a selection of particle sizes to design the best Stormceptor for your site
- Within a single project, multiple Stormceptor units can be sized and the information revisited as project parameters change
- Provides a summary report that includes projected performance calculations
  www.imbriumsystems.com/PCSWMMforStormceptor

With over 40,000 units operating worldwide, Stormceptor performs and protects every day, in every storm.

Stormceptor® STC

The calm *during* the storm

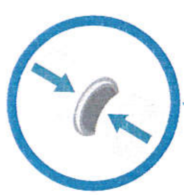




* *Fiberglass construction is an option*

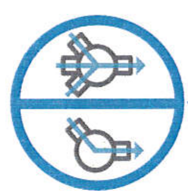
Easy to install

Small footprint saves time and money with limited disruption to your site.



Seamless

Minimal drop between inlet and outlet pipes makes Stormceptor ideal for retrofits and new development projects.



Flexible

Multiple inlets can connect to a single unit.

Can be used as a bend structure.

imbrium
www.imbriumsystems.com

CANADA: (800) 565 4801 | USA: (888) 279 8826 | INTERNATIONAL: +1 (416) 960 9900

Vegetated Buffer Strip

General Description

Vegetated buffer strips (vegetated filter strips, biostrips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. They are an effective, easy to implement BMP that often go unrecognized at industrial and commercial facilities.

Vegetated buffer strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. They are well-suited to treating runoff from roads, roof downspouts, small parking lots, and pervious surfaces. They can be implemented to provide effective pretreatment for detention and infiltration stormwater BMPs.

Vegetated buffer strips can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems. Therefore, they are best suited for small landscaped portions of industrial or commercial facilities with low peak flow rates. They are not well suited to treat stormwater runoff from industrial areas that have insufficient source control BMPs.

Inspection/Maintenance Considerations

Vegetated buffer strips require frequent landscape maintenance. In many cases, vegetated buffer strips initially require intense maintenance, but less maintenance is needed over time. Maintenance tasks may be conducted by a landscaping contractor. Maintenance requirements typically include grass or shrub-growing activities such as irrigation, mowing, trimming, removal of invasive species, and replanting when necessary. Buffer strips require more attention as the volume of sediment increases. Vegetated buffer strips can become a nuisance due to mosquito breeding in level spreaders (unless

Advanced BMPs Covered

Treatment Control

Maintenance Concerns

- *Vector Control*
- *Invasive Species Management*
- *Vegetation/Landscape Maintenance*
- *Erosion*
- *Channelization of Flow*
- *Aesthetics*

Targeted Constituents

Sediment	■
Nutrients	●
Trash	▲
Metals	■
Bacteria	●
Oil and Grease	■
Organics	▲

Legend (Removal Effectiveness)

● Low ■ High ▲ Medium

✱ Requires Pretreatment

Note: The removal effectiveness ratings shown in the table are for properly designed, sited, and maintained BMPs; some configurations will have variations in pollutant effectiveness.

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION®

designed to dewater completely in 96 hours or less) and/or if proper drainage slopes are not maintained.

Inspection Activities	Suggested Frequency
☐ Once the vegetated buffer strip is established, inspect at least three times per year. Repair all damage immediately. ☐ Inspect buffer strips after seeding and repair as needed.	Post construction
☐ Inspect buffer strip and repair all damage immediately. ☐ Inspect soil and repair eroded areas.	After major storms
☐ Inspect for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the strips are ready for winter. However, additional inspection after periods of heavy runoff is desirable. ☐ Inspect pea-gravel diaphragm/level spreader for clogging and effectiveness and remove built-up sediment. ☐ Inspect for rolls and gullies. Immediately fill with topsoil, install erosion control blanket and seed or sod. ☐ Inspect to ensure vegetation is well established. If not, either prepare soil and reseed or replace with alternative species. Install erosion control blanket. ☐ Check for debris and litter, and areas of sediment accumulation.	Semi-annual
Maintenance Activities	**Suggested Frequency**
☐ Water plants daily for 2 weeks after construction.	Post construction
☐ Mow regularly to maintain vegetation height between 2 - 4 inches, and to promote thick, dense vegetative growth. Cut only when soil is dry to prevent tracking damage to vegetation, soil compaction and flow concentrations. Clippings are to be removed immediately after mowing. ☐ Remove all litter, branches, rocks, or other debris. Damaged areas of the filter strip should be repaired immediately by reseeding and applying mulch. ☐ Regularly maintain inlet flow spreader. ☐ Irrigate during dry season (April through October) when necessary to maintain the vegetation.	Frequently, as needed
☐ Remulch void areas. ☐ Treat diseased trees and shrubs, remove dead vegetation.	Semi-annual
☐ Remove sediment and replant in areas of buildup. Sediment accumulating near culverts and in channels should be removed when it builds up to 3 in. at any spot, or covers vegetation. ☐ Limit fertilizer applications based on plant vigor and soil test results. ☐ Rework or replant buffer strip if concentrated flow erodes a channel through the strip.	Annual

Additional Information

Research (Colwell et al., 2000) indicates that grass height and mowing frequency have little impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

The buffer strip should be covered with dense vegetative cover to filter pollutants out of runoff and helps reduce flow velocities and protect the strip from erosion. Fine, close-growing grasses are ideal because increasing the surface area of the vegetation exposed to runoff improves the effectiveness of the swale. Drought tolerant vegetation that can tolerate sediment and debris accumulations is best-suited for vegetated buffer strips.

References

California Department of Transportation. *Treatment BMP Technology Report (CTSW-RT-09-239.06).* April, 2010. Available online at: http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-09-239-06.pdf.

California Stormwater Quality Association. *Stormwater Best Management Practice Handbook, New Development and Redevelopment,* 2003. Available online at: https://www.casqa.org/resources/bmp-handbooks/new-development-redevelopment-bmp-handbook.

California Stormwater Quality Association. *Stormwater Best Management Practice Handbook, New Development and Redevelopment,* 2003. Available online at: https://www.casqa.org/resources/bmp-handbooks/new-development-redevelopment-bmp-handbook.

Colwell, Shanti R., Horner, Richard R., and Booth, Derek B. *Characterization of Performance Predictors and Evaluation of Mowing Practices in Biofiltration Swales.* Report to King County Land and Water Resources Division and others by Center for Urban Water Resources Management, Department of Civil and Environmental Engineering, University of Washington, Seattle, 2000.

San Francisco Public Utilities Commission, et al. San Francisco Stormwater Design Guidelines. Appendix A, Stormwater BMP Fact Sheets, 2010. Available online at: http://www.sfwater.org/modules/showdocument.aspx?documentid=2778.

Stormwater Managers Resource Center. http://www.stormwatercenter.net.

Tahoe Regional Planning Agency. Best Management Practices Handbook, 2012. Available online at: http://www.tahoebmp.org/Documents/2012%20BMP%20Handbook.pdf.

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development and Redevelopment. BMP Fact Sheets. Available online at: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5.

Ventura Countywide Stormwater Quality Management Program. *Technical Guidance Manual for Stormwater Quality Control Measures*, 2010. Available online at: http://www.vcstormwater.org/documents/workproducts/technicalguidancemanual/2010revisions/Ventura%20Technical%20Guidance%20Document_5-6-10.pdf.

Watershed Management Institute, Inc. *Operation, Maintenance, and Management of Stormwater Management Systems*. August, 1997. Available online at: http://www.stormwater.ucf.edu/research/stormwaterOMM/stormwateromm.pdf.

Vegetated Swale TC-30

General Description

Vegetated swales (also referred to as bioswales, biofiltration swales, or landscaped swales) are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, reduce flow velocity, and increase time of concentration of stormwater runoff. Vegetated swales can be implemented to provide effective pretreatment for detention and infiltration stormwater BMPs.

Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems. Therefore, swales are best suited for small landscaped portions of industrial or commercial facilities with low peak flow rates. They are not well suited to treat stormwater runoff from industrial areas that have insufficient source control BMPs.

Inspection/Maintenance Considerations

A thick vegetative cover is needed for vegetated swales to function properly. Usually, swales require little more than normal landscape maintenance activities such as irrigation and mowing to maintain pollutant removal efficiency. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g., debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained. The application of fertilizers and pesticides should be minimized.

Advanced BMPs Covered

Treatment Control

Maintenance Concerns

- *Channelization*
- *Vegetation/Landscape Maintenance*
- *Vector Control*
- *Aesthetics*
- *Flow Obstructions*

Targeted Constituents

Sediment	▲
Nutrients	●
Trash	●
Metals	▲
Bacteria	●
Oil and Grease	▲
Organics	▲

Legend (Removal Effectiveness)

● Low ■High ▲ Medium

✱ Requires Pretreatment

Note: The removal effectiveness ratings shown in the table are for properly designed, sited, and maintained BMPs; some configurations will have variations in pollutant effectiveness.

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

Inspection Activities	Suggested Frequency
☐ Inspect after seeding and after first major storms for any damages.	Post construction
☐ Inspect for signs of erosion, damage to vegetation, channelization of flow, debris and litter, and areas of sediment accumulation. Perform inspections at the beginning and end of the wet season. Additional inspections after periods of heavy runoff are desirable.	Semi-annual
☐ Inspect level spreader for clogging, grass alongside slopes for erosion and formation of rills or gullies, and sand/soil bed for erosion problems.	Annual

Maintenance Activities	Suggested Frequency
☐ Mow grass to maintain a height of 3–4 inches, for safety, aesthetic, or other purposes. Litter should always be removed prior to mowing. Clippings should be composted. ☐ Irrigate swale during dry season (April through October) or when necessary to maintain the vegetation. ☐ Provide weed control, if necessary to control invasive species.	As needed (frequent, seasonally)
☐ Remove litter, branches, rocks blockages, and other debris and dispose of properly. ☐ Maintain inlet flow spreader (if applicable). ☐ Repair any damaged areas within a channel identified during inspections. Erosion rills or gullies should be corrected as needed. Bare areas should be replanted as necessary.	Semi-annual
☐ Declog the pea gravel diaphragm, if necessary. ☐ Correct erosion problems in the sand/soil bed of dry swales. ☐ Plant an alternative grass species if the original grass cover has not been successfully established. Reseed and apply mulch to damaged areas.	Annual (as needed)
☐ Remove all accumulated sediment that may obstruct flow through the swale. Sediment accumulating near culverts and in channels should be removed when it builds up to 3 in. at any spot, or covers vegetation, or once it has accumulated to 10% of the original design volume. Replace the grass areas damaged in the process. ☐ Rototill or cultivate the surface of the sand/soil bed of dry swales if the swale does not draw down within 48 hours.	As needed (infrequent)

Additional Information

Research (Colwell et al., 2000) indicates that grass height and mowing frequency have little impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

The swale bottom and side slopes should be covered with dense vegetative cover to filter pollutants out of runoff and helps reduce flow velocities and protect the swale from erosion. Fine, close-growing grasses are ideal because increasing the surface area of the vegetation exposed to runoff improves the effectiveness of the swale. Drought tolerant vegetation than can tolerate sediment and debris accumulations are best-suited for swales.

References

California Department of Transportation. *Treatment BMP Technology Report (CTSW-RT-09-239.06)*, 2010. Available online at: http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-09-239-06.pdf.

California Stormwater Quality Association. *Stormwater Best Management Practice Handbook, New Development and Redevelopment,* 2003. Available online at: https://www.casqa.org/resources/bmp-handbooks/new-development-redevelopment-bmp-handbook.

Colwell, Shanti R., Horner, Richard R., and Booth, Derek B., 2000. *Characterization of Performance Predictors and Evaluation of Mowing Practices in Biofiltration Swales.* Report to King County Land and Water Resources Division and others by Center for Urban Water Resources Management, Department of Civil and Environmental Engineering, University of Washington, Seattle.

San Francisco Public Utilities Commission, et al. San Francisco Stormwater Design Guidelines. Appendix A, Stormwater BMP Fact Sheets, 2010. Available online at: http://www.sfwater.org/modules/showdocument.aspx?documentid=2778.

Stormwater Managers Resource Center. http://www.stormwatercenter.net.

Stormwater Mangers Resource Center, Stormwater Practices for Cold Climates. http://www.stormwatercenter.net/Cold%20Climates/cold-climates.htm.

Tahoe Regional Planning Agency. Best Management Practices Handbook, 2012. Available online at: http://www.tahoebmp.org/Documents/2012%20BMP%20Handbook.pdf.

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development and Redevelopment. BMP Fact Sheets. Available online at: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5.

Ventura Countywide Stormwater Quality Management Program. *Technical Guidance Manual for Stormwater Quality Control Measures*, 2010. Available online at: http://www.vcstormwater.org/documents/workproducts/technicalguidancemanual/2010revisions/Ventura%20Technical%20Guidance%20Document_5-6-10.pdf.

Watershed Management Institute, Inc. *Operation, Maintenance, and Management of Stormwater Management Systems*, 1997. Available online at: http://www.stormwater.ucf.edu/research/stormwaterOMM/stormwateromm.pdf.

Design Considerations

- Soil for Infiltration
- Slope
- Aesthetics

Targeted Constituents

☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

Description

An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater. Infiltration basins use the natural filtering ability of the soil to remove pollutants in stormwater runoff. Infiltration facilities store runoff until it gradually exfiltrates through the soil and eventually into the water table. This practice has high pollutant removal efficiency and can also help recharge groundwater, thus helping to maintain low flows in stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

California Experience

Infiltration basins have a long history of use in California, especially in the Central Valley. Basins located in Fresno were among those initially evaluated in the National Urban Runoff Program and were found to be effective at reducing the volume of runoff, while posing little long-term threat to groundwater quality (EPA, 1983; Schroeder, 1995). Proper siting of these devices is crucial as underscored by the experience of Caltrans in siting two basins in Southern California. The basin with marginal separation from groundwater and soil permeability failed immediately and could never be rehabilitated.

Advantages

- Provides 100% reduction in the load discharged to surface waters.

- The principal benefit of infiltration basins is the approximation of pre-development hydrology during which a significant portion of the average annual rainfall runoff is infiltrated and evaporated rather than flushed directly to creeks.

- If the water quality volume is adequately sized, infiltration basins can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration basins once clogged.

Design and Sizing Guidelines

- Water quality volume determined by local requirements or sized so that 85% of the annual runoff volume is captured.
- Basin sized so that the entire water quality volume is infiltrated within 48 hours.
- Vegetation establishment on the basin floor may help reduce the clogging rate.

Construction/Inspection Considerations

- Before construction begins, stabilize the entire area draining to the facility. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction or remove the top 2 inches of soil after the site is stabililized. Stabilize the entire contributing drainage area, including the side slopes, before allowing any runoff to enter once construction is complete.
- Place excavated material such that it can not be washed back into the basin if a storm occurs during construction of the facility.
- Build the basin without driving heavy equipment over the infiltration surface. Any equipment driven on the surface should have extra-wide ("low pressure") tires. Prior to any construction, rope off the infiltration area to stop entrance by unwanted equipment.
- After final grading, till the infiltration surface deeply.
- Use appropriate erosion control seed mix for the specific project and location.

Performance

As water migrates through porous soil and rock, pollutant attenuation mechanisms include precipitation, sorption, physical filtration, and bacterial degradation. If functioning properly, this approach is presumed to have high removal efficiencies for particulate pollutants and moderate removal of soluble pollutants. Actual pollutant removal in the subsurface would be expected to vary depending upon site-specific soil types. This technology eliminates discharge to surface waters except for the very largest storms; consequently, complete removal of all stormwater constituents can be assumed.

There remain some concerns about the potential for groundwater contamination despite the findings of the NURP and Nightingale (1975; 1987a,b,c; 1989). For instance, a report by Pitt et al. (1994) highlighted the potential for groundwater contamination from intentional and unintentional stormwater infiltration. That report recommends that infiltration facilities not be sited in areas where high concentrations are present or where there is a potential for spills of toxic material. Conversely, Schroeder (1995) reported that there was no evidence of groundwater impacts from an infiltration basin serving a large industrial catchment in Fresno, CA.

Siting Criteria

The key element in siting infiltration basins is identifying sites with appropriate soil and hydrogeologic properties, which is critical for long term performance. In one study conducted in Prince George's County, Maryland (Galli, 1992), all of the infiltration basins investigated clogged within 2 years. It is believed that these failures were for the most part due to allowing infiltration at sites with rates of less than 0.5 in/hr, basing siting on soil type rather than field infiltration tests, and poor construction practices that resulted in soil compaction of the basin invert.

A study of 23 infiltration basins in the Pacific Northwest showed better long-term performance in an area with highly permeable soils (Hilding, 1996). In this study, few of the infiltration basins had failed after 10 years. Consequently, the following guidelines for identifying appropriate soil and subsurface conditions should be rigorously adhered to.

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30% clay or more than 40% of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15% should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

Secondary Screening Based on Site Geotechnical Investigation

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.

- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Additional Design Guidelines

(1) Basin Sizing - The required water quality volume is determined by local regulations or sufficient to capture 85% of the annual runoff.

(2) Provide pretreatment if sediment loading is a maintenance concern for the basin.

(3) Include energy dissipation in the inlet design for the basins. Avoid designs that include a permanent pool to reduce opportunity for standing water and associated vector problems.

(4) Basin invert area should be determined by the equation:

$$A = \frac{WQV}{kt}$$

where A = Basin invert area (m^2)

WQV = water quality volume (m^3)

k = 0.5 times the lowest field-measured hydraulic conductivity (m/hr)

t = drawdown time (48 hr)

(5) The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).

Maintenance

Regular maintenance is critical to the successful operation of infiltration basins. Recommended operation and maintenance guidelines include:

- Inspections and maintenance to ensure that water infiltrates into the subsurface completely (recommended infiltration rate of 72 hours or less) and that vegetation is carefully managed to prevent creating mosquito and other vector habitats.
- Observe drain time for the design storm after completion or modification of the facility to confirm that the desired drain time has been obtained.
- Schedule semiannual inspections for beginning and end of the wet season to identify potential problems such as erosion of the basin side slopes and invert, standing water, trash and debris, and sediment accumulation.
- Remove accumulated trash and debris in the basin at the start and end of the wet season.
- Inspect for standing water at the end of the wet season.
- Trim vegetation at the beginning and end of the wet season to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and regrade when the accumulated sediment volume exceeds 10% of the basin.
- If erosion is occurring within the basin, revegetate immediately and stabilize with an erosion control mulch or mat until vegetation cover is established.
- To avoid reversing soil development, scarification or other disturbance should only be performed when there are actual signs of clogging, rather than on a routine basis. Always remove deposited sediments before scarification, and use a hand-guided rotary tiller, if possible, or a disc harrow pulled by a very light tractor.

Cost

Infiltration basins are relatively cost-effective practices because little infrastructure is needed when constructing them. One study estimated the total construction cost at about $2 per ft (adjusted for inflation) of storage for a 0.25-acre basin (SWRPC, 1991). As with other BMPs, these published cost estimates may deviate greatly from what might be incurred at a specific site. For instance, Caltrans spent about $18/ft^3 for the two infiltration basins constructed in southern California, each of which had a water quality volume of about 0.34 ac.-ft. Much of the higher cost can be attributed to changes in the storm drain system necessary to route the runoff to the basin locations.

Infiltration basins typically consume about 2 to 3% of the site draining to them, which is relatively small. Additional space may be required for buffer, landscaping, access road, and fencing. Maintenance costs are estimated at 5 to 10% of construction costs.

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly maintained, infiltration basins have a high failure rate. Thus, it may be necessary to replace the basin with a different technology after a relatively short period of time.

References and Sources of Additional Information

Caltrans, 2002, BMP Retrofit Pilot Program Proposed Final Report, Rpt. CTSW-RT-01-050, California Dept. of Transportation, Sacramento, CA.

Galli, J. 1992. ***Analysis of Urban BMP Performance and Longevity in Prince George's County, Maryland***. Metropolitan Washington Council of Governments, Washington, DC.

Hilding, K. 1996. Longevity of infiltration basins assessed in Puget Sound. ***Watershed Protection Techniques*** 1(3):124–125.

Maryland Department of the Environment (MDE). 2000. ***Maryland Stormwater Design Manual***. http://www.mde.state.md.us/environment/wma/stormwatermanual. Accessed May 22, 2002.

Metzger, M. E., D. F. Messer, C. L. Beitia, C. M. Myers, and V. L. Kramer. 2002. The Dark Side Of Stormwater Runoff Management: Disease Vectors Associated With Structural BMPs. Stormwater 3(2): 24-39.

Nightingale, H.I., 1975, "Lead, Zinc, and Copper in Soils of Urban Storm-Runoff Retention Basins," American Water Works Assoc. Journal. Vol. 67, p. 443-446.

Nightingale, H.I., 1987a, "Water Quality beneath Urban Runoff Water Management Basins," Water Resources Bulletin, Vol. 23, p. 197-205.

Nightingale, H.I., 1987b, "Accumulation of As, Ni, Cu, and Pb in Retention and Recharge Basin Soils from Urban Runoff," Water Resources Bulletin, Vol. 23, p. 663-672.

Nightingale, H.I., 1987c, "Organic Pollutants in Soils of Retention/Recharge Basins Receiving Urban Runoff Water," Soil Science Vol. 148, pp. 39-45.

Nightingale, H.I., Harrison, D., and Salo, J.E., 1985, "An Evaluation Technique for Ground-water Quality Beneath Urban Runoff Retention and Percolation Basins," Ground Water Monitoring Review, Vol. 5, No. 1, pp. 43-50.

Oberts, G. 1994. Performance of Stormwater Ponds and Wetlands in Winter. ***Watershed Protection Techniques*** 1(2): 64–68.

Pitt, R., et al. 1994, ***Potential Groundwater Contamination from Intentional and Nonintentional Stormwater Infiltration***, EPA/600/R-94/051, Risk Reduction Engineering Laboratory, U.S. EPA, Cincinnati, OH.

Schueler, T. 1987. ***Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs***. Metropolitan Washington Council of Governments, Washington, DC.

Schroeder, R.A., 1995, ***Potential For Chemical Transport Beneath a Storm-Runoff Recharge (Retention) Basin for an Industrial Catchment in Fresno, CA***, USGS Water-Resource Investigations Report 93-4140.

Southeastern Wisconsin Regional Planning Commission (SWRPC). 1991. ***Costs of Urban Nonpoint Source Water Pollution Control Measures***. Southeastern Wisconsin Regional Planning Commission, Waukesha, WI.

U.S. EPA, 1983, ***Results of the Nationwide Urban Runoff Program: Volume 1 – Final Report***, WH-554, Water Planning Division, Washington, DC.

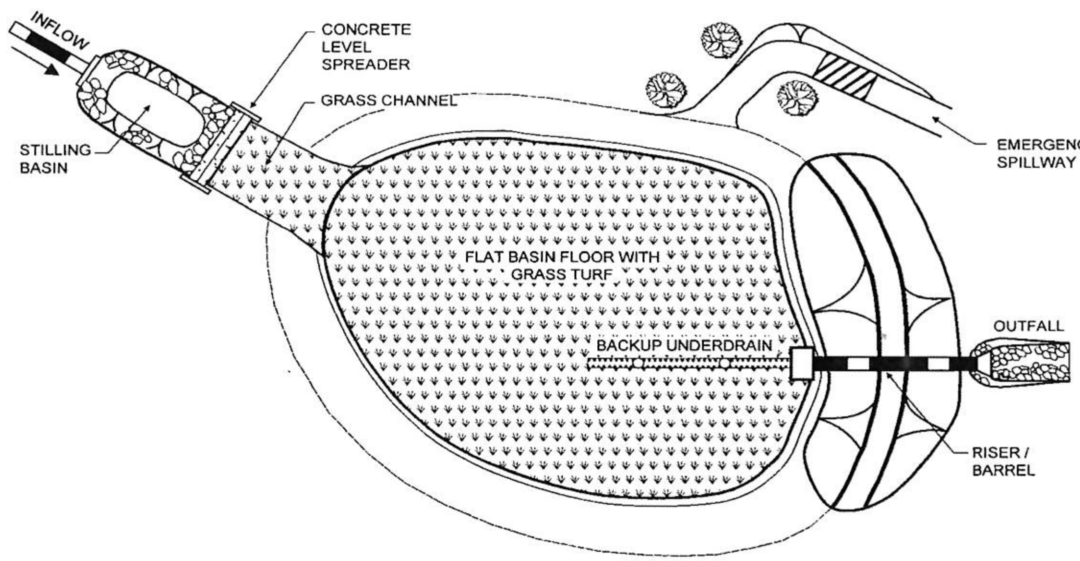
Watershed Management Institute (WMI). 1997. ***Operation, Maintenance, and Management of Stormwater Management Systems***. Prepared for U.S. Environmental Protection Agency Office of Water, Washington, DC.

Information Resources

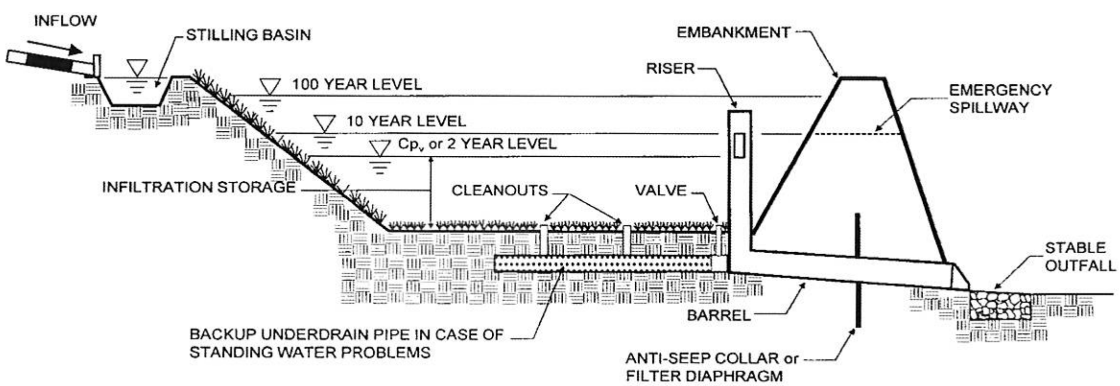
Center for Watershed Protection (CWP). 1997. ***Stormwater BMP Design Supplement for Cold Climates***. Prepared for U.S. Environmental Protection Agency Office of Wetlands, Oceans and Watersheds. Washington, DC.

Ferguson, B.K., 1994. ***Stormwater Infiltration***. CRC Press, Ann Arbor, MI.

USEPA. 1993. ***Guidance to Specify Management Measures for Sources of Nonpoint Pollution in Coastal Waters***. EPA-840-B-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.



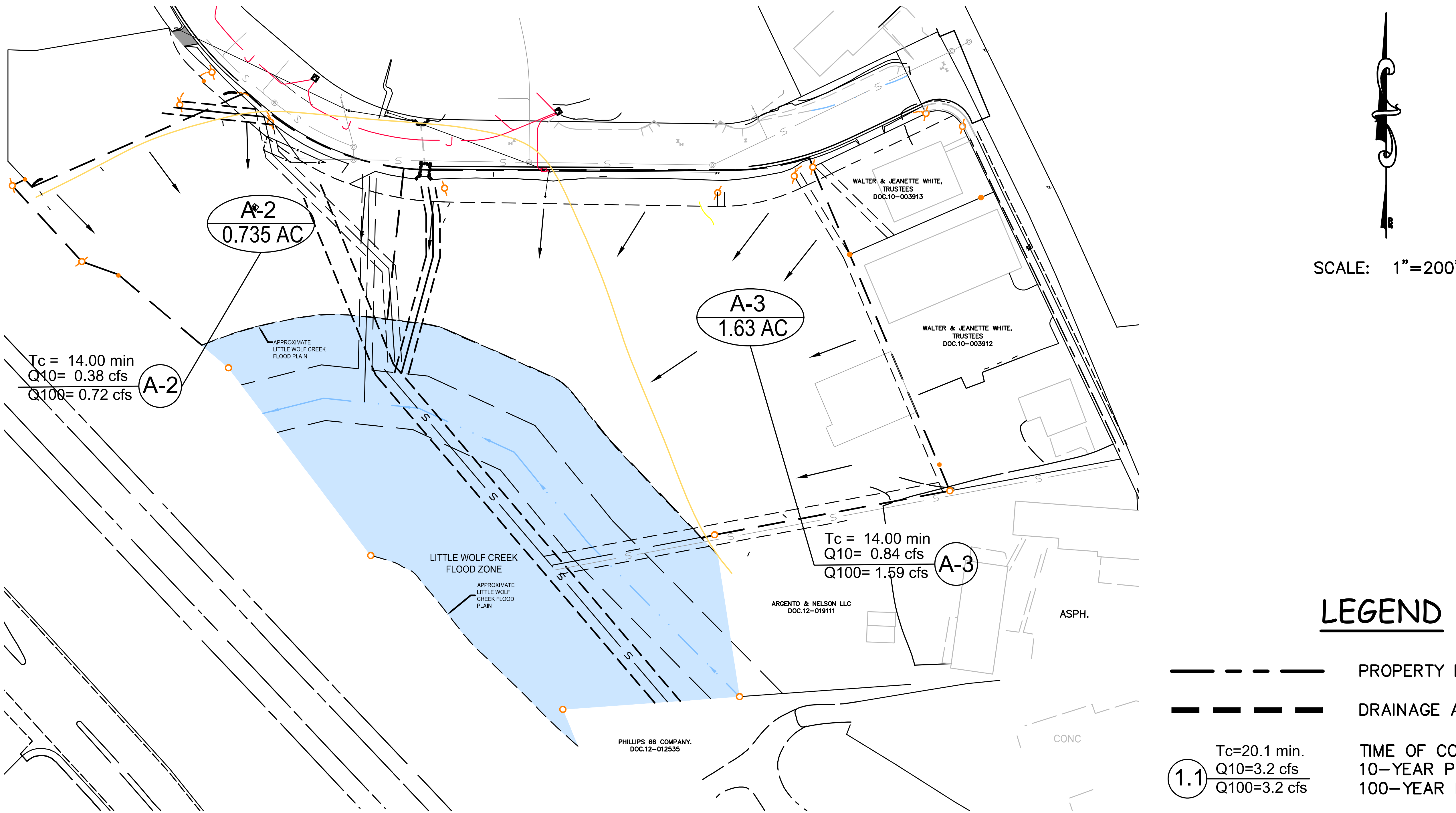
PLAN VIEW



PROFILE

APPENDIX A:

HYDROLOGY MAPS



LEGEND

— — — —	PROPERTY LINE
▬ ▬ ▬ ▬	DRAINAGE AREA BOUNDARY
(1.1) Tc=20.1 min. Q10=3.2 cfs Q100=3.2 cfs	TIME OF CONCENTRATION 10–YEAR PEAK RUNOFF 100–YEAR PEAK RUNOFF
A-3 / 1.5 AC	DRAINAGE AREA NO. DRAINAGE AREA IN ACRES
— — (orange)	EXISTING STORM DRAIN
⟶	FLOW PATH

DESIGNED: MDW
DRAWN: MDW
PROJ NO: 201808
DWG: 201808_hydrology.dwg
DATE: CITY OF GRASS VALLEY

NO.	REVISIONS	DATE

HABITAT FOR HUMANITY – JOYCE DRIVE

PRE–DEVELOPMENT

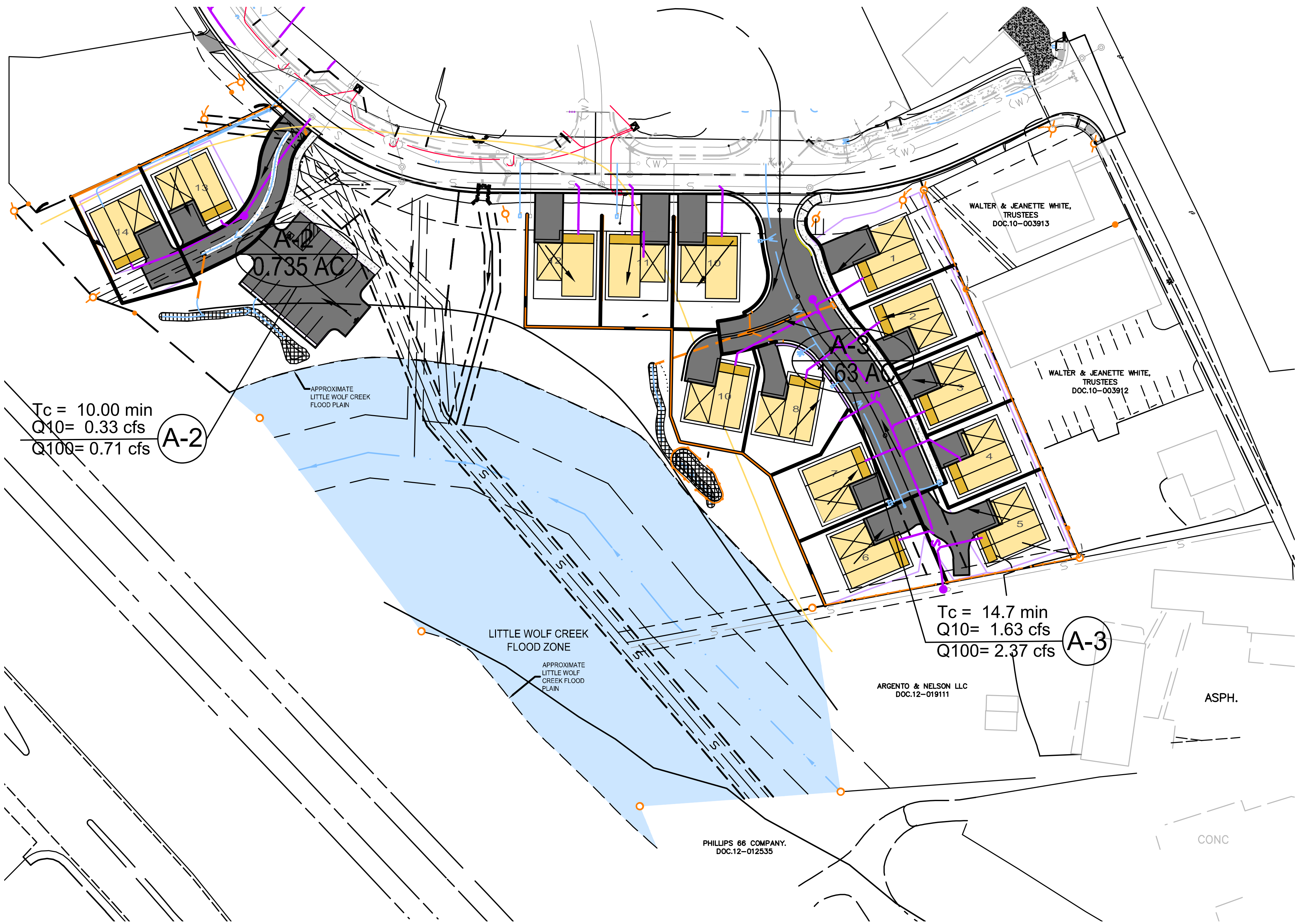
HYDROLOGY MAP

CALIFORNIA

SCO PLANNING & ENGINEERING

GRASS VALLEY 530-272-5841
FAX: 530-272-5880
TRUCKEE 530-582-4043

1 OF 1



SCALE: 1"=200'

LEGEND

	PROPERTY LINE
	DRAINAGE AREA BOUNDARY
1.1 Tc=20.1 min. Q10=3.2 cfs Q100=3.2 cfs	TIME OF CONCENTRATION 10-YEAR PEAK RUNOFF 100-YEAR PEAK RUNOFF
A-3 1.5 AC	DRAINAGE AREA NO. DRAINAGE AREA IN ACRES
	EXISTING STORM DRAIN
	FLOW PATH

NO.	REVISIONS	DATE	
			DESIGNED: MDW
			DRAWN: MDW
			PROJ NO: 201808
			DWG: 201808_hydrology.dwg
			DATE: CITY OF GRASS VALLEY

CALIFORNIA

HABITAT FOR HUMANITY - JOYCE DRIVE

POST-DEVELOPMENT

HYDROLOGY MAP

SCO PLANNING & ENGINEERING

GRASS VALLEY
530-272-5841
FAX: 530-272-5880
TRUCKEE
530-582-4043

1 OF 1