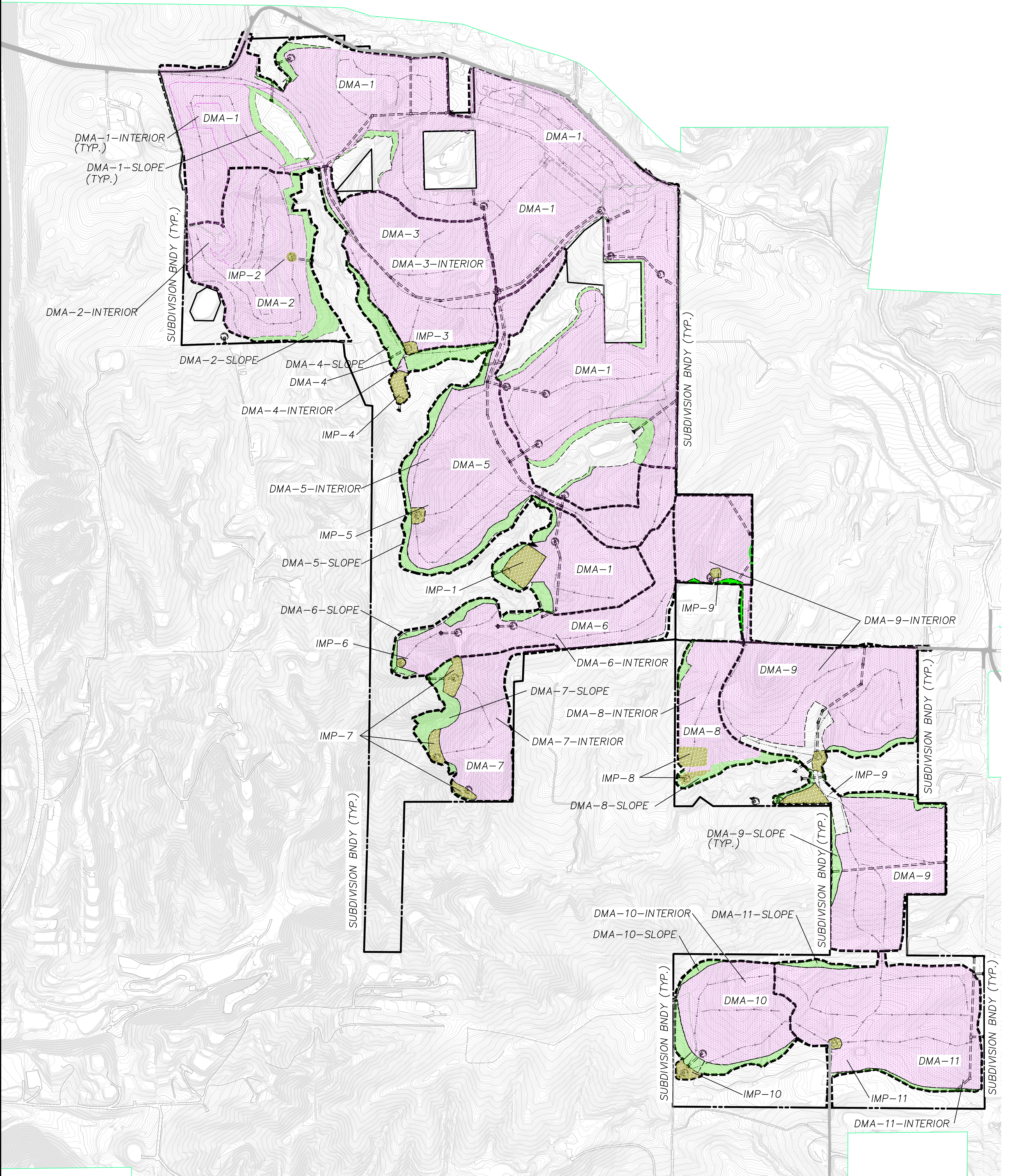
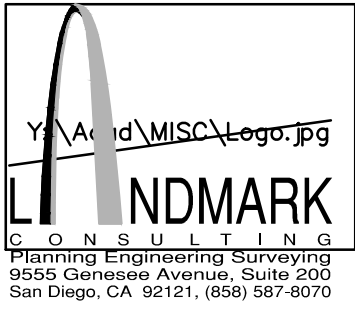
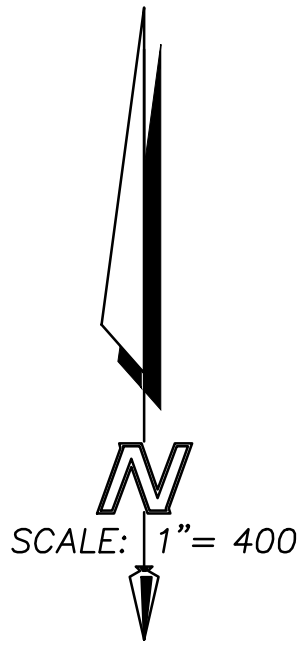


DMA SITE PLAN FOR
LILAC HILLS RANCH, TM 5571 RPL-1



LEGEND

SELF TREATING AREA	
IMP AREA	
INTERIOR AREA DRAINING INTO IMP AREA	



ATTACHMENT D

Sizing Design Calculations and TC-BMP/LID Design Details

(Provide BMP Sizing Calculator results and/or continuous simulation modeling results, if applicable)

DMA 1

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-1-SLOPE	10.8

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SURFACE TYPE	RUNOFF FACTOR	RECEIVING SELF-RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)	IMP SOIL TYPE	IMP NAME			
DMA-1-INTERIOR	150.9	HYDROSEEDDED/ LANDSCAPED	0.1	15.1	B	IMP 1			
					IMP SIZING FACTOR		MIN. VOL (Ac)	PROPOSED VOL (Ac)	IMP VOL (Ac)
			TOTAL	15.1	0.04		0.6	1.8*	1.8

- Detention basin also sized for 100-year discharge vol. attenuation.

DMA 2

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-2-SLOPE	3.6

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SRUFACE TYPE	RUNOFF FACTOR	RECEIVING SELF- RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)					
DMA-2-INTERIOR	26.2	HYDROSEEDED/ LANDSCAPED	0.1	2.6	IMP SOIL TYPE	IMP NAME			
					B	IMP 2			
					IMP SIZING FACTOR		MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
			TOTAL	2.6	0.04		0.1	0.2	0.2

DMA 3

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-3-SLOPE	0

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SRUFACE TYPE	RUNOFF FACTOR	RECEIVING SELF- RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)					
DMA-3-INTERIOR	31.8	HYDROSEEDDED/ LANDSCAPED	0.1	3.2	IMP SOIL TYPE	IMP NAME			
					B	IMP 3			
					IMP SIZING FACTOR		MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
			TOTAL	3.2	0.04		0.13	0.2	0.2

DMA 4

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-4-SLOPE	3.5

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SURFACE TYPE	RUNOFF FACTOR	RECEIVING SELF-RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)	IMP SOIL TYPE	IMP NAME	MIN. AREA (sf)	PROPOSED AREA (sf)	IMP AREA (sf)
DMA-4-INTERIOR	0.2	HYDROSEEDDED/ LANDSCAPED	0.1	0.02	IMP SOIL TYPE	IMP NAME			
					B	IMP 4			
					IMP SIZING FACTOR		MIN. AREA (sf)	PROPOSED AREA (sf)	IMP AREA (sf)
			TOTAL	0.02	0.04		35	30500	30500

DMA 5

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-5-SLOPE	4.1

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SURFACE TYPE	RUNOFF FACTOR	RECEIVING SELF-RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)	IMP SOIL TYPE	IMP NAME	MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
DMA-5-INTERIOR	44.8	HYDROSEEDDED/ LANDSCAPED	0.1	4.5	B	IMP 5			
					IMP SIZING FACTOR				
			TOTAL	4.5	0.04		0.18	0.3	0.3

DMA 6

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-6-SLOPE	1.7

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SURFACE TYPE	RUNOFF FACTOR	RECEIVING SELF-RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)	IMP SOIL TYPE	IMP NAME	MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
DMA-6-INTERIOR	22.2	HYDROSEEDDED/ LANDSCAPED	0.1	2.2	B	IMP 6			
					IMP SIZING FACTOR				
			TOTAL	2.2	0.04		0.1	2.5	2.5

DMA 7

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-7-SLOPE	2.8

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SURFACE TYPE	RUNOFF FACTOR	RECEIVING SELF-RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)	IMP SOIL TYPE	IMP NAME	MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
DMA-7-INTERIOR	16.4	HYDROSEEDDED/ LANDSCAPED	0.1	1.6	IMP SOIL TYPE	IMP NAME			
					B	IMP 7			
					IMP SIZING FACTOR		MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
			TOTAL	1.6	0.04		0.06	0.1	0.1

DMA 8

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-8-SLOPE	1.3

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SURFACE TYPE	RUNOFF FACTOR	RECEIVING SELF-RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)	IMP SOIL TYPE	IMP NAME	MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
DMA-8-INTERIOR	12.0	HYDROSEEDDED/ LANDSCAPED	0.1	1.2	B	IMP 8			
					IMP SIZING FACTOR				
			TOTAL	1.2	0.04		0.05	0.1	0.1

DMA 9

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-9-SLOPE	3.6

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SURFACE TYPE	RUNOFF FACTOR	RECEIVING SELF-RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)	IMP SOIL TYPE	IMP NAME	MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
DMA-9-INTERIOR	72.3	HYDROSEEDDED/ LANDSCAPED	0.1	7.2	B	IMP 9			
					IMP SIZING FACTOR				
			TOTAL	7.2	0.04		0.3	0.5	0.5

DMA 10

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
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DMA-10-SLOPE	3.5
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SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)
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AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SRUFACE TYPE	RUNOFF FACTOR	RECEIVING SELF- RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)					
DMA-10-INTERIOR	16.5	HYDROSEEDED/ LANDSCAPED	0.1	1.6	IMP SOIL TYPE	IMP NAME			
					B	IMP 10			
					IMP SIZING FACTOR		MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
			TOTAL	1.6	0.04		0.07	0.1	0.1

DMA 11

SELF-TREATING AREAS – Vegetated manufactured slopes discharge to natural areas

DMA NAME	AREA (Ac)
DMA-11-SLOPE	0.6

SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)

AREAS DRAINING TO SELF-RETAINING AREAS (N/A)

DMA NAME	AREA (Ac)	POST-DEV. SURFACE TYPE	RUNOFF FACTOR	RECEIVING SELF-RETAINING DMA	AREA(Ac)

INTERGRATED MANAGEMENT PRACTICE

DMA NAME	DMA AREA (AC)	POST-DEV SURFACE TYPE	DMA RUNOFF FACTOR	DMA AREA X RUNOFF FACTOR (AC)	IMP SOIL TYPE	IMP NAME			
DMA-11-INTERIOR	37.1	HYDROSEEDDED/ LANDSCAPED	0.1	3.7	IMP SOIL TYPE	IMP NAME			
					B	IMP 11			
					IMP SIZING FACTOR		MIN. AREA (Ac)	PROPOSED AREA (Ac)	IMP AREA (Ac)
			TOTAL	3.7	0.04		0.15	0.2	0.2

ATTACHMENT E

Geotechnical Certification Sheet

The design of stormwater treatment and other control measures proposed in this plan requiring specific soil infiltration characteristics and/or geological conditions has been reviewed and approved by a registered Civil Engineer, Geotechnical Engineer, or Geologist in the State of California.

Name

Date

N/A, even though the project proposes infiltration BMPs such as the Retention/Irrigation, the anticipated water quality runoff volume is not required to infiltrate into the underlying native soil. The runoff only needs to infiltrate into the top soil section and be discharge to downstream channel via outlet pipe. The pad retention/irrigation BMP will retain the water quality runoff volume.

ATTACHMENT F

Maintenance Plan

(Use Chapter 5 of the SUSMP as guidance in developing your Maintenance Plan)

I. Inspection, Maintenance Log and Self-Verification Forms

Black forms and logs are located at the end of the Attachment F

II. Updates and Revisions

Updates and revisions to this SWMP shall be inserted into the SWMP and be stored on site.

III. Introduction

The project is located on the southerly side of W. Lilac Road, easterly of I-15, in the community of Valley Center, County of San Diego. The project consists of the subdividing of approximately 610.7 acres of rural agricultural and residential land into 27 lots including 15 super lots for future master-planned community use, 12 open space lots and 1 roadway lot for backbone access to the 15 super lots.

The proposed construction activities include the mass grading of the master-planned community super lots, and the paving of the backbone road and detention and HMP mitigation facilities. No home construction is proposed for this project.

The only impervious area of the development will be the roadways. The remaining mass-graded areas will be hydroseeded and stabilized until the individual parcels are sold to future builder for future development. Separate SWMP will be required for these future developments.

IV. Designated Responsible Person:

<p>Randy Goodson Accretive Capital Partners, LLC 12275 El Camino Real, Suite 110 San Diego, Ca 92130 858-546-0700</p>

V. Summary of Drainage Areas and Stormwater facilities

See BMP Site Map for Lilac Hills Ranch in Attachment C and D for detailed depictions of pervious and impervious areas and drainage patterns

VI. General Maintenance Requirements:

BMP CATEGORY (FIRST)	MAINTENANCE ACTIVITIES	ANNUAL COST
BIO-FILTRATION AREAS	<ul style="list-style-type: none"> - CUT VEGETATION IN CHANNEL TO 8" or 6" HEIGHT - RESEED/VEGETATE BARE SPOTS AS NECESSARY - REMOVE SEDIMENT FROM CHANNEL AS NECESSARY - BACKFILL BURROW HOLES AS NECESSARY 	\$38,500
	TOTAL	\$ 38,500
MAINTENANCE RESPONSIBILITY	The County should have only minimal concern for ongoing maintenance. The property owners and HOA can naturally be expected to do so as a requirement of taking care of their property.	
BMP CATEGORY (SECOND)	MAINTENANCE ACTIVITIES	ANNUAL COST
SEDIMENT TRAPS (15 total)	<ul style="list-style-type: none"> - INSPECT STRUCTURAL INTEGRITY - REMOVE SEDIMENT FROM BASIN AS NECESSARY 	\$18,000
	TOTAL	\$18,000
MAINTENANCE RESPONSIBILITY	The County needs to assure ongoing maintenance. It is appropriate for the HOA to be given primary responsibility for maintenance. The County needs to be able to step in and perform the maintenance if HOA fails, and needs to have security to provide funding for such maintenance.	
<u>BMP CATEGORY</u> (THIRD)	MAINTENANCE ACTIVITIES	ANNUAL COST
DETENTION BASIN (1 total)	<ul style="list-style-type: none"> - CUT VEGETATION IN BASIN TO 8" HEIGHT - RESEED/VEGETATE BARE SPOTS AS NECESSARY - REMOVE SEDIMENT FROM BASIN AS NECESSARY - INSPECT STRUCTURAL INTEGRITY - BACKFILL BURROW HOLES AS NECESSARY 	\$10,000
MAINTENANCE RESPONSIBILITY	The County needs to assure ongoing maintenance is heightened, to the point that the County is willing to take on this responsibility. The master HOA will be primarily responsible for maintenance. A permanent funding mechanism needs to be established. A special assessment district will be established for this project, the assessment will be collected with property tax.	
	TOTAL	\$10,000
	GRAND TOTAL	\$66,500

ATTACHMENT G

Treatment Control BMP Certification for DPW Permitted Land Development Projects



County of San Diego

DEPARTMENT OF PUBLIC WORKS

Treatment Control BMP Certification for DPW Permitted Land Development Projects

Permit Number _____ SWMP # _____

Project Name _____

Location / Address _____

Responsible Party for Construction Phase

Developer's Name: _____

Address: _____

City _____ State _____ Zip _____

Email Address: _____

Phone Number: _____

Engineer of Work: _____

Engineer's Phone Number: _____

Responsible Party for Perpetual Maintenance

Owner's Name(s)* _____

Address: _____

City _____ State _____ Zip _____

Email Address: _____

Phone Number: _____

* Note: If a corporation or LLC, provide information for principal partner or Agent for Service of Process. If an HOA, provide information of president at time of project closeout.

Maintenance Agreement No.: _____

Percent Impervious Before Construction: % _____

Percent Impervious After Construction: % _____

Proposed Disturbed Area: _____ Acres

Hydromodification Management:

Yes ☐ or No ☐

Primary or Secondary Pollutants of Concerns *(check all that apply)*

- | | |
|--|---|
| <input type="checkbox"/> Sediment | <input type="checkbox"/> Nutrients |
| <input type="checkbox"/> Organic Compounds | <input type="checkbox"/> Trash and Debris |
| <input type="checkbox"/> Oxygen Demanding Substances | <input type="checkbox"/> Oil and Grease |
| <input type="checkbox"/> Bacteria and Viruses | <input type="checkbox"/> Pesticides |

Site Layout Strategies *(check all that apply)*

- | | |
|--|--|
| <input type="checkbox"/> Conserve Natural Areas | <input type="checkbox"/> Minimize Disturbance to Natural Areas |
| <input type="checkbox"/> Minimize and Disconnect Imp. Surfaces | <input type="checkbox"/> Minimize Soil Compaction |
| <input type="checkbox"/> Minimize erosion from slopes | |

Disperse Runoff from Impervious Surfaces to Pervious *(check all that apply)*

- | | |
|---|--|
| <input type="checkbox"/> Use of pervious surfaces | <input type="checkbox"/> Street and Road Design |
| <input type="checkbox"/> Parking Lot Design | <input type="checkbox"/> Driveway, Sidewalk, Bikepath Design |
| <input type="checkbox"/> Building Design | <input type="checkbox"/> Landscape Design |

Source BMPs *(check all that apply)*

- | | |
|--|---|
| <input type="checkbox"/> Storm Drain Inlets | <input type="checkbox"/> Interior Floor Drains |
| <input type="checkbox"/> Interior Parking Garages | <input type="checkbox"/> Indoor & Structural Pest Control |
| <input type="checkbox"/> Landscape/Outdoor Pesticide Use | <input type="checkbox"/> Pools, spas, etc. |
| <input type="checkbox"/> Food Service | <input type="checkbox"/> Refuse Areas |
| <input type="checkbox"/> Industrial Processes | <input type="checkbox"/> Outdoor Storage of Equipment and Materials |
| <input type="checkbox"/> Vehicle and Equipment Cleaning | <input type="checkbox"/> Vehicle/ Equipment Repair and Maintenance |
| <input type="checkbox"/> Fuel Dispensing Areas | <input type="checkbox"/> Loading Docks |
| <input type="checkbox"/> Fire Sprinkler Test Water | <input type="checkbox"/> Misc. drain or wash water |
| <input type="checkbox"/> Plazas, sidewalks, and parking lots | |

Treatment Control, Hydromodification and LID BMPs

BMP Identifier: (Identifier to match TCBMPs on TCBMP Table.)	Type	Record Plan Page for TCBMP	BMP Pollutant of Concern Efficiency (H,M,L)

(Add sheet for all additional BMPs)

The Maintenance Agreement has been recorded. Yes ☐ or No ☐

I certify that the above items for this project are in substantial conformance with the approved plans. Yes ☐ or No ☐

Please sign your name and seal.

[SEAL]

Engineer's Print Name: _____

Engineer's Signed Name: _____

Date: _____

Submittals Required with Certification:

- Copy of the final approved SWMP.
- Copy of the approved record plan showing Stormwater TCBMP Table and the location of each verified as-built TCBMP.
- Copy of the specification sheets for the verified proprietary TCBMPs
- Recorded Maintenance Agreement (Category 1 or 2 only)
- Photograph(s) of TCBMP(s)

COUNTY - OFFICIAL USE ONLY:

For PDCI:

PDCI Inspector: _____

Date Project has/expects to close: _____

Date Certification received from EOW: _____

DPW Inspector concurs that every noted BMP on the plan and the SWMP or SWMP Addendum is installed onsite through field verification and completed as certified: Yes ☐
or No ☐

PDCI Inspector's Signed Name: _____ Date: _____

FOR WPP:

Date Received from PDCI: _____

WPP Submittal Reviewer: _____

WPP Reviewer concurs that the provided TC-BMP information is acceptable to enter into the TC-BMP Maintenance verification inventory. Yes ☐ or No ☐

WPP Reviewer's Signed Name: _____ Date: _____

ATTACHMENT H

HMP Exemption Documentation (if applicable)

ATTACHMENT I

Addendum

Description

Retention/irrigation refers to the capture of stormwater runoff in a holding pond and subsequent use of the captured volume for irrigation of landscape of natural pervious areas. This technology is very effective as a stormwater quality practice in that, for the captured water quality volume, it provides virtually no discharge to receiving waters and high stormwater constituent removal efficiencies. This technology mimics natural undeveloped watershed conditions wherein the vast majority of the rainfall volume during smaller rainfall events is infiltrated through the soil profile. Their main advantage over other infiltration technologies is the use of an irrigation system to spread the runoff over a larger area for infiltration. This allows them to be used in areas with low permeability soils.

Capture of stormwater can be accomplished in almost any kind of runoff storage facility, ranging from dry, concrete-lined ponds to those with vegetated basins and permanent pools. The pump and wet well should be automated with a rainfall sensor to provide irrigation only during periods when required infiltration rates can be realized. Generally, a spray irrigation system is required to provide an adequate flow rate for distributing the water quality volume (LCRA, 1998). Collection of roof runoff for subsequent use (rainwater harvesting) also qualifies as a retention/irrigation practice.

This technology is still in its infancy and there are no published reports on its effectiveness, cost, or operational requirements. The guidelines presented below should be considered tentative until additional data are available.

California Experience

This BMP has never been implemented in California, only in the Austin, Texas area. The use there is limited to watersheds where no increase in pollutant load is allowed because of the sensitive nature of the watersheds.

Advantages

- Pollutant removal effectiveness is high, accomplished primarily by: (1) sedimentation in the primary storage facility; (2) physical filtration of particulates through the soil profile; (3) dissolved constituents uptake in the vegetative root zone by the soil-resident microbial community.

Design Considerations

- Soil for Infiltration
- Area Required
- Slope
- Environmental Side-effects

Targeted Constituents

<input checked="" type="checkbox"/>	Sediment	■
<input checked="" type="checkbox"/>	Nutrients	■
<input checked="" type="checkbox"/>	Trash	■
<input checked="" type="checkbox"/>	Metals	■
<input checked="" type="checkbox"/>	Bacteria	■
<input checked="" type="checkbox"/>	Oil and Grease	■
<input checked="" type="checkbox"/>	Organics	■

Legend (Removal Effectiveness)

- Low
- High
- ▲ Medium



The hydrologic characteristics of this technique are effective for simulating pre-developed watershed conditions through: (1) containment of higher frequency flood volumes (less than about a 2-year event); and (2) reduction of flow rates and velocities for erosive flow events.

- Pollutant removal rates are estimated to be nearly 100% for all pollutants in the captured and irrigated stormwater volume. However, relatively frequent inspection and maintenance is necessary to assure proper operation of these facilities.
- This technology is particularly appropriate for areas with infrequent rainfall because the system is not required to operate often and the ability to provide stormwater for irrigation can reduce demand on surface and groundwater supplies.

Limitations

- Retention-irrigation is a relatively expensive technology due primarily to mechanical systems, power requirements, and high maintenance needs.
- Due to the relative complexity of irrigation systems, they must be inspected and maintained at regular intervals to ensure reliable system function.
- Retention-irrigation systems use pumps requiring electrical energy inputs (which cost money, create pollution, and can be interrupted). Mechanical systems are also more complex, requiring skilled maintenance, and they are more vulnerable to vandalism than simpler, passive systems.
- Retention-irrigation systems require open space for irrigation and thus may be difficult to retrofit in urban areas.
- Effective use of retention irrigation requires some form of pre-treatment of runoff flows (i.e., sediment forebay or vegetated filter) to remove coarse sediment and to protect the long-term operating capacity of the irrigation equipment.
- Retention/irrigation BMPs capture and store water that, depending on design may be accessible to mosquitoes and other vectors for breeding.

Design and Sizing Guidelines

- Runoff Storage Facility Configuration and Sizing - Design of the runoff storage facility is flexible as long as the water quality volume and an appropriate pump and wet well system can be accommodated.
- Pump and Wet Well System - A reliable pump, wet well, and rainfall or soil moisture sensor system should be used to distribute the water quality volume. These systems should be similar to those used for wastewater effluent irrigation, which are commonly used in areas where "no discharge" wastewater treatment plant permits are issued.
- Detention Time - The irrigation schedule should allow for complete drawdown of the water quality volume within 72 hours. Irrigation should not begin within 12 hours of the end of rainfall so that direct storm runoff has ceased and soils are not saturated. Consequently, the length of the active irrigation period is 60 hours. The irrigation should include a cycling factor of $\frac{1}{2}$, so that each portion of the area will be irrigated for only 30 hours during the

total of 60 hours allowed for disposal of the water quality volume. Irrigation also should not occur during subsequent rainfall events.

- **Irrigation System** - Generally a spray irrigation system is required to provide an adequate flow rate for timely distribution of the water quality volume.
- Designs that utilize covered water storage should be accessible to vector control personnel via access doors to facilitate vector surveillance and control if needed.
- **Irrigation Site Criteria** – The area selected for irrigation must be pervious, on slopes of less than 10%. A geological assessment is required for proposed irrigation areas to assure that there is a minimum of 12 inches of soil cover. Rocky soils are acceptable for irrigation; however, the coarse material (diameter greater than 0.5 inches) should not account for more than 30% of the soil volume. Optimum sites for irrigation include recreational and greenbelt areas as well as landscaping in commercial developments. The stormwater irrigation area should be distinct and different from any areas used for wastewater effluent irrigation. Finally, the area designated for irrigation should have at least a 100-foot buffer from wells, septic systems, and natural wetlands.
- **Irrigation Area** – The irrigation rate must be low enough so that the irrigation does not produce any surface runoff; consequently, the irrigation rate may not exceed the permeability of the soil. The minimum required irrigation area should be calculated using the following formula:

$$A = \frac{12 \times V}{T \times r}$$

where:

A = area required for irrigation (ft²)

V = water quality volume (ft³)

T = period of active irrigation (30 hr)

r = Permeability (in/hr)

- The permeability of the soils in the area proposed for irrigation should be determined using a double ring infiltrometer (ASTM D 3385-94) or from county soil surveys prepared by the Natural Resource Conservation Service. If a range of permeabilities is reported, the average value should be used in the calculation. If no permeability data is available, a value of 0.1 inches/hour should be assumed.
- It should be noted that the minimum area requires intermittent irrigation over a period of 60 hours at low rates to use the entire water quality volume. This intensive irrigation may be harmful to vegetation that is not adapted to long periods of wet conditions. In practice, a much larger irrigation area will provide better use of the retained water and promote a healthy landscape.

Performance

This technology is still in its infancy and there are no published reports on its effectiveness, cost, or operational requirements.

Siting Criteria

Capture of stormwater can be accomplished in almost any kind of runoff storage facility, ranging from dry, concrete-lined ponds to those with vegetated basins and permanent pools. Siting is contingent upon the type of facility used.

Additional Design Guidelines

This technology is still in its infancy and there are no published reports on its effectiveness, cost, or operational requirements.

Maintenance

Relatively frequent inspection and maintenance is necessary to verify proper operation of these facilities. Some maintenance concerns are specific to the type or irrigation system practice used.

BMPs that store water can become a nuisance due to mosquito and other vector breeding. Preventing mosquito access to standing water sources in BMPs (particularly below-ground) is the best prevention plan, but can prove challenging due to multiple entrances and the need to maintain the hydraulic integrity of the system. Reliance on electrical pumps is prone to failure and in some designs (e.g., sumps, vaults) may not provide complete dewatering, both which increase the chances of water standing for over 72 hours and becoming a breeding place for vectors. BMPs that hold water for over 72 hours and/or rely on electrical or mechanical devices to dewater may require routine inspections and treatments by local mosquito and vector control agencies to suppress mosquito production. Open storage designs such as ponds and basins (see appropriate fact sheets) will require routine preventative maintenance plans and may also require routine inspections and treatments by local mosquito and vector control agencies.

Cost

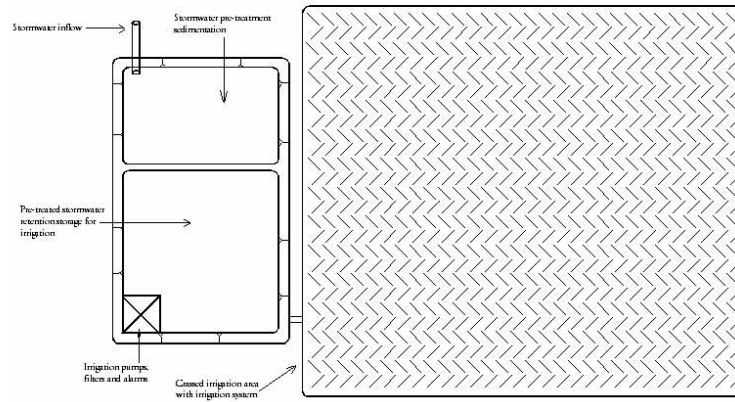
This technology is still in its infancy and there are no published reports on its effectiveness, cost, or operational requirements. However, O&M costs for retention-irrigation systems are high compared to virtually all other stormwater quality control practices because of the need for: (1) frequent inspections; (2) the reliance on mechanical equipment; and (3) power costs.

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Infiltration Trench

TC-10



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.

Design Considerations

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

Targeted Constituents

- | | |
|--|---|
| <input checked="" type="checkbox"/> Sediment | ■ |
| <input checked="" type="checkbox"/> Nutrients | ■ |
| <input checked="" type="checkbox"/> Trash | ■ |
| <input checked="" type="checkbox"/> Metals | ■ |
| <input checked="" type="checkbox"/> Bacteria | ■ |
| <input checked="" type="checkbox"/> Oil and Grease | ■ |
| <input checked="" type="checkbox"/> Organics | ■ |

Legend (Removal Effectiveness)

- Low ■ High
▲ Medium



- 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 ft³ 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/ft³; 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.

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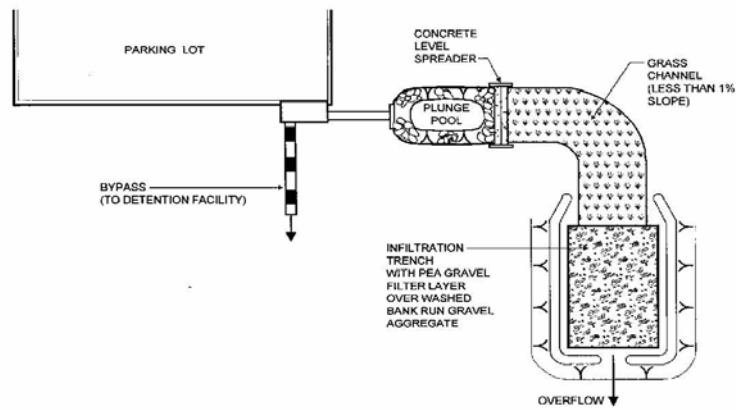
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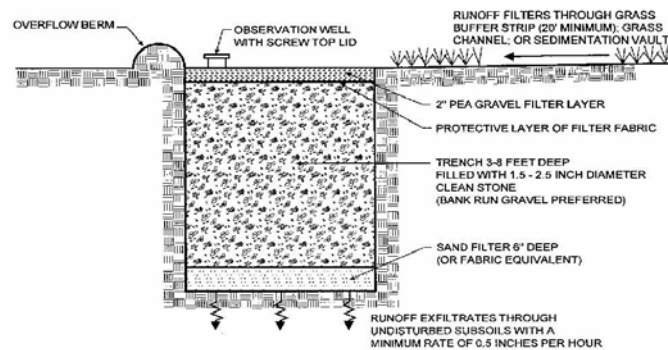
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Infiltration Trench

TC-10



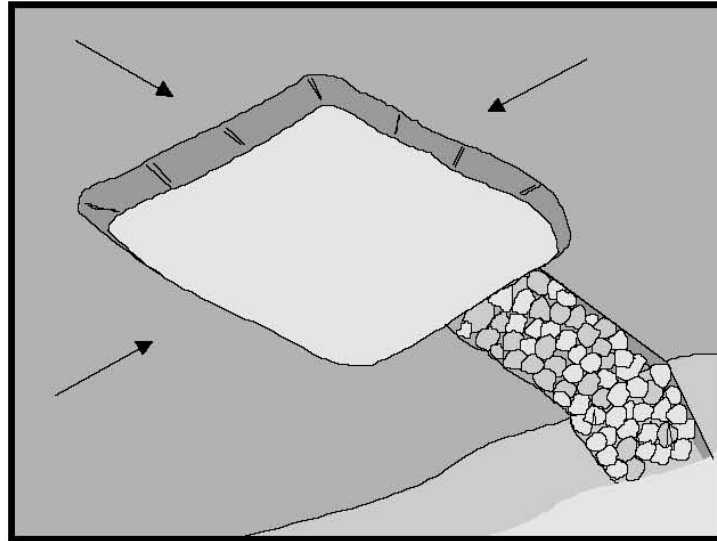
PLAN VIEW



SECTION

Sediment Trap

SE-3



Description and Purpose

A sediment trap is a containment area where sediment-laden runoff is temporarily detained under quiescent conditions, allowing sediment to settle out or before the runoff is discharged. Sediment traps are formed by excavating or constructing an earthen embankment across a waterway or low drainage area.

Suitable Applications

Sediment traps should be considered for use:

- At the perimeter of the site at locations where sediment-laden runoff is discharged offsite.
- At multiple locations within the project site where sediment control is needed.
- Around or upslope from storm drain inlet protection measures.
- Sediment traps may be used on construction projects where the drainage area is less than 5 acres. Traps would be placed where sediment-laden stormwater may enter a storm drain or watercourse. SE-2, Sediment Basins, must be used for drainage areas greater than 5 acres.
- As a supplemental control, sediment traps provide additional protection for a water body or for reducing sediment before it enters a drainage system.

Objectives

EC	Erosion Control	
SE	Sediment Control	<input checked="" type="checkbox"/>
TR	Tracking Control	
WE	Wind Erosion Control	
NS	Non-Stormwater Management Control	
WM	Waste Management and Materials Pollution Control	

Legend:

- ☒ Primary Objective
- ☒ Secondary Objective

Targeted Constituents

Sediment	<input checked="" type="checkbox"/>
Nutrients	
Trash	<input checked="" type="checkbox"/>
Metals	
Bacteria	
Oil and Grease	
Organics	

Potential Alternatives

SE-2 Sediment Basin (for larger areas)



Limitations

- Requires large surface areas to permit infiltration and settling of sediment.
- Not appropriate for drainage areas greater than 5 acres.
- Only removes large and medium sized particles and requires upstream erosion control.
- Attractive and dangerous to children, requiring protective fencing.
- Conducive to vector production.
- Should not be located in live streams.

Implementation***Design***

A sediment trap is a small temporary ponding area, usually with a gravel outlet, formed by excavation or by construction of an earthen embankment. Its purpose is to collect and store sediment from sites cleared or graded during construction. It is intended for use on small drainage areas with no unusual drainage features and projected for a quick build-out time. It should help in removing coarse sediment from runoff. The trap is a temporary measure with a design life of approximately six months to one year and is to be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

Sediment traps should be used only for small drainage areas. If the contributing drainage area is greater than 5 acres, refer to SE-2, Sediment Basins, or subdivide the catchment area into smaller drainage basins.

Sediment usually must be removed from the trap after each rainfall event. The SWPPP should detail how this sediment is to be disposed of, such as in fill areas onsite, or removal to an approved offsite dump. Sediment traps used as perimeter controls should be installed before any land disturbance takes place in the drainage area.

Sediment traps are usually small enough that a failure of the structure would not result in a loss of life, damage to home or buildings, or interruption in the use of public roads or utilities. However, sediment traps are attractive to children and can be dangerous. The following recommendations should be implemented to reduce risks:

- Install continuous fencing around the sediment trap or pond. Consult local ordinances regarding requirements for maintaining health and safety.
- Restrict basin side slopes to 3:1 or flatter.

Sediment trap size depends on the type of soil, size of the drainage area, and desired sediment removal efficiency (see SE-2, Sediment Basin). As a rule of thumb, the larger the basin volume the greater the sediment removal efficiency. Sizing criteria are typically established under the local grading ordinance or equivalent. The runoff volume from a 2-year storm is a common design criteria for a sediment trap. The sizing criteria below assume that this runoff volume is 0.042 acre-ft/acre (0.5 in. of runoff). While the climatic, topographic, and soil type extremes make it difficult to establish a statewide standard, the following criteria should trap moderate to high amounts of sediment in most areas of California:

- Locate sediment traps as near as practical to areas producing the sediment.
- Trap should be situated according to the following criteria: (1) by excavating a suitable area or where a low embankment can be constructed across a swale, (2) where failure would not cause loss of life or property damage, and (3) to provide access for maintenance, including sediment removal and sediment stockpiling in a protected area.
- Trap should be sized to accommodate a settling zone and sediment storage zone with recommended minimum volumes of 67 yd³/acre and 33 yd³/acre of contributing drainage area, respectively, based on 0.5 in. of runoff volume over a 24-hour period. In many cases, the size of an individual trap is limited by available space. Multiple traps or additional volume may be required to accommodate specific rainfall, soil, and site conditions.
- Traps with an impounding levee greater than 4.5 ft tall, measured from the lowest point to the impounding area to the highest point of the levee, and traps capable of impounding more than 35,000 ft³, should be designed by a Registered Civil Engineer. The design should include maintenance requirements, including sediment and vegetation removal, to ensure continuous function of the trap outlet and bypass structures.
- The outlet pipe or open spillway must be designed to convey anticipated peak flows.
- Use rock or vegetation to protect the trap outlets against erosion.
- Fencing should be provided to prevent unauthorized entry.

Installation

Sediment traps can be constructed by excavating a depression in the ground or creating an impoundment with a small embankment. Sediment traps should be installed outside the area being graded and should be built prior to the start of the grading activities or removal of vegetation. To minimize the area disturbed by them, sediment traps should be installed in natural depressions or in small swales or drainage ways. The following steps must be followed during installation:

- The area under the embankment must be cleared, grubbed, and stripped of any vegetation and root mat. The pool area should be cleared.
- The fill material for the embankment must be free of roots or other woody vegetation as well as oversized stones, rocks, organic material, or other objectionable material. The embankment may be compacted by traversing with equipment while it is being constructed.
- All cut-and-fill slopes should be 3:1 or flatter.
- When a riser is used, all pipe joints must be watertight.
- When a riser is used, at least the top two-thirds of the riser should be perforated with 0.5 in. diameter holes spaced 8 in. vertically and 10 to 12 in. horizontally. See SE-2, Sediment Basin.
- When an earth or stone outlet is used, the outlet crest elevation should be at least 1 ft below the top of the embankment.

- When crushed stone outlet is used, the crushed stone used in the outlet should meet AASHTO M43, size No. 2 or 24, or its equivalent such as MSHA No. 2. Gravel meeting the above gradation may be used if crushed stone is not available.

Costs

Average annual cost per installation and maintenance (18 month useful life) is \$0.73 per ft³ (\$1,300 per drainage acre). Maintenance costs are approximately 20% of installation costs.

Inspection and Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Inspect outlet area for erosion and stabilize if required.
- Inspect trap banks for seepage and structural soundness, repair as needed.
- Inspect outlet structure and spillway for any damage or obstructions. Repair damage and remove obstructions as needed.
- Inspect fencing for damage and repair as needed.
- Inspect the sediment trap for area of standing water during every visit. Corrective measures should be taken if the BMP does not dewater completely in 72 hours or less to prevent vector production.
- Sediment that accumulates in the BMP must be periodically removed in order to maintain BMP effectiveness. Sediment should be removed when the sediment accumulation reaches one-third of the trap capacity. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed of at an appropriate location.
- Remove vegetation from the sediment trap when first detected to prevent pools of standing water and subsequent vector production.
- BMPs that require dewatering shall be continuously attended while dewatering takes place. Dewatering BMPs shall be implemented at all times during dewatering activities.

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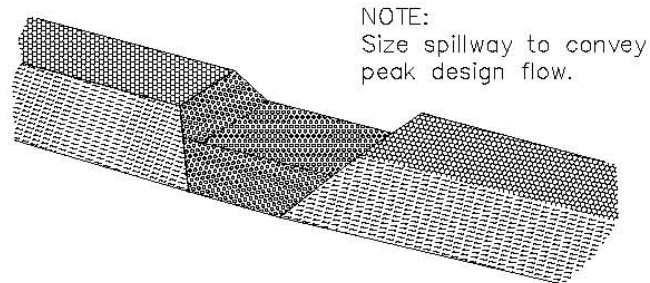
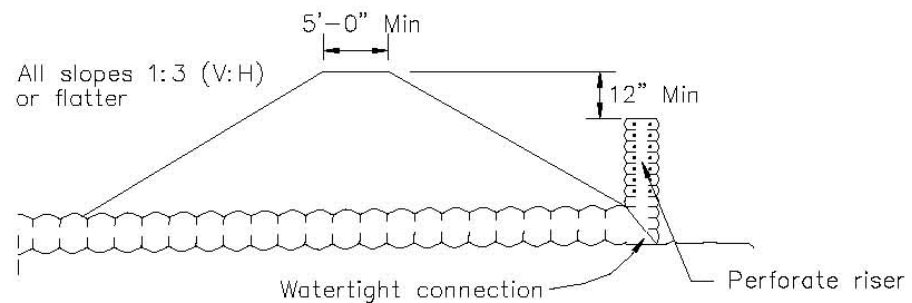
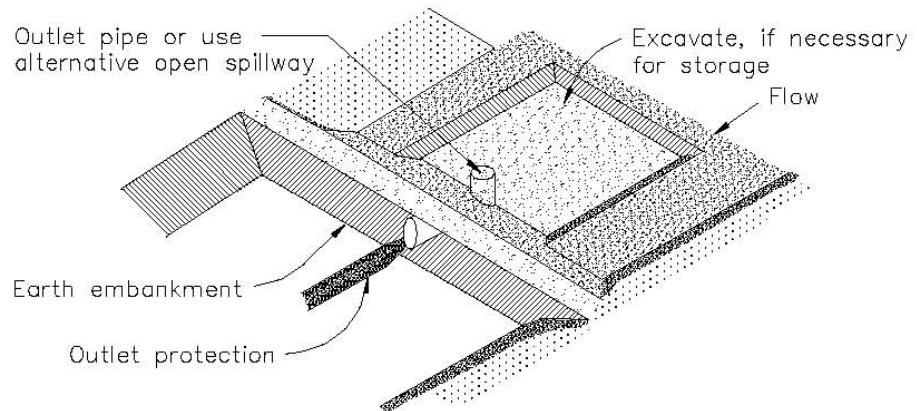
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TYPICAL OPEN SPILLWAYEMBANKMENT SECTION THRU RISERTYPICAL SEDIMENT TRAP
NOT TO SCALE

Extended Detention Basin

TC-22



Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

Targeted Constituents

<input checked="" type="checkbox"/>	Sediment	▲
<input checked="" type="checkbox"/>	Nutrients	●
<input checked="" type="checkbox"/>	Trash	■
<input checked="" type="checkbox"/>	Metals	▲
<input checked="" type="checkbox"/>	Bacteria	▲
<input checked="" type="checkbox"/>	Oil and Grease	▲
<input checked="" type="checkbox"/>	Organics	▲

Legend (Removal Effectiveness)

- Low
- High
- ▲ Medium



relationships resulting from the increase of impervious cover in a watershed.

Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).
- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.
- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.
- Outlet designed to discharge the capture volume over a period of hours.
- Length to width ratio of at least 1.5:1 where feasible.
- Basin depths optimally range from 2 to 5 feet.
- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.
- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.
- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.
- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices



Figure 1
Example of Extended Detention Outlet Structure

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

Summary of Design Recommendations

- (1) **Facility Sizing** - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

- (2) **Pond Side Slopes** - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.
- (3) **Basin Lining** – Basins must be constructed to prevent possible contamination of groundwater below the facility.
- (4) **Basin Inlet** – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.
- (5) **Outflow Structure** - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2g(H-H_o))^{0.5}$$

where: Q = discharge (ft³/s)
 C = orifice coefficient
 A = area of the orifice (ft²)
 g = gravitational constant (32.2)
 H = water surface elevation (ft)
 H_o = orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_o . When using multiple orifices the discharge from each is summed.

- (6) **Splitter Box** - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.
- (7) **Erosion Protection at the Outfall** - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.
- (8) **Safety Considerations** - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation

management to ensure that the basin dewater completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and re-grade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

Cost

Construction Cost

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume (ft³).

Using this equation, typical construction costs are:

\$ 41,600 for a 1 acre-foot pond

\$ 239,000 for a 10 acre-foot pond

\$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about \$160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the