Appendix H.2008 Hydrology and Water Quality Technical Report

Appendix

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Appendix H: Hydrology and Water Quality

H.1 - Preliminary Water Quality Management Plan
Prepared by Huitt-Zollars, Inc. - January 2008

H.2 - Hydrology and Hydraulic Calculations
Prepared by Huitt-Zollars, Inc.- Revised January 2008

H.1 - Preliminary Water Quality Management Plan Prepared by Huitt-Zollars, Inc. - January 2008

PRELIMINARY WATER QUALITY MANAGEMENT PLAN (PWQMP)

For compliance with Santa Ana Regional Water Quality Control Board

Order Number R8-2002-0012 (NPDES Permit No. CAS618036)

for

Edgewater Lake Communities
SCH 2006-121093

Prepared for:
Edgewater Associates I, LLC
Contact Name: Donald Rosier
South-West corner of Chino Corona Road and Comet Avenue
Chino, California 91710
Tel. 303-986-2222
Fax 303-986-7990

Prepared by:
Huitt-Zollars, Inc.
Civil Engineer: Maurice Murad
Tel. 909-390-8400
Fax 909-390-8406
HZI #: 10-1073-04

WQMP Preparation Date
JANUARY 2008

Revised June 09, 2005

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WATER QUALITY MANAGEMENT PLAN (WQMP)

PROJECT SITE INFORMATION

Name of Project: Edgewater Lake Communities

Project Location: South-West corner of Chino Corona Road and Comet Avenue

Size of Significant Re-Development on an Already Developed Site (in $feet^2$): N/A

Size of New Development (in $feet^2$): 11,888,830.8 sf (272.93 Ac.)

Number of Home Subdivisions: 1

SIC Codes: 1521 (Single Family Houses)

Erosive Site Conditions?: *The Soils Report does not indicate any findings of erosive site conditions. BMPs will be implemented during the construction phase to prevent erosion.*

Natural Slope More Than 25%?: None

WATER QUALITY MANAGEMENT PLAN (WQMP)

Check the appropriate project category below:

Check below	**Project Categories**
	1. All significant re-development projects. Significant re-development is defined as the addition or creation of 5,000 or more square feet of impervious surface on an already developed site. This includes, but is not limited to, additional buildings and/or structures, extension of existing footprint of a building, construction of parking lots, etc. Where redevelopment results in an increase of less than fifty percent of the impervious surfaces of a previously existing development, and the existing development was not subject to SUSMPs, the design standards apply only to the addition, and not the entire development. When the redevelopment results in an increase of more than fifty percent of the impervious surfaces, then a WQMP is required for the entire development (new and existing).
X	2. Home subdivisions of 10 units or more. This includes single family residences, multi-family residence, condominiums, apartments, etc.
	3. Industrial/commercial developments of 100,000 square feet or more. Commercial developments include non-residential developments such as hospitals, educational institutions, recreational facilities, mini-malls, hotels, office buildings, warehouses, and light industrial facilities.
	4. Automotive repair shops (with SIC codes 5013, 5014, 5541, 7532- 7534, 7536-7539).
	5. Restaurants where the land area of development is 5,000 square feet or more.
	6. Hillside developments of 10,000 square feet or more which are located on areas with known erosive soil conditions or where the natural slope is twenty-five percent or more.
X	7. Developments of 2,500 square feet of impervious surface or more adjacent to (within 200 feet) or discharging directly into environmentally sensitive areas such as areas designated in the Ocean Plan as areas of special biological significance or waterbodies listed on the CWA Section 303(d) list of impaired waters.
X	8. Parking lots of 5,000 square feet or more exposed to storm water. Parking lot is defined as land area or facility for the temporary storage of motor vehicles.
	The project does not fall into any of the categories described above. (If the project requires a precise plan of development [e.g. all commercial or industrial projects, residential projects of less than 10 dwelling units, and all other land development projects with potential for significant adverse water quality impacts] or subdivision of land, it is defined as a Non-Category Project.)

Section 1
Introduction And Project Description

1.1 Project Information

- **Owner:** *Edgewater Associates I, LLC*
- **Address:** *165 S. Union Blvd., Suite 510, Lakewood, CO 80228*
- ***Contact Info:*** *Tel. (303) 986-2222 Fax (303) 986-7990*
- ***Contact Person:*** *Donald Rosier*
- ***Project Site Address:*** *South-West corner of Chino Corona Road and Comet Avenue*

1.2 Permits

- **List all tract or permit number(s), condition number(s), and any acquired waste discharge identification numbers (WDIDs) pertaining to project.**

  -WDID No.: *(pending)*
  -Design Review No.: *SCH 2006-121093*
  -Conditions of Approval No.: *(pending)*
  -Certifications: *A 401 Water Quality Certification is not required for this project.*

1.3 Project Description

- **Provide a detailed project description include following:**
  - **Land-use type (refer to Tables 1-1 and 2-1 in the WQMP Guidance).**

    The proposed project site will include a large scaled subdivision composed of single family homes, multi-family homes (condominiums) and a church or school.
  - **Project size.**

    272.93 acres
  - **Homeowners association or property owner association formation.**

    There will be a Home Owners Association in place for this project.
- **Include location map and site plan identifying storm drain facilities and structures, structural BMPs, stormwater flow (drainage), and the receiving water. The location and site plan may be shown on the same map.**

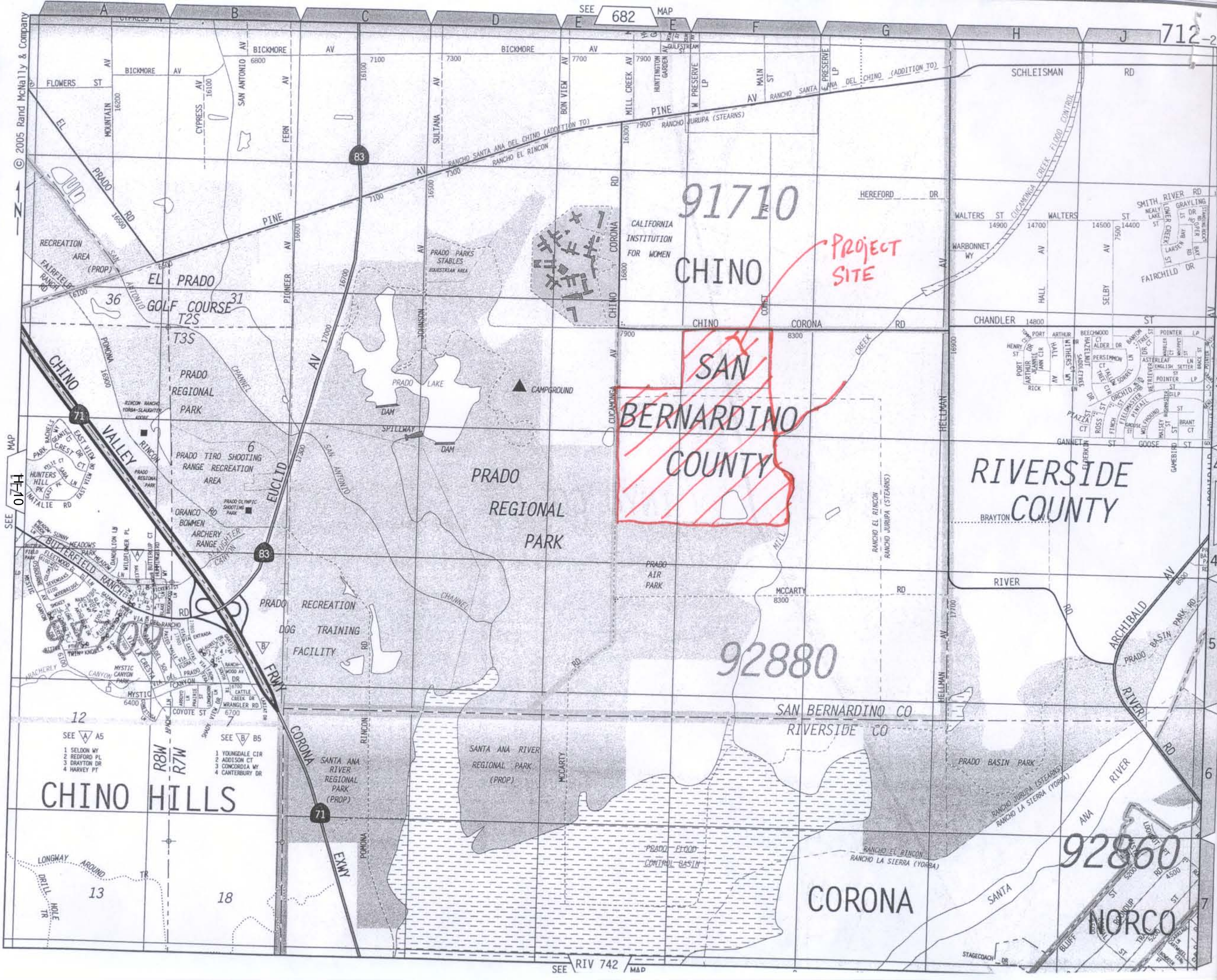
  -The following page depicts a vicinity map (Thomas Guide) for our project and it also depicts our project site in relation to the Prado Flood Control Basin (Google Earth).
  -Attachment E is the WQMP Site Plan which depicts any proposed or existing storm drain facilities, proposed structural BMPs, stormwater flow (drainage), and the receiving water which is the Mill Creek.

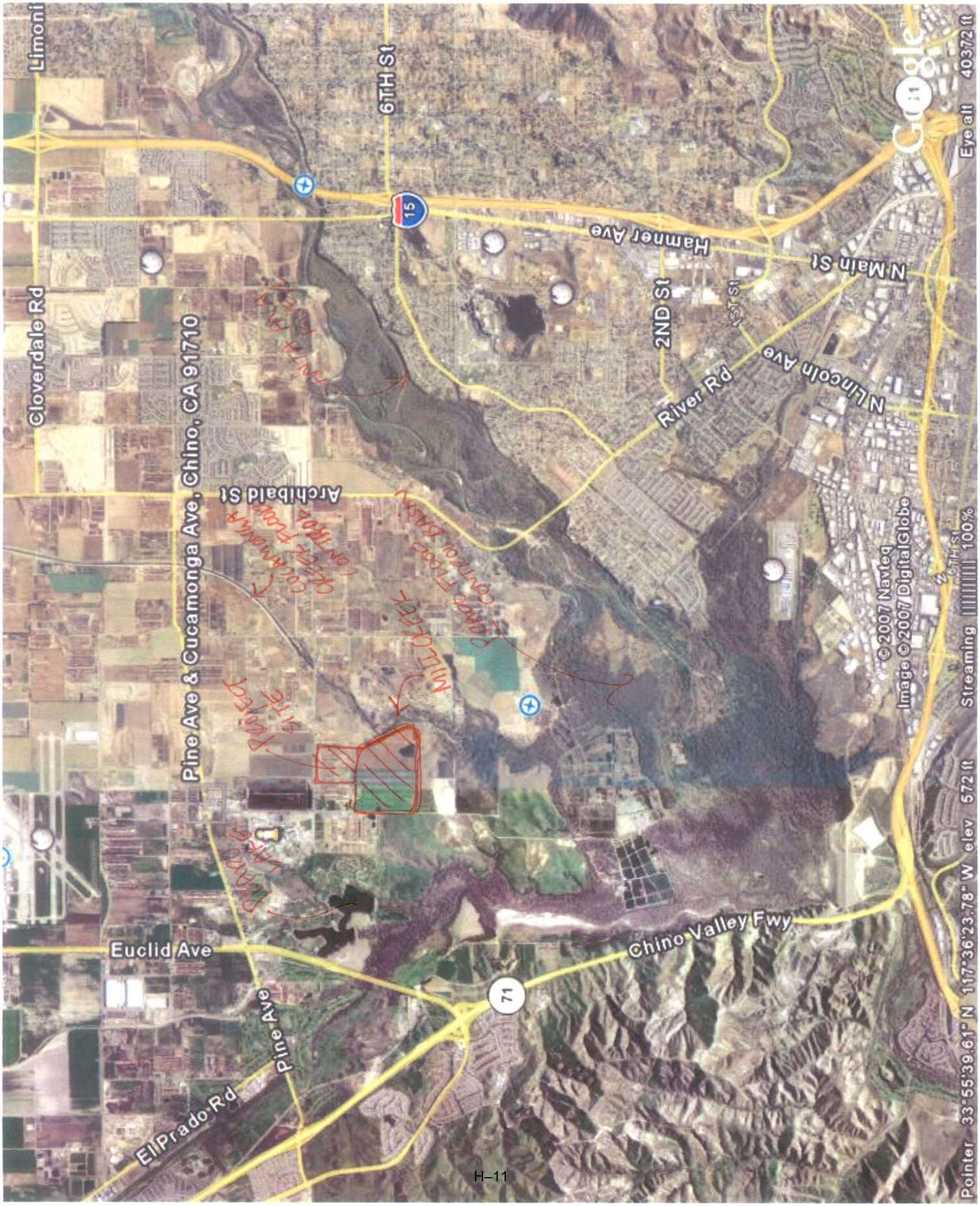
1.4 Site Description

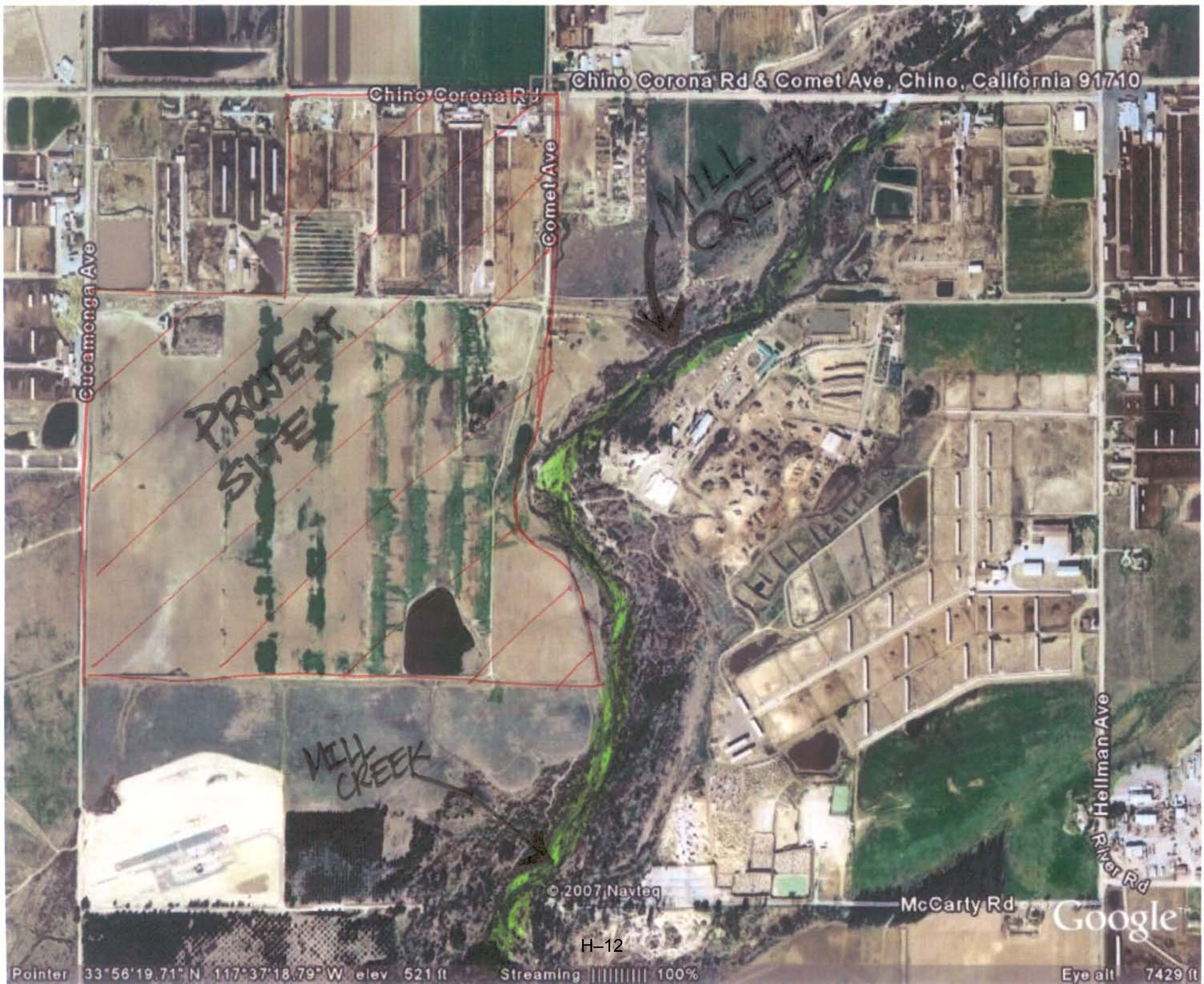
- **Describe and identify the watershed(s) that the project lies within.**

  The project lies within the Santa Ana Watershed. Please see page 5, Section 2.1 for identification on the proximate and downstream receiving waters which also includes the Hydrologic Unit Basin Numbers.
- **Include any pre-existing water quality problems that have been identified.**

  Due to the fact that large areas of our project site were dairy farms, certain corrective measures will be taken to remove it. First, the upper foot of material in all dairy areas will be removed due to the fact that it is predominantly dairy waste. This material should be removed, stockpiled, hauled offsite and disposed of in a proper manner according to local regulations. Undocumented fill, native soil, and low-density older alluvium encountered below the dairy waste should be removed. The corrective grading removals are anticipated to be about 5 to 11 feet deep. The corrective grading should extend to sufficient depths until dense older alluvium is encountered.
  Per the 2006 CWA Section 303(d) List of Water Quality Limited Segments for the Santa Ana Regional Board found in Attachment B, the Mill Creek (Prado Area) is impaired due to nutrients and total suspended solids.


712
SEE 682 MAP
SEE RIV 742 MAP
SAN BERNARDINO COUNTY
PROJECT SITE
91710
CHINO
CALIFORNIA INSTITUTION FOR WOMEN
RIVERSIDE COUNTY
92880
92860
CORONA
NORCO
CHINO HILLS
PRADO REGIONAL PARK
PRADO RECREATION DOG TRAINING FACILITY
PRADO TIRO SHOOTING RANGE RECREATION AREA
EL PRADO GOLF COURSE
SANTA ANA RIVER REGIONAL PARK (PROP)
PRADO BASIN PARK
PRADO AIR PARK
PRADO LAKE
CAMPGROUND
SAN BERNARDINO CO
RIVERSIDE CO
PINE AV
CHINO CORONA RD
EUCLID AV
HELLMAN AV
SCHLEISMAN RD
RIVER RD
MCCARTY RD
CHINO VALLEY FRWY
CORONA EXWY
© 2005 Rand McNally & Company


Limoni
Cloverdale Rd
Pine Ave & Cucamonga Ave, Chino, CA 91710
Archibald St
6TH St
15
Hamner Ave
N Main St
2ND St
1ST St
River Rd
N Lincoln Ave
Euclid Ave
Pine Ave
El Prado Rd
Chino Valley Fwy
71
PROJECT SITE
MILL CREEK
CUCAMONGA CREEK FLOOD CONTROL
PRADO LAKE
© 2007 Navteq
Image © 2007 DigitalGlobe
Streaming 100%
Pointer 33°55'39.61" N 117°36'23.78" W elev 572 ft
Eye alt 40372 ft
Google


Chino Corona Rd & Comet Ave, Chino, California 91710
Chino Corona Rd
Comet Ave
Cucamonga Ave
MILL CREEK
PROJECT SITE
MILL CREEK
Hellman Ave
River Rd
McCarty Rd
© 2007 Navteq
Google
Pointer 33°56'19.71" N 117°37'18.79" W elev 521 ft
Streaming |||||||||| 100%
Eye alt 7429 ft


River Rd
McCarty Rd
MILL CREEK
PRADO FLOOD CONTROL BASIN
© 2007 Navteq
Google
Pointer 33°55'25.41" N 117°37'18.38" W elev 537 ft
Streaming 100%
Eye alt 7429 ft


MILL CREEK
PRADO FLOOD CONTROL BASIN
PRADO DAM
Chino Valley Fwy
Archibald St
River Rd
Corydon Ave
71
91
© 2007 Navteq
Image © 2007 DigitalGlobe
Google
Pointer 33°54'26.27" N 117°37'09.37" W elev 496 ft
Streaming 100%
Eye alt 21642 ft

Section 2
Pollutants of concern and hydrologic conditions of concern

2.1 Pollutants of Concern (NOT REQUIRED FOR NON-CATEGORY PROJECTS)

Use Table 2-1 in the WQMP Guidance to identify the potential pollutants expected to be generated by the development. List all expected pollutants of concern for the project site as directed below:

- **List all expected and potential pollutants using Table 2-1.**

  Nutrients, pesticides, sediments, trash & debris, oxygen demanding substances, bacteria/virus, heavy metals, organic compounds, and oil & grease.
- **List any other pollutants of concern from the project site not listed in Tables 2-1 and B-1.**

  No pollutants of concern known.
- **Identify pollutants of concern in the receiving waters as follows:**

1. **For each of the proposed project discharge points, identify the proximate receiving water for each point of discharge and all downstream receiving waters, using hydrologic unit basin numbers as identified in the most recent version of the Water Quality Control Plan for the Santa Ana Basin prepared by the RWQCB.**

- The proposed tract will have in place proposed engineered and hardened storm drain facilities to accept all project flows. All flows will be treated before entering the proximate receiving waters, the Mill Creek (Prado Area). From hereon, flows will continue on the downstream waters, the Santa Ana River, Reach 3 and eventually terminate at the Pacific Ocean.

The Hydrologic Unit Basin numbers are as follows:

Mill Creek (Prado Area)	*801.25*
The Santa Ana River, Reach 3	*801.21*

2. **Identify each proximate and downstream receiving water identified above that is listed on the most recent list of Clean Water Act Section 303(d) (CWA 303(d) list) impaired water bodies (Attachment B, Table B-1). List any and all pollutants for which the receiving waters are impaired.**

- Per the 2006 CWA Section 303(d) List of Water Quality Limited Segments for the Santa Ana Regional Board found in Attachment B of the Water Quality Management Plan Guidance, the proximate receiving waters, the Mill Creek (Prado Area) is impaired due to nutrients and total suspended solids.
Per the EPA's TMDL reports, Mill Creek (Prado Area) is impaired due to pathogens.

3. **Compare the list of pollutants for which the receiving waters are impaired with the pollutants expected to be generated by the project (and listed above).**
-See the Pollutant of Concern Summary Table below.

4. **List all pollutants that are expected or potential from the project site, and for which the receiving waters are impaired.**
- See the Pollutant of Concern Summary Table below.

5. **Summarize identified pollutants of concern by checking the applicable boxes in the following table. (For identified pollutants of concern that are causing impairment in receiving waters, the project WQMP shall incorporate one or more Treatment Control BMPs of medium or high effectiveness in reducing those pollutants.)**
-See the Pollutant of Concern Summary Table below. The project site will incorporate Treatment Control BMPs to treat the following project site generated pollutants stated in the Summary Table below.
We will also incorporate Treatment Control BMPs that will reduce with medium or high effectiveness for the following pollutants of concern: bacteria/virus, nutrients, and sediments. These are considered pollutants of concern since these are pollutants generated by the project site in which it will discharge into existing impaired receiving waters with similar pollutants which are causing impairment.

<u>Pollutant of Concern Summary Table</u>

Pollutant Type	Expected	Potential	Listed for Receiving Water
Bacteria/Virus	X	X	Mill Creek (Prado Area)
Heavy Metals	X		
Nutrients	X	X	Mill Creek (Prado Area)
Pesticides	X	X	
Organic Compounds	X		
Sediments	X	X	Mill Creek (Prado Area)
Trash & Debris	X		
Oxygen Demanding Substances	X	X	
Oil & Grease	X	X	
Other—specify pollutant(s):			

2.2 HYDROLOGIC CONDITIONS OF CONCERN (NOT REQUIRED FOR NON-CATEGORY PROJECTS)

All Category projects must identify any hydrologic condition of concern (HCOC) that will be caused by the project, and implement Site Design, Source Control, and/or Treatment Control BMPs to address identified impacts. Project proponents must follow the procedure for identifying HCOCs specified in Section 2.3 of the Model WQMP. Use the following Table and instructions as a guide.

1. (from Section 2.3, Part 2): Determine if the project will create a Hydrologic Condition of Concern. Check "yes" or "no" as applicable and proceed to the appropriate section as outlined below.	**Yes**	**No**
A. All downstream conveyance channels, that will receive runoff from the project, are engineered, hardened (concrete, riprap or other), and regularly maintained to ensure design flow capacity, and no sensitive stream habitat areas will be affected. Engineered, hardened, and maintained channels include channel reaches that have been fully and properly approved (including CEQA review, and permitting by USACOE, RWQCB and California Dept. of Fish & Game) by June 1, 2004 for construction and hardening to achieve design capacity, whether construction of the channels is complete. Discharge from the project will be in full compliance with Agency requirements for connections and discharges to the MS4, including both quality and quantity requirements, and the project will be permitted by the Agency for the connection or discharge to the MS4.		X
B. Project runoff rates, volumes, velocities, and flow duration for the post-development condition will not exceed those of the pre-development condition for 1-year, 2-year and 5-year frequency storm events. This condition will be substantiated with hydrologic modeling methods that are acceptable to the Agency, to the U.S. Army Corps of Engineers (USACOE), and to local watershed authorities.	X	
C. Can the conditions in part A or B above be demonstrated for the project?	X	
▪ If the answer for A, B, and/or C above is yes, then the project does not create a HCOC—in this case go to Section 3 (page A-12). ▪ If the answer for C above is no, the go to section 2.3. Part 3, below.		

-See the following page for discussion on how post-development conditions will not exceed those of the pre-development conditions. The following page will also include hydrological summary tables.

- We have prepared hydrological studies to support the fact that runoff rates for the post-development conditions will not exceed those of the pre-development condition for 2-year, 5-year, 10-year, and 100-year frequency storm events.
We have designed the proposed project site to reduce runoff for all cases. The difference between flows for pre-development conditions versus post-development conditions for 2-year, 5-year, and 10-year frequency storms is greater than the flows as calculated in the WQMP for $Q_{bmp.}$ The difference between flows for pre-development conditions versus post-development conditions for a 100-year frequency storm is lower than the flows as calculated in the WQMP for Q_{bmp}.
Reducing runoff is accomplished by having in place infiltration basins sized large enough to detain and infiltrate the post-development and pre-development generated volume difference. All three infiltration basins will be in place for water quality mitigation measures as well to serve as flood control purposes. The intent is for the project to not create a HCOC and this is achieved by making sure the post-development runoff rates, volumes, velocities, and flow duration do not exceed the pre-development condition for 2-year, 5-year, 10-year, and 100-year frequency storm events. Since the infiltration basins will act as detention basins as well, the basins are capable of releasing the post-development 2-year, 5-year, 10-year, and 100-year, 24 hour volume at flow rates less than or equal to the pre-development 2-year, 5-year, 10-year, and 100-year, 24 hour peak flow rates. The basins will pass the 100-year storm events without damaging the facilities. The outlet velocities will be controlled such that the downstream erosion and habitat loss is minimized.

- The project will include the construction of on-site lakes which will help mitigate the runoff generated by the developed site to levels acceptable by the City and State agencies. The site will include 5 storm drain systems that will intercept the generated runoff and ultimately outlet the runoff onto the proposed infiltration basins located within the proposed recreational open space areas surrounding the site.
The post developed condition ultimately will not increase the runoff generated by the site due to the construction of lakes and infiltration basins throughout the site. Each line (Line A, B, C, and D) will drain to an infiltration basin and then will outlet the spillway into the proposed recreational open space before it sheet flows into the Mill Creek. Before the flows reach the infiltration basins, an offline Vortech Unit will be in place each line to ensure pre-treatment before entering the infiltration basin. All flows exiting our proposed project site will be treated by a train system of treatment control BMPs. First, the Offline Vortech Unit will pre-treat the calculated required flow of rate (the first flush), immediately after all flows will continue to the infiltration basins which are sized large enough to detain and infiltrate the post-development and pre-development generated volume difference. The calculated required volume (the first flush) which is significantly less than the post-development and pre-development generated volume difference will be infiltrated and therefore treated. The excess flows greater than the post-development and pre-development generated volume flows will then exit the spillway into the proposed recreational open space before it sheet flows into the Mill Creek.

This in turn will provide additional help in reducing flow velocities, runoff rates, volumes, and flow duration.

-Each infiltration basin will treat the runoff rate from the pre-development conditions versus post-development conditions for 2-year, 5- year, 10-year, and 100-year frequency storms which in actuality is greater than our calculated Q_{bmps}.
Please see the following pages for the Summary Tables for reductions and the Hydrological Summary Table for the project site.

-Therefore it is determined that this project will not create a Hydrologic Condition of Concern.

LINE A, B, C AND D				
	STORM EVENT RUNOFF (AC–FT)			
	2 (YR)	5 (YR)	10 (YR)	100 (YR)
EXISTING CONDITION	2.4	4.9	21.8	80.3
PROPOSED CONDITION	8.8	13.7	20.2	52.2
DIFFERENCE	6.4	8.8	(–1.6)	(–28.1)
*MITTIGATED RUNOFF/ % OF EXISTING	0 / 0%	4.9 / 100%	11.4 / 52.3%	43.4 / 54.0%
**APPROXIMATE RUNOFF ROUTED TO THE DETENTION BASINS	8.8	8.8	8.8	8.8

* MITTIGATED RUNOFF IS CALCULATED BY SUBTRACTING THE DIFFERENCE FROM THE PROPOSED CONDITION RUNOFF

LINE A WILL BE SIZED TO DETAIN 2.8 ACRE–FT, LINE B WILL BE DESIGNED TO DETAIN 2.4 ACRE–FT, LINE C WILL BE DESIGNED TO DETAIN 2.0 ACRE–FT, AND LINE D WILL BE DESIGNED TO DETAIN 1.6 ACRE–FT (A TOTAL OF 8.8 ACRE–FT).

APPROXIMATE LIMITS OF EACH DETENTION BASIN IS SHOWN ON THIS MAP.

SECTION 3
BEST MANAGEMENT PRACTICE SELECTION PROCESS

3.1 SITE DESIGN BMPS

For listed Site Design BMPs, indicate in the following table whether it will be used (yes/no) and describe how used, or, if not used, provide justification/alternative. Provide detailed descriptions of planned Site Design BMPs, if applicable.

1. Minimize Stormwater Runoff, Minimize Project's Impervious Footprint, and Conserve Natural Areas		
Maximize the permeable area. This can be achieved in various ways, including but not limited to, increasing building density (number of stories above or below ground) and developing land use regulations seeking to limit impervious surfaces.		
Yes **X**	No	
Describe actions taken or justification/alternative: *LANDSCAPED AREAS ARE PART OF THE SITE DESIGN AND ARE INCORPORATED THROUGHOUT THE PROJECT SITE. THE BUILDING DENSITY WILL BE INCREASED BY UTILIZING TWO STORIES HIGH HOMES. THE DEVELOPER WILL INSURE TO PROVIDE SUFFICIENT LANDSCAPE AREA TO MEET OR EXCEED THE CITY OF CHINO MINIMUM REQUIREMENTS.*		
Runoff from developed areas may be reduced by using alternative materials or surfaces with a lower Coefficient of Runoff, or "C-Factor".		
Yes **X**	No	
Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER THE USE OF PERVIOUS MATERIALS FOR HARDSCAPING THROUGH OUT THE SITE. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		
Conserve natural areas. This can be achieved by concentrating or clustering development on the least environmentally sensitive portions of a site while leaving the remaining land in a natural, undisturbed condition.		
Yes **X**	No	
Describe actions taken or justification/alternative: *THE SITE DESIGN DOES INCORPORATE THE CONSERVATION OF NATURAL AREAS LOCATED ON THE SOUTH-EAST AREA OF THE PROJECT SITE. THE DEVELOPER WILL ALSO INSURE THAT THE LANDSCAPE ARCHITECT WILL DESIGN THE SITE TO INCORPORATE PLANTING OF NATIVE AND DROUGHT TOLERANT TREES AND LARGE SHRUBS.*		

Construct walkways, trails, patios, overflow parking lots, alleys, driveways, low-traffic streets, and other low-traffic areas with open-jointed paving materials or permeable surfaces, such as pervious concrete, porous asphalt, unit pavers, and granular materials.		
Yes **X**	No	
Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER THE USE OF PERVIOUS MATERIALS FOR WALKWAYS, TRAILS, PARKING LOTS, AND/OR DRIVEWAYS, THROUGH OUT THE SITE. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		
Construct streets, sidewalks, and parking lot aisles to the minimum widths necessary, provided that public safety and a pedestrian friendly environment are not compromised[1]. Incorporate landscaped buffer areas between sidewalks and streets.		
Yes **X**	No	
Describe actions taken or justification/alternative: *THE DEVELOPER WILL INSURE TO PROVIDE LANDSCAPE BUFFER AREAS BETWEEN SIDEWALKS AND STREETS. HE WILL ALSO CONSTRUCT STREETS, SIDEWALKS, AND PARKING LOT AILSES TO MINIMUM WIDTHS AS REQUIRED BY LOCAL AGENCIES. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		
Reduce widths of street where off-street parking is available[2].		
Yes **X**	No	
Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER REDUCING THE WIDTHS OF STREETS WHERE OFF-STREET PARKING IS AVAILABLE. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		
Maximize canopy interception and water conservation by preserving existing native trees and shrubs, and planting additional native or drought tolerant trees and large shrubs.		
Yes **X**	No	
Describe actions taken or justification/alternative: *THE SITE DESIGN DOES INCORPORATE THE CONSERVATION OF NATURAL AREAS LOCATED ON THE SOUTH-EAST AREA OF THE PROJECT SITE. THE DEVELOPER WILL ALSO INSURE THAT THE LANDSCAPE ARCHITECT WILL DESIGN THE SITE TO INCORPORATE PLANTING OF NATIVE AND DROUGHT TOLERANT TREES AND LARGE SHRUBS. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		

[1] Sidewalk widths must still comply with Americans with Disabilities Act regulations and other life safety requirements.

[2] However, street widths must still comply with life safety requirements for fire and emergency vehicle access.

Other comparable site design options that are equally effective. *None*		
Describe actions taken or justification/alternative:		

Minimize the use of impervious surfaces, such as decorative concrete, in the landscape design.		
Yes **x**	No	
Describe actions taken or justification/alternative: *THE DEVELOPER WILL INSURE TO MINIMIZE THE USE OF IMPERVIOUS SURFACES IN THE LANDSCAPE DESIGN. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		

Use natural drainage systems.		
Yes **x**	No	
Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER USING SITE DESIGN BMPs THAT FALL UNDER THE CATEGORY NATURAL DRAINAGE SYSTEMS. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		

Where soils conditions are suitable, use perforated pipe or gravel filtration pits for low flow infiltration[3].		
Yes **x**	No	
Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER USING PERFORATED PIPES OR GRAVEL INFILTRATION PITS FOR LOW FLOW INFILTRATION. PERCOLATION TESTING WILL BE PERFORMED TO DETERMINE IF THE SOILS CONDITIONS ARE SUITABLE FOR INFILTRATION. THIS WILL DETERMINE ARE USAGE. FURTHER DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		

Construct onsite ponding areas, rain gardens, or retention facilities to increase opportunities for infiltration, while being cognizant of the need to prevent the development of vector breeding areas.		
Yes **x**	No	
Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER CONSTRUCTING PONDING AREAS, RAIN GARDENS, OR RETENTION FACILITIES TO INCREASE OPPORTUNITIES FOR INFILTRATION. IF ONE OF THESE FACILITIES WILL BE USED, THE DEVELOPER WILL INSURE INSPECTION AND MAINTENANCE OF THE FACILITY TO PREVENT THE DEVELOPMENT OF VECTOR BREEDING. FURTHER DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		

[3]However, projects must still comply with hillside grading ordinances that limit or restrict infiltration of runoff. Infiltration areas may be subject to regulation as Class V injection wells and may require a report to the USEPA. Consult the Agency for more information on use of this type of facility.

2. Minimize Directly Connected Impervious Areas

Where landscaping is proposed, drain rooftops into adjacent landscaping prior to discharging to the storm drain.

Yes **X**	No	

Describe actions taken or justification/alternative: *THE DEVELOPER WILL INSURE ROOF RUNOFF WILL DRAIN INTO ADJACENT LANDSCAPING AS A ROOF RUNOFF CONTROL. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*

Where landscaping is proposed, drain impervious sidewalks, walkways, trails, and patios into adjacent landscaping.

Yes **X**	No	

Describe actions taken or justification/alternative: *THE DEVELOPER WILL INSURE PROPOSED SIDEWALKS, WALKWAYS, TRAILS, AND PATIOS LOCATED ADJACENT TO ANY LANDSCAPING WILL DRAIN INTO THIS LANDSCAPING. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*

Increase the use of vegetated drainage swales in lieu of underground piping or imperviously lined swales.

Yes **X**	No	

Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER USING VEGETATED DRAINAGE SWALES IN LIEU OF UNDERGOUND PIPING OR IMPERVIOUSLY LINED SWALES. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*

Use one or more of the following:

Yes	**No**	**Design Feature**
	X	Rural swale system: street sheet flows to vegetated swale or gravel shoulder, curbs at street corners, culverts under driveways and street crossings
X		Urban curb/swale system; street slopes to curb; periodic swale inlets drain to vegetated swale/biofilter.
	X	Dual drainage system: First flush captured in street catch basins and discharged to adjacent vegetated swale or gravel shoulder, high flows connect directly to municipal storm drain systems.
X		Other comparable design concepts that are equally effective.

Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER USING URBAN CURB / SWALE SYSTEMS OR OTHER DESIGN FEATURES IN THE PROJECT SITE. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*

Use one or more of the following features for design of driveways and private residential parking areas:		
Yes	No	Design Feature
	X	▪ Design driveways with shared access, flared (single lane at street) or wheel strips (paving only under tires); or, drain into landscaping prior to discharging to the municipal storm drain system.
X		▪ Uncovered temporary or guest parking on private residential lots may be paved with a permeable surface; or designed to drain into landscaping prior to discharging to the municipal storm drain system.
X		▪ Other comparable design concepts that are equally effective.
Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER CONSTRUCTING TEMPORARY OR PRIVATE RESIDENTIAL PARKING SPACES WITH A PERMEABLE SURFACES OR DESIGN THEM TO DRAIN INTO LANDSCAPING PRIOR TO DISCHARGING INTO THE STORM DRAIN SYSTEM. THE DEVELOPER WILL ALSO CONSIDER OTHER DESIGN FEATURES FOR THE PROJECT SITE. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		

Use one or more of the following design concepts for the design of parking areas:		
Yes	**No**	Design Feature
X		Where landscaping is proposed in parking areas, incorporate landscape areas into the drainage design.
X		Overflow parking (parking stalls provided in excess of the Agency's minimum parking requirements) may be constructed with permeable paving.
X		Other comparable design concepts that are equally effective.
Describe actions taken or justification/alternative: *THE DEVELOPER WILL CONSIDER DRAINING PARKING AREAS INTO THE LANDSCAPING OR CONSTRUCTING OVERFLOW PARKING WITH PERMEABLE PAVING. THE DEVELOPER WILL ALSO CONSIDER OTHER DESIGN FEATURES FOR THE PROJECT SITE. DETAILS WILL BE DETERMINED DURING FINAL DESIGN.*		

3.2 SOURCE CONTROL BMPS

Complete the following selection table for Source Control BMPs, by checking boxes that are applicable. All listed BMPs shall be implemented for the project. Where a required Source Control BMP is not applicable to the project due to project characteristics, justification and/or alternative practices for preventing pollutants must be provided. In addition to completing the following tables, provide detailed descriptions on the implementation of planned Source Control BMPs.

*****ONCE THE FINAL WQMP IS IN MOTION, SECTION 4 WILL FULLY DESCRIBE OPERATIONS AND MAINTENANCE REQUIREMENTS AND HANDLING OF WASTES FOR APPLICABLE SOURCE CONTROL BMPs.***

****DETAILED INFORMATION ON THE IMPLEMENTATION OF PLANNED SOURCE CONTROL BMPs WILL BE DETERMINED AND DISCUSSED IN THE FINAL WQMP.***

Source Control BMP Selection Matrix*

Project Category	Source Control BMPs																							
	Education of Property Owners	*Activity Restrictions*	*Spill Contingency Plan*	*Employee Training/Education Program*	*Street Sweeping Private Street and Parking Lots*	*Common Areas Catch Basin Inspection*	*Landscape Planning (SD-10)*	*Hillside Landscaping*	*Roof Runoff Controls (SD-11)*	*Efficient Irrigation (SD-12)*	*Protect Slopes and Channels*	*Storm Drain Signage (SD-13)*	*Inlet Trash Racks*	*Energy Dissipaters*	*Trash Storage Areas (SD-32) and Litter Control*	*Fueling Areas (SD-30)*	*Air/Water Supply Area Drainage*	*Maintenance Bays and Docks (SD-31)*	*Vehicle Washing Areas (SD-33)*	*Outdoor Material Storage Areas (SD-34)*	*Outdoor Work Areas (SD-35)*	*Outdoor Processing Areas (SD-36)*	*Wash Water Controls for Food Preparation Areas*	*Pervious Pavement (SD-20)*	*Alternative Building Materials (SD-21)*
Significant Re-development																									
Home subdivisions of 10 or more units	X	X	X	X	X	X	X		X	X	X	X		X	X									X	X
Commercial/ Industrial Development >100,000 ft^2																									
Automotive Repair Shop																									
Restaurants																									
Hillside Development >10,000 ft^2																									
Development of impervious surface >2,500 ft^2																									
Parking Lots >5,000 ft^2 of exposed storm water	X	X	X	X	X	X	X		X	X	X	X		X	X									X	X

* Provide justification of each Source Control BMP that will not be incorporated in the project WQMP, or explanation of proposed equally effective alternatives in the following table.

Justification for Source Control BMPs not incorporated into the project WQMP			
Source Control BMP	Used in Project (yes/no)?	Justification/Alternative*	Implementation Description
Education of Property Owners	**YES**		The Developer will insure the "Education of Property Owners" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Activity Restrictions	**YES**		The Developer will insure the "Activity Restrictions" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Spill Contingency Plan	**YES**		The Developer will insure the "Spill Contingency Plan" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Employee Training/Education Program	**YES**		The Developer will insure the "Employee Training/Education Program" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Street Sweeping Private Street and Parking Lots	**YES**		The Developer will insure the "Street Sweeping and Parking Lots" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Common Areas Catch Basin Inspection	**YES**		The Developer will insure the "Catch Basin Inspection" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Landscape Planning (SD-10)	**YES**		The Developer will insure the "Landscaping Planning" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Hillside Landscaping	**NO**	There are no existing hillsides within the project site that would be disturbed.	
Roof Runoff Controls (SD-11)	**YES**		The Developer will insure the "Roof Runoff Controls" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Efficient Irrigation (SD-12)	**YES**		The Developer will insure the "Efficient Irrigation" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Protect Slopes and Channels	**YES**		The Developer will insure the "Protect Slopes and Channels" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Storm Drain Signage (SD-13)	**YES**		The Developer will insure the "Storm Drain Signage" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.

Inlet Trash Racks	**NO**	Will not be necessary since onsite catch basins will be equipped with filter systems and there will also be offline Vortech units placed downstream to treat the project site Q_{bmp} flows.	
Energy Dissipaters	**YES**		The Developer will insure the “Energy Dissipaters” BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Trash Storage Areas (SD-32) and Litter Control	**YES**		The Developer will insure the “Trash Storage Areas and Litter Control” BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Fueling Areas (SD-30)	**NO**	There are no fueling areas within project site. Not a proposed land use. The resident’s terms will prohibit the use of fueling areas in order to protect storm water quality. The tenant/occupant’s lease term will prohibit the use of fueling areas in order to protect storm water quality.	
Air/Water Supply Area Drainage	**NO**	There is no air/water supply area within the project site. Not a proposed land use. The resident’s terms will prohibit the use of air/water supply area drainage in order to protect storm water quality. The tenant/occupant’s lease term will prohibit the use of air/water supply area drainage in order to protect storm water quality.	
Maintenance Bays and Docks (SD-31)	**NO**	There are no maintenance bays or docks within the project site. Not a proposed land use. The resident’s terms will prohibit the use of maintenance bays and docks in order to protect storm water quality. The tenant/occupant’s lease term will prohibit the use of maintenance bays and docks in order to protect storm water quality.	
Vehicle Washing Areas (SD-33)	**NO**	The owner shall prohibit vehicle-washing areas. Not a proposed land use. The resident’s terms will prohibit the use of vehicle washing areas in order to protect storm water quality. The tenant/occupant’s lease term will prohibit the use of vehicle washing areas in order to protect storm water quality.	
Outdoor Material Storage Areas (SD-34)	**NO**	There are no outdoor material storage areas within project site. Not a proposed land use. The resident’s terms will prohibit the use of outdoor material storage areas order to protect storm water quality. The tenant/occupant’s lease term will prohibit the use of outdoor material storage areas order to protect storm water quality.	
Outdoor Work Areas (SD-35)	**NO**	There are no outdoor work areas within project site. Not a proposed land use. The resident’s terms will prohibit the use of outdoor work areas in order to protect storm water quality. The tenant/occupant’s lease term will prohibit the use of outdoor work areas in order to protect storm water quality.	
Outdoor Processing Areas (SD-36)	**NO**	There are no outdoor processing areas within project site. Not a proposed land use. The resident’s terms will prohibit the use of outdoor processing areas in order to protect storm water quality. The tenant/occupant’s lease term will prohibit the use of outdoor processing areas in order to protect storm water quality.	

Wash Water Controls for Food Preparation Areas	**NO**	There are no food preparation areas within the project site. Not a proposed land use. The resident's terms will prohibit the use of wash water controls for food preparation areas in order to protect storm water quality. The tenant/occupant's lease term will prohibit the use of wash water controls for food preparation areas in order to protect storm water quality.	
Pervious Pavement (SD-20)	**YES**		The Developer will insure the "Pervious Pavement" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
Alternative Building Materials (SD-21)	**YES**		The Developer will insure the "Alternative Building Materials" BMP will be implemented for our specific project site. Detailed information on the implementation of this planned source control BMP will be determined and discussed in the Final WQMP, Section 3.2.
*Attach additional sheets if necessary for justification.			

3.3 TREATMENT CONTROL BMPS (Not required for Non-Category projects)

- **Complete the following Treatment Control BMPs Selection Matrix. For each pollutant of concern enter "yes" if identified in Section 2.1, above, or "no" if not identified for the project. Check the boxes of selected BMPs that will be implemented for the project to address each pollutant of concern from the project as listed above in section 2.1. Treatment Control BMPs must be selected and installed with respect to identified pollutant characteristics and concentrations that will be discharged from the site. For any identified pollutants of concern not listed in the Treatment Control BMP Selection Matrix, provide an explanation of how they will be addressed by Treatment Control BMPs. For identified pollutants of concern that are causing an impairment in receiving waters (as identified in Section 2.1, above), the project WQMP shall incorporate one or more Treatment Control BMPs of medium or high effectiveness in reducing those pollutants. It is the responsibility of the project proponent to demonstrate, and document in the project WQMP, that all pollutants of concern will be fully addressed. The Agency may require information beyond the minimum requirements of this WQMP to demonstrate that adequate pollutant treatment is being accomplished.**

- **In addition to completing the Selection Matrix, provide detailed descriptions on the location, implementation, installation, and long-term O&M of planned Treatment Control BMPs.**

    - *Educational materials of the Treatment Control BMPs are found in Attachment H. Sizing calculations for all primary (full) treatment BMPs will be provided in the final WQMP within Attachment I.*
    - *Locations of Treatment Control BMPs are found within the WQMP Site Plan in Attachment E and discussed about in this section of the Water Quality Management Plan. For the Final WQMP, other primary (full) treatment control BMPs could be utilized and if so, it will be discussed in full detail.*
    - *Implementation, installation, and O&M descriptions will be discussed in the final WQMP within this section, section 4.1.1, and Attachment F.*

Infiltration Basins (TC-11): The infiltration basins are the primary/full treatment control BMP for the entire project site and they are incorporated within the proposed recreational open space areas surrounding the project site on the south and east sides.
The basins are sized large enough to detain and infiltrate the post-development and pre-development generated volume difference. All three infiltration basins will be in place for water quality and mitigation measures as well to serve as flood control purposes. The intent is for the project to not create a HCOC and this is achieved by making sure the post-development runoff rates, volumes, velocities, and flow duration do not exceed the pre-development conditions for 2-year, 5-year, 10-year, and 100-year frequency storm events. Since the infiltration basins will act as detention basins as well, the basins are capable of releasing the post-development 2-year, 5-year, 10-year, and 100-year, 24 hour volume at flow rates less than or equal to the pre-development 2-year, 5-year, 10-year, and 100-year, 24 hour peak flow rates. The basins will pass the 100-year storm events without damage to the facilities. The outlet velocities will be controlled such that the downstream erosion and habitat loss is minimized.
The infiltration basins will be designed treat the required capture volume of the BMP per the assigned drainage area. The infiltration basins will have spillways to convey excess volumes of water that are not necessary to capture, anything greater than the difference between pre-development and post-development conditions. All infiltration basins will be

lined with a vegetated groundcover to reduce runoff velocities and to provide water quality benefits from filtering by the vegetation and infiltration into the underlying soils. The vegetated groundcover will be drought tolerant. All storm drain outlets entering the infiltration basins will be incorporate rock areas at the mouth of the outlets to prevent scouring and erosion at these specific locations within the infiltration basins.
The infiltration basins are implemented to be the primary BMP for removal of sediment and associated pollutants. It is proven to have a “High” Removal Effectiveness rating for all targeted constituents that are expected or potential for our project site.

Vortechs System (MP-51): Offline Vortechs units will be installed on the storm drain lines before entering the proposed infiltration basins located throughout the project site and each unit is designed and sized to treat the required flow rate of flow through the BMP per the assigned drainage area. The Vortechs Systems orientations are an offline design to meet our water quality objectives and site constraints. Offline units are sized to treat only peak design treatment flows (Q_{bmp}). All excess flows will be bypassed due to its configuration and continue downstream. All Vortech Systems have been designed to treat 80% removal of the 80 micron sized particle.
These Vortechs units are will act as pre-treatment control BMPs within the train system before entering the infiltration basins.
Table 2-5 of the WQMP by the San Bernardino County Stormwater Program states that this BMP has a “High” or “Medium” Removal Effectiveness rating for the following targeted constituents that are expected or potential for our specific project site BMP drainage areas: sediment, trash, and oil & grease. To insure performance, all Vortechs systems must be maintained as required per the manufacturer’s guidelines and through further information found in Section 4.1.1 and Attachment F of this Water Quality Management Plan.

Treatment Control BMP Selection Matrix

Pollutant of Concern		Treatment Control BMP Categories							
		Biofilters	Detention Basins(2)	Infiltration Basins(3)	Wet Ponds or Wetlands	Filtration	Water Quality Inlets	Hydrodynamic Separator Systems (4) **Vortech Units**	Manufactured/ Proprietary Devices
Sediment/Turbidity		H/M	M	H/M	H/M	H/M	L	H/M (L for turbidity)	U
Yes/No?	**YES**			**X**				**X**	
Nutrients		L	M	H/M	H/M	L/M	L	L	U
Yes/No?	**YES**			**X**				**X**	
Organic Compounds		U	U	U	U	H/M	L	L	U
Yes/No?	**YES**			**X**				**X**	
Trash & Debris		L	M	U	U	H/M	M	H/M	U
Yes/No?	**YES**			**X**				**X**	
Oxygen Demanding Substances		L	M	H/M	H/M	H/M	L	L	U
Yes/No?	**YES**			**X**				**X**	
Bacteria & Viruses		U	U	H/M	U	H/M	L	L	U
Yes/No?	**YES**			**X**				**X**	
Oils & Grease		H/M	M	U	U	H/M	M	L/M	U
Yes/No?	**YES**			**X**				**X**	
Pesticides (non-soil bound)		U	U	U	U	U	L	L	U
Yes/No?	**YES**			**X**				**X**	
Metals		H/M	M	H	H	H	L	L	U
Yes/No?	**YES**			**X**				**X**	

3.4 BMP DESIGN CRITERIA

- The following Treatment Control BMP(s) (Flow Based or Volume Based) will be implemented for this project (***check "Implemented" box, if used***):

Design Basis of Treatment Control BMPs

Implemented	Treatment Control BMP	Design Basis
	Vegetated Buffer Strips	Flow Based
	Vegetated Swales	
	Multiple Systems	
X	**Vortechs systems (MP-51)**	
	Bioretention	Volume Based
	Wet Pond	
	Constructed Wetland	
	Extended Detention Basin	
	Water Quality Inlet	
	Retention/Irrigation	
X	**Infiltration Basins**	
	Infiltration Trench	
	Media Filter	
	Manufactured/Proprietary	

3.4.1 Flow Based Design Criteria

- Calculate the BMP design flow by using the method described in Attachment D, Section A. Show calculations in detail-attach a separate sheet of calculations.
- SEE ATTACHMENT D FOR CALCULATIONS.

3.4.2 Volume-Based Design Criteria

- Calculate the required capture volume of the BMP using the method described in Attachment D, Section B. Show calculations in detail-attach a separate sheet of calculations.
- SEE ATTACHMENT D FOR CALCULATIONS.

Section 4
Operation and Maintenance

4.1 Operations and Maintenance

Operation and maintenance (O&M) requirements for all Source Control, Site Design, and Treatment Control BMPs shall be identified within the WQMP. The WQMP shall include the following:

4.1.1 O&M DESCRIPTION AND SCHEDULE THAT MUST:

- **List and identify each BMP that requires O&M.**
  Maximizing canopy interception and water conservation, Landscape planning (SD-10), Roof Runoff Controls (SD-11), Efficient irrigation (SD-12), Storm drain system signage (SD-13), Trash storage areas and litter control (SD-32), Employee training/education program, Protect slopes and channels, Street sweeping and parking lots, Common area catch basin inspection, Energy dissipaters, Pervious Concrete / Alternative Materials, Infiltration Basins and Vortechs units..

- **Provide a thorough description of O&M activities (include the O&M process, and the handling and placement of any wastes).**
  -DETAILED INFORMATION ON THE OPERATION AND MAINTENANCE ACTIVITIES INCLUDING THE O&M PROCESS AND THE HANDLING AND PLACEMENT OF ANY WASTES WILL BE DETERMINED AND THEN DISCUSSED IN THIS SECTION FOR THE FINAL WQMP.

- **Include BMP start-up dates.**
  - BMP's will be in effect by the scheduled completion of the subdivision. The approximate scheduled completion date is to be determined.

- **Provide a schedule of the frequency of O&M for each BMP.**
  -DETAILED INFORMATION ON THE OPERATION AND MAINTENANCE FREQUENCY FOR EACH BMP WILL BE DETERMINED AND THEN DISCUSSED IN THIS SECTION FOR THE FINAL WQMP.

4.1.2 INSPECTION & MONITORING REQUIREMENTS THAT MUST:

- **Provide thorough descriptions of water quality monitoring (if locally required).**
  -CURRENTLY NOT REQUIRED
  Provide self-inspections and record keeping requirements for BMPs (review local specific requirements regarding self-inspections and/or annual reporting), including identification of responsible parties for inspection and record keeping.
  -FURTHER DETAILED INFORMATION FOR SELF-INSPECTIONS AND RECORD KEEPING REPORTS WILL BE DETERMINED AND THEN DISCUSSED IN ATTACHMENT F FOR THE FINAL WQMP.

4.1.3 IDENTIFICATION OF RESPONSIBLE PARTIES THAT MUST:

- Provide the party or parties that will be responsible for each BMP O&M. For each responsible party, include the party's name, address, contact name and telephone number.

Interim:
Edgewater Associates I, LCC**
Contact: Donald Rosier
165 SOUTH UNION BLVD., SUITE 510
LAKEWOOD, CO 80228
PHONE NO. (303) 986-2222
FAX NO. (303) 986-7990

Ultimate (Long Term):
HOA - To be determined.

**Edgewater Associates I, LLC will be the responsible party for operation and maintenance of each BMP until the community HOA is formed. The community HOA will be the long term responsible party for operation and maintenance of the site BMP's.

SECTION 5
FUNDING

5.1 Funding

The Permit requires that for all Treatment Control BMPs, a funding source or sources for operation and maintenance of each BMP be identified within the WQMP. Project proponents must:

- Indicate funding sources or sources for O&M for this project. For each funding source, include the responsible party's name, address, contact name and telephone number.

  Interim:
  Edgewater Associates I, LCC**
  Contact: Donald Rosier
  165 SOUTH UNION BLVD., SUITE 510
  LAKEWOOD, CO 80228
  PHONE NO. (303) 986-2222
  FAX NO. (303) 986-7990

  Ultimate (Long Term):
  HOA - To be determined.

  **Edgewater Associates I, LLC will be the initial party for funding of operation and maintenance of each BMP until the community HOA is formed. The community HOA will be the long term funding source for the operation and maintenance of the site BMP's.

SECTION 6
WQMP Certification

6.1 Certification

"This Water Quality Management Plan has been prepared for Edgewater Associates I, LLC by Huitt-Zollars Inc. It is intended to comply with the requirements of the City of Chino requiring the preparation of a Water Quality Management Plan (WQMP). The undersigned is aware that Best Management practices (BMPs) are enforceable pursuant to the City of Chino' Municipal Code. The undersigned, while it owns the subject property, is responsible for the implementation of the provisions of this plan and will ensure that this plan is amended as appropriate to reflect up-to-date conditions on the site consistent with San Bernardino County's Municipal Stormwater Management Program and the intent of the NPDES Permit for San Bernardino County and the incorporated cities of San Bernardino County within the Santa Ana Region. Once the undersigned transfers its interest in the property, its successors in interest and the City of Chino shall be notified of the transfer. The new owner will be informed of its responsibility under this WQMP. A copy of the approved WQMP shall be available on the subject site in perpetuity."

"I certify under a penalty of law that the provisions (implementation, operation, maintenance, and funding) of the WQMP have been accepted and that the plan will be transferred to future successors."

Applicant's Signature	Date

Applicant's Name	Applicant's Telephone Number

Attachment B
Tables

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION

ABBREVIATIONS

REGIONAL WATER QUALITY CONTROL BOARDS

1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River Basin
8 Santa Ana
9 San Diego

WATER BODY TYPE

B = Bays and Harbors
C = Coastal Shorelines/Beaches
E = Estuaries
L = Lakes/Reserviors
R = Rivers and Streams
S = Saline Lakes
T = Wetlands, Tidal
W= Wetlands, Freshwater

CALWATER WATERSHED

"Calwater Watershed" is the State Water Resources Control Board hydrological subunit area or an even smaller area delineation.

GROUP A PESTICIDES OR CHEM A

aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan, and toxaphene

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Lead		221 Acres	2019
					Source Unknown		
				Nickel *This listing was made by USEPA.*		221 Acres	2019
					Source Unknown		
				Pathogens		221 Acres	2019
					Urban Runoff/Storm Sewers		
				PCBs (Polychlorinated biphenyls) (tissue) *This listing was made by USEPA.*		221 Acres	2019
					Source Unknown		
				Sediment Toxicity		221 Acres	2019
					Source Unknown		
8	R	Knickerbocker Creek	80171000				
				Metals		2 Miles	2007
					Unknown Nonpoint Source		
8	R	Los Trancos Creek (Crystal Cove Creek)	80111000				
				Fecal Coliform *Listing is downstream of Pacific Coast Highway.*		0.19 Miles	2019
					Source Unknown		
				Total Coliform *Listing is downstream of Pacific Coast Highway.*		0.19 Miles	2019
					Source Unknown		
8	R	Lytle Creek	80141000				
				Pathogens		41 Miles	2019
					Unknown Nonpoint Source		
8	R	Mill Creek (Prado Area)	80121000				
				Nutrients		1.6 Miles	2019
					Agriculture		
					Dairies		

Attachment C
Pollutants of Concern

Pollutants of Concern

- *Bacteria and Viruses* – Bacteria and Viruses are ubiquitous microorganisms that thrive under certain environmental conditions. Their proliferation is typically cause by the transport of animal or human fecal wastes from the watershed. Water, containing excessive bacteria and viruses, can alter the aquatic habitat and create a harmful environment for humans and aquatic life. Also, the decomposition of excess organic waste causes increased growth of undesirable organisms in the water.

- *Metals* – The primary source of metal pollution in stormwater is typically commercially available metals and metal products. Metals of concern include cadmium, chromium, copper, lead, mercury, and zinc. Lead and chromium have been used as corrosion inhibitors in primer coatings and cooling tower systems. Metals are also raw material components in non-metal products such as fuels, adhesives, paints, and other coatings. At low concentrations naturally occurring in soil, metals may not be toxic. However, at higher concentrations, certain metals can be toxic to aquatic life. Humans can be impacted from contaminated groundwater resources, and bioaccumulation of metals in fish and shellfish. Environmental concerns, regarding the potential for release of metals to the environment, have already led to restricted metal usage in certain applications (OC 2003).

- *Nutrients* – Nutrients are inorganic substances, such as nitrogen and phosphorus. Excessive discharge of nutrients to water bodies and streams causes eutrophication, where aquatic plants and algae growth can lead to excessive decay of organic matter in the water body, loss of oxygen in the water, release of toxins in sediment, and the eventual death of aquatic organisms. Primary sources of nutrients in urban runoff are fertilizers and eroded soils.

- *Pesticides* -- Pesticides (including herbicides) are chemical compounds commonly used to control nuisance growth or prevalence of organisms. Relatively low levels of the active component of pesticides can result in conditions of aquatic toxicity. Excessive or improper application of a pesticide may result in runoff containing toxic levels of its active ingredient (OC 2003).

- *Organic Compounds* – Organic compounds are carbon-based. Commercially available or naturally occurring organic compounds are found in pesticides, solvents, and hydrocarbons. Organic compounds can, at certain concentrations, indirectly or directly constitute a hazard to life or health. When rinsing off objects, toxic levels of solvents and cleaning compounds can be discharged to storm drains. Dirt, grease, and grime retained in the cleaning fluid or rinse water may also adsorb levels of organic compounds that are harmful or hazardous to aquatic life (OC 2003).

- *Sediments* – Sediments are solid materials that are eroded from the land surface. Sediments can increase turbidity, clog fish gills, reduce spawning habitat, lower young aquatic organisms survival rates, smother bottom dwelling organisms, and suppress aquatic vegetation growth.

- *Trash and Debris* – Trash (such as paper, plastic, polystyrene packing foam, and aluminum materials) and biodegradable organic matter (such as leaves, grass cuttings, and food waste) are general waste products on the landscape. The presence of trash and debris may have a significant impact on the recreational value of a water body and aquatic habitat. Trash impacts water quality by increasing biochemical oxygen demand.

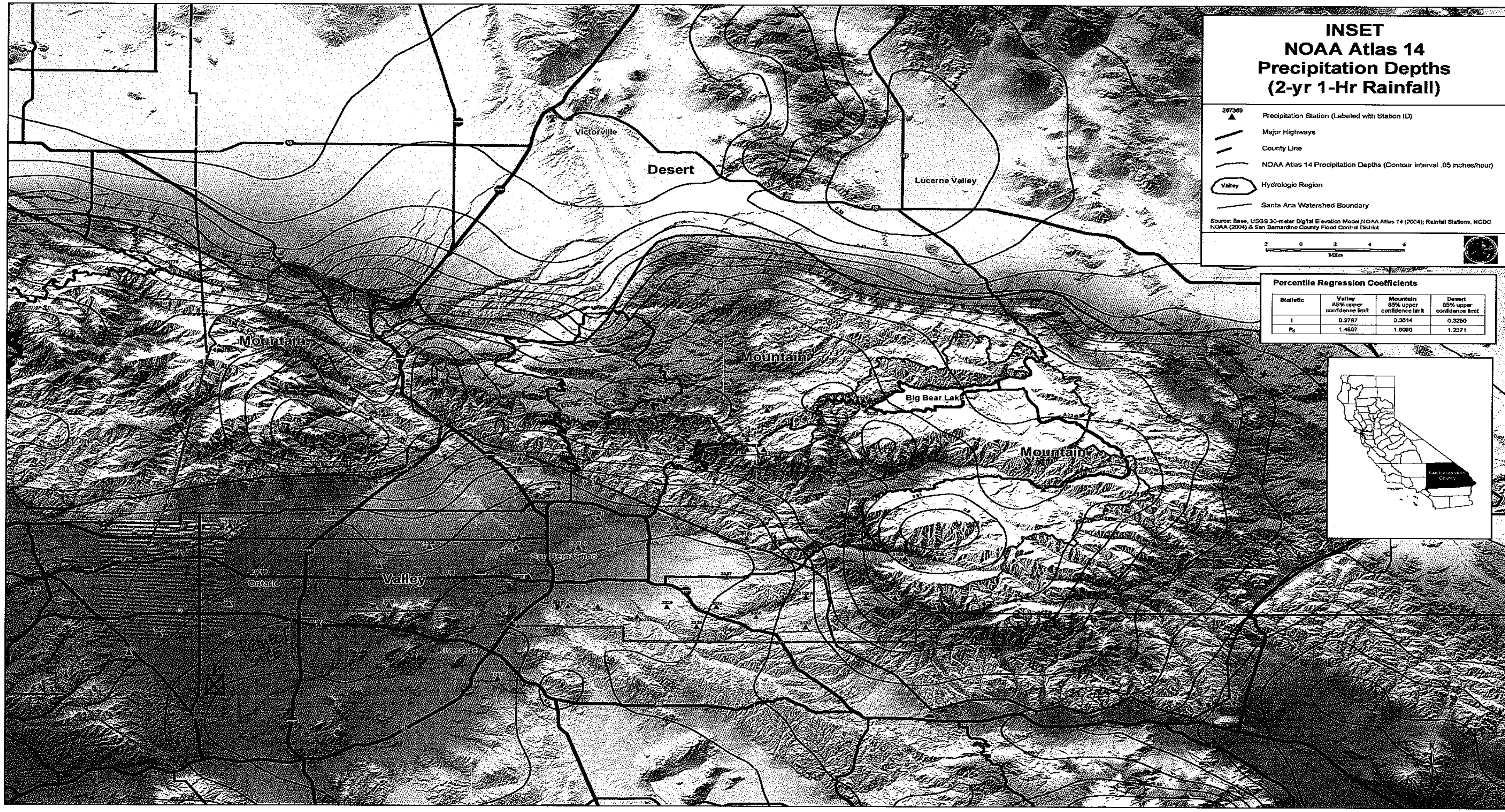
- *Oxygen-Demanding Substances* – This category includes biodegradable organic material as well as chemicals that react with dissolved oxygen in water to form other compounds. Proteins, carbohydrates, and fats are examples of biodegradable organic compounds. Compounds such as ammonia and hydrogen sulfide are examples of oxygen-demanding compounds. The oxygen demand of a substance can lead to depletion of dissolved oxygen in a water body and possibly the development of septic conditions. A reduction of dissolved oxygen is detrimental to aquatic life and can generate hazardous compounds such as hydrogen sulfides.

- *Oil and Grease* – Oil and grease in water bodies decreases the aesthetic value of the water body, as well as the water quality. Primary sources of oil and grease are petroleum hydrocarbon products, motor products from leaking vehicles, esters, oils, fats, waxes, and high molecular-weight fatty acids.

Attachment D

Volume Base BMP Design Calculations

Figure D-1: NOAA Atlas 14 Inset Map.



Statistic	Valley 85% upper confidence limit	Mountain 85% upper confidence limit	Desert 85% upper confidence limit
I	0.2787	0.3614	0.3250
P_6	1.4807	1.9090	1.2371

FLOW-BASED BMP DESIGN CALCULATIONS FOR AREA: $A_{(1)}$

PROJECT:	EDGEWATER LAKE COMMUNITIES	*BY*:	E.A.J.
CLIENT:	ALLIANCE COMMERCIAL PARTNERS	*DATE*:	10/15/2007
JOB NO:	10-1073-04		

GOAL: CALCULATE THE TARGET BMP FLOW RATE FOR THE PROPOSED DRAINAGE AREA, $A_{(1)}$

A.) DETERMINE THE "WATERSHED IMPERVIOUSNESS RATIO", i, WHICH IS EQUAL TO THE PERCENT OF IMPERVIOUS AREA IN THE BMP DRAINAGE AREA DIVIDED BY 100.

Includes all areas that will contribute runoff to proposed BMP.

$A_{(T)}$ = TOTAL BMP DRAINAGE AREA (Ac) = A_1
$A_{(IMPERVIOUS)}$ = IMPERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
$A_{(PERVIOUS)}$ = PERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
i = SITE IMPERVIOUS RATIO ($A_{IMPERVIOUS} / A_T$)

$A_{(T)}$ = **38.245 Acres**
$A_{(IMPERVIOUS)}$ = **21.03 Acres**
$A_{(PERVIOUS)}$ = **17.21 Acres**

THEREFORE, i = **0.55**

B.) CALCULATE THE COMPOSITE RUNOFF COEFFICIENT, C_{BMP} FOR THE DRAINAGE AREA ABOVE USING THE FOLLOWING EQUATION:

$C_{BMP} = 0.858i^3 - 0.78i^2 + 0.774i + 0.04 = .1427-.2360+.4257+.04$ C_{BMP} = **0.372**

C.) DETERMINE WHICH REGION THE DRAINAGE AREA IS LOCATED (VALLEY, MOUNTAIN OR DESERT)
THE DRAINAGE AREA IS LOCATED IN A VALLEY REGION.

D.) DETERMINE BMP DESIGN RAINFALL INTENSITY, I_{BMP}, BY MULTIPLYING THE AREA-AVERAGED 2-YEAR 1-HOUR VALUE FROM THE NOAA ATLAS 14 MAP BY THE APPROPRIATE REGRESSION COEFFICIENT FROM TABLE D-1 ("I"), AND THEN MULTIPLYING BY THE SAFETY FACTOR SPECIFIED IN THE CRITERIA - USUALLY A FACTOR OF 2.

I_{BMP} = BMP DESIGN RAINFALL INTENSITY, IN INCHES/HOUR
I_{BMP} = n x 2 x (REGRESSION COEFFICIENT FOR INTENSITY)
= 0.50 x 2 x 0.2787 I_{BMP} = **0.3177 in/hr**

E.) CALCULATE THE TARGET BMP FLOW RATE, Q, BY USING THE FOLLOWING FORMULA.

Q = TARGET BMP FLOW RATE IN FT^3/S
$Q = C_{BMP} \times I_{BMP} \times A$ =
= 0.3725 x 0.3177 x 38.245

Q = **4.526** **c.f.s.**

F.) FOR THE PROPOSED BMP DRAINAGE AREA, WE HAVE CALCULATED THE TARGET BMP FLOW RATE TO BE, **4.526 c.f.s**

FLOW-BASED BMP DESIGN CALCULATIONS FOR AREA: $A_{(2)}$

PROJECT:	EDGEWATER LAKE COMMUNITIES	*BY*:	E.A.J.
CLIENT:	ALLIANCE COMMERCIAL PARTNERS	*DATE*:	10/15/2007
JOB NO:	10-1073-04		

GOAL: CALCULATE THE TARGET BMP FLOW RATE FOR THE PROPOSED DRAINAGE AREA, $A_{(2)}$

A.) DETERMINE THE "WATERSHED IMPERVIOUSNESS RATIO", i, WHICH IS EQUAL TO THE PERCENT OF IMPERVIOUS AREA IN THE BMP DRAINAGE AREA DIVIDED BY 100.

Includes all areas that will contribute runoff to proposed BMP.

$A_{(T)}$ = TOTAL BMP DRAINAGE AREA (Ac) = A_2
$A_{(IMPERVIOUS)}$ = IMPERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
$A_{(PERVIOUS)}$ = PERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
i = SITE IMPERVIOUS RATIO ($A_{IMPERVIOUS} / A_T$)

$A_{(T)}$ =	**88.316**	**Acres**
$A_{(IMPERVIOUS)}$ =	**55.20**	**Acres**
$A_{(PERVIOUS)}$ =	**33.12**	**Acres**

THEREFORE, i = **0.63**

B.) CALCULATE THE COMPOSITE RUNOFF COEFFICIENT, C_{BMP} FOR THE DRAINAGE AREA ABOVE USING THE FOLLOWING EQUATION:

$C_{BMP} = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$ = .1427-.2360+.4257+.04 C_{BMP} = **0.429**

C.) DETERMINE WHICH REGION THE DRAINAGE AREA IS LOCATED (VALLEY, MOUNTAIN OR DESERT)

THE DRAINAGE AREA IS LOCATED IN A VALLEY REGION.

D.) DETERMINE BMP DESIGN RAINFALL INTENSITY, I_{BMP}, BY MULTIPLYING THE AREA-AVERAGED 2-YEAR 1-HOUR VALUE FROM THE NOAA ATLAS 14 MAP BY THE APPROPRIATE REGRESSION COEFFICIENT FROM TABLE D-1 ("I"), AND THEN MULTIPLYING BY THE SAFETY FACTOR SPECIFIED IN THE CRITERIA - USUALLY A FACTOR OF 2.

I_{BMP} = BMP DESIGN RAINFALL INTENSITY, IN INCHES/HOUR
I_{BMP} = n x 2 x (REGRESSION COEFFICIENT FOR INTENSITY)
= 0.50 x 2 x 0.2787 I_{BMP} = **0.3177** **in/hr**

E.) CALCULATE THE TARGET BMP FLOW RATE, Q, BY USING THE FOLLOWING FORMULA.

Q = TARGET BMP FLOW RATE IN FT^3/S
Q = C_{BMP} x I_{BMP} x A =
= 0.4285 x 0.3177 x 88.316

Q = **12.025 c.f.s.**

F.) FOR THE PROPOSED BMP DRAINAGE AREA, WE HAVE CALCULATED THE TARGET BMP FLOW RATE TO BE, **12.025 c.f.s**

FLOW-BASED BMP DESIGN CALCULATIONS FOR AREA: A $_{(3)}$

PROJECT:	EDGEWATER LAKE COMMUNITIES	*BY:*	E.A.J.
CLIENT:	ALLIANCE COMMERCIAL PARTNERS	*DATE:*	10/15/2007
JOB NO:	10-1073-04		

GOAL: CALCULATE THE TARGET BMP FLOW RATE FOR THE PROPOSED DRAINAGE AREA, $A_{(3)}$

A.) DETERMINE THE "WATERSHED IMPERVIOUSNESS RATIO", i, WHICH IS EQUAL TO THE PERCENT OF IMPERVIOUS AREA IN THE BMP DRAINAGE AREA DIVIDED BY 100.

Includes all areas that will contribute runoff to proposed BMP.

$A_{(T)}$ = TOTAL BMP DRAINAGE AREA (Ac) = A_3
$A_{(IMPERVIOUS)}$ = IMPERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
$A_{(PERVIOUS)}$ = PERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
i = SITE IMPERVIOUS RATIO ($A_{IMPERVIOUS} / A_T$)

$A_{(T)}$ =	**33.195**	**Acres**
$A_{(IMPERVIOUS)}$ =	**19.92**	**Acres**
$A_{(PERVIOUS)}$ =	**13.28**	**Acres**

THEREFORE, i = **0.60**

B.) CALCULATE THE COMPOSITE RUNOFF COEFFICIENT, C_{BMP} FOR THE DRAINAGE AREA ABOVE USING THE FOLLOWING EQUATION:

$C_{BMP} = 0.858i^3 - 0.78i^2 + 0.774i + 0.04 = .1427 - .2360 + .4257 + .04$ C_{BMP} = **0.409**

C.) DETERMINE WHICH REGION THE DRAINAGE AREA IS LOCATED (VALLEY, MOUNTAIN OR DESERT)
THE DRAINAGE AREA IS LOCATED IN A VALLEY REGION.

D.) DETERMINE BMP DESIGN RAINFALL INTENSITY, I_{BMP}, BY MULTIPLYING THE AREA-AVERAGED 2-YEAR 1-HOUR VALUE FROM THE NOAA ATLAS 14 MAP BY THE APPROPRIATE REGRESSION COEFFICIENT FROM TABLE D-1 ("I"), AND THEN MULTIPLYING BY THE SAFETY FACTOR SPECIFIED IN THE CRITERIA - USUALLY A FACTOR OF 2.

I_{BMP} = BMP DESIGN RAINFALL INTENSITY, IN INCHES/HOUR
I_{BMP} = n x 2 x (REGRESSION COEFFICIENT FOR INTENSITY)
= 0.50 x 2 x 0.2787 I_{BMP} = **0.3177 in/hr**

E.) CALCULATE THE TARGET BMP FLOW RATE, Q, BY USING THE FOLLOWING FORMULA.

Q = TARGET BMP FLOW RATE IN FT^3/S
$Q = C_{BMP} \times I_{BMP} \times A$ =
= 0.4089 x 0.3177 x 33.195

Q = **4.313 c.f.s.**

F.) FOR THE PROPOSED BMP DRAINAGE AREA, WE HAVE CALCULATED THE TARGET BMP FLOW RATE TO BE, **4.313 c.f.s**

FLOW-BASED BMP DESIGN CALCULATIONS FOR AREA: $A_{(4)}$

PROJECT:	EDGEWATER LAKE COMMUNITIES	*BY*:	E.A.J.
CLIENT:	ALLIANCE COMMERCIAL PARTNERS	*DATE*:	10/15/2007
JOB NO:	10-1073-04		

GOAL: CALCULATE THE TARGET BMP FLOW RATE FOR THE PROPOSED DRAINAGE AREA, $A_{(4)}$

A.) DETERMINE THE "WATERSHED IMPERVIOUSNESS RATIO", i, WHICH IS EQUAL TO THE PERCENT OF IMPERVIOUS AREA IN THE BMP DRAINAGE AREA DIVIDED BY 100.

Includes all areas that will contribute runoff to proposed BMP.

$A_{(T)}$ = TOTAL BMP DRAINAGE AREA (Ac) = A_4
$A_{(IMPERVIOUS)}$ = IMPERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
$A_{(PERVIOUS)}$ = PERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
i = SITE IMPERVIOUS RATIO ($A_{IMPERVIOUS} / A_T$)

$A_{(T)}$ =	**49.087**	**Acres**
$A_{(IMPERVIOUS)}$ =	**27.00**	**Acres**
$A_{(PERVIOUS)}$ =	**22.09**	**Acres**

THEREFORE, i = **0.55**

B.) CALCULATE THE COMPOSITE RUNOFF COEFFICIENT, C_{BMP} FOR THE DRAINAGE AREA ABOVE USING THE FOLLOWING EQUATION:

$C_{BMP} = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$ = .1427-.2360+.4257+.04 C_{BMP} = **0.372**

C.) DETERMINE WHICH REGION THE DRAINAGE AREA IS LOCATED (VALLEY, MOUNTAIN OR DESERT)
THE DRAINAGE AREA IS LOCATED IN A VALLEY REGION.

D.) DETERMINE BMP DESIGN RAINFALL INTENSITY, I_{BMP}, BY MULTIPLYING THE AREA-AVERAGED 2-YEAR 1-HOUR VALUE FROM THE NOAA ATLAS 14 MAP BY THE APPROPRIATE REGRESSION COEFFICIENT FROM TABLE D-1 ("I"), AND THEN MULTIPLYING BY THE SAFETY FACTOR SPECIFIED IN THE CRITERIA - USUALLY A FACTOR OF 2.

I_{BMP} = BMP DESIGN RAINFALL INTENSITY, IN INCHES/HOUR
I_{BMP} = n x 2 x (REGRESSION COEFFICIENT FOR INTENSITY)
= 0.50 x 2 x 0.2787 I_{BMP} = **0.3177 in/hr**

E.) CALCULATE THE TARGET BMP FLOW RATE, Q, BY USING THE FOLLOWING FORMULA.

Q = TARGET BMP FLOW RATE IN FT^3/S
Q = C_{BMP} x I_{BMP} x A =
= 0.3725 x 0.3177 x 49.087

Q =	**5.809**	**c.f.s.**

F.) FOR THE PROPOSED BMP DRAINAGE AREA, WE HAVE CALCULATED THE TARGET BMP FLOW RATE TO BE, **5.809 c.f.s**

VOLUME-BASE BMP DESIGN CALCULATIONS FOR AREA: $A_{(1)}$

***SEE THE WQMP SITE PLAN FOR BMP DRAINAGE AREAS**

PROJECT:	EDGEWATER LAKE COMMUNITY	*BY*:	E.A.J.
CLIENT:	ALLIANCE COMMERCIAL PARTNERS	*DATE*:	10/15/2007
JOB NO:	10-1073-04		

GOAL: CALCULATE THE TARGET CAPTURE VOLUME FOR THE PROPOSED DRAINAGE AREA, $A_{(1)}$

A.) DETERMINE THE "WATERSHED IMPERVIOUSNESS RATIO", i, WHICH IS EQUAL TO THE PERCENT OF IMPERVIOUS AREA IN THE BMP DRAINAGE AREA DIVIDED BY 100.

Includes all areas that will contribute runoff to proposed BMP.

$A_{(T)}$ = TOTAL BMP DRAINAGE AREA (Ac)
$A_{(IMPERVIOUS)}$ = IMPERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
$A_{(PERVIOUS)}$ = PERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
i = SITE IMPERVIOUS RATIO ($A_{IMPERVIOUS} / A_T$)

$A_{(T)}$ = **38.245 Acres**
$A_{(IMPERVIOUS)}$ = **21.035 Acres**
$A_{(PERVIOUS)}$ = **17.210 Acres**

THEREFORE, i = **0.550**

B.) CALCULATE THE COMPOSITE RUNOFF COEFFICIENT, C_{BMP} FOR THE DRAINAGE AREA ABOVE USING THE FOLLOWING EQUATION:

$C_{BMP} = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$ C = **0.372**

C.) DETERMINE WHICH REGION THE DRAINAGE AREA IS LOCATED (VALLEY, MOUNTAIN OR DESERT)

THE DRAINAGE AREA IS LOCATED IN A VALLEY REGION.

D.) DETERMINE THE AREA-AVERAGED "6-HOUR MEAN STORM RAINFALL", P_6, FOR THE DRAINAGE AREA.

This is calculated by multiplying the area averaged 2-year 1-hour value by the appropriate regression coefficient from Table 1.

$P_6 = n \times P_{2YR\text{-}1HR}$
P_6 = 6-HOUR MEAN STORM RAINFALL, IN INCHES

n = **1.4807**
$P_{2YR\text{-}1HR}$ = **0.52**
P_6 = **0.770 inches**

E.) DETERMINE THE APPROPRIATE DRAWDOWN TIME. USE THE REGRESSION CONSTANT a=1.582 FOR 24 HOURS AND a=1.963 FOR 48 HOURS.
(A 48-HOUR DRAWDOWNTIME IS RECOMMENDED FOR MOST SITE IN CALIFORNIA)

a = **1.963**

F.) CALCULATE THE "MAXIMIZED DETENTION VOLUME", P_0, USING THE FOLLOWING EQUATION:

$P_0 = a \times C_{BMP} \times P_6$

P_0 =MAXIMIZED DETENTION VOLUME, IN INCHES P_0 = **0.563** **inches**

G.) CALCULATE THE "TARGET CAPTURE VOLUME", V_0, USING THE FOLLOWING EQUATION:

V_0 = TARGET CAPTURE VOLUME, IN ACRE-FEET

$V_0 = (P_0 \times A) / 12$

V_0 = **1.794** **acre-feet**

MULTIPLY BY 43,560 FT^2 TO GET CUBIC FEET (FT^3)

V_0 = 78,162 ft^3

H.) FOR THE PROPOSED BMP DRAINAGE AREA, WE HAVE CALCULATED THE TARGET CAPTURE VOLUME RUNOFF TO BE, **78,162 ft^3**. WE INTEND TO UTILIZE AN INFILTRATION BASIN IN IN ORDER TO CAPTURE AND TREAT THE CALCULATED TARGETED VOLUME.

VOLUME-BASE BMP DESIGN CALCULATIONS FOR AREA: $A_{(2)}$

***SEE THE WQMP SITE PLAN FOR BMP DRAINAGE AREAS**

PROJECT:	EDGEWATER LAKE COMMUNITY	*BY*:	E.A.J.
CLIENT:	ALLIANCE COMMERCIAL PARTNERS	*DATE*:	10/15/2007
JOB NO:	10-1073-04		

GOAL: CALCULATE THE TARGET CAPTURE VOLUME FOR THE PROPOSED DRAINAGE AREA, $A_{(2)}$

A.) DETERMINE THE "WATERSHED IMPERVIOUSNESS RATIO", i, WHICH IS EQUAL TO THE PERCENT OF IMPERVIOUS AREA IN THE BMP DRAINAGE AREA DIVIDED BY 100.

Includes all areas that will contribute runoff to proposed BMP.

$A_{(T)}$ = TOTAL BMP DRAINAGE AREA (Ac)
$A_{(IMPERVIOUS)}$ = IMPERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
$A_{(PERVIOUS)}$ = PERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
i = SITE IMPERVIOUS RATIO ($A_{IMPERVIOUS} / A_T$)

$A_{(T)}$ = **88.316 Acres**
$A_{(IMPERVIOUS)}$ = **55.198 Acres**
$A_{(PERVIOUS)}$ = **33.119 Acres**

THEREFORE, i = **0.625**

B.) CALCULATE THE COMPOSITE RUNOFF COEFFICIENT, C_{BMP} FOR THE DRAINAGE AREA ABOVE USING THE FOLLOWING EQUATION:

$C_{BMP} = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$ C = **0.429**

C.) DETERMINE WHICH REGION THE DRAINAGE AREA IS LOCATED (VALLEY, MOUNTAIN OR DESERT)

THE DRAINAGE AREA IS LOCATED IN A VALLEY REGION.

D.) DETERMINE THE AREA-AVERAGED "6-HOUR MEAN STORM RAINFALL", P_6, FOR THE DRAINAGE AREA.

This is calculated by multiplying the area averaged 2-year 1-hour value by the appropriate regression coefficient from Table 1.

$P_6 = n \times P_{2YR\text{-}1HR}$
P_6 = 6-HOUR MEAN STORM RAINFALL, IN INCHES

n = **1.4807**
$P_{2YR\text{-}1HR}$ = **0.52**
P_6 = **0.770 inches**

E.) DETERMINE THE APPROPRIATE DRAWDOWN TIME. USE THE REGRESSION CONSTANT a=1.582 FOR 24 HOURS AND a=1.963 FOR 48 HOURS.
(A 48-HOUR DRAWDOWNTIME IS RECOMMENDED FOR MOST SITE IN CALIFORNIA)

a = **1.963**

F.) CALCULATE THE "MAXIMIZED DETENTION VOLUME", P_0, USING THE FOLLOWING EQUATION:

$P_0 = a \times C_{BMP} \times P_6$

P_0 =MAXIMIZED DETENTION VOLUME, IN INCHES P_0 = **0.648** **inches**

G.) CALCULATE THE "TARGET CAPTURE VOLUME", V_0, USING THE FOLLOWING EQUATION:

V_0 = TARGET CAPTURE VOLUME, IN ACRE-FEET

$V_0 = (P_0 \times A) / 12$

V_0 = **4.767** **acre-feet**

MULTIPLY BY 43,560 FT^2 TO GET CUBIC FEET (FT^3)

V_0 = 207,646 ft^3

H.) FOR THE PROPOSED BMP DRAINAGE AREA, WE HAVE CALCULATED THE TARGET CAPTURE VOLUME RUNOFF TO BE, **207,646 ft^3**. WE INTEND TO UTILIZE AN INFILTRATION BASIN IN IN ORDER TO CAPTURE AND TREAT THE CALCULATED TARGETED VOLUME.

VOLUME-BASE BMP DESIGN CALCULATIONS FOR AREA: $A_{(3)}$

***SEE THE WQMP SITE PLAN FOR BMP DRAINAGE AREAS**

PROJECT:	EDGEWATER LAKE COMMUNITY	*BY*:	E.A.J.
CLIENT:	ALLIANCE COMMERCIAL PARTNERS	*DATE*:	10/15/2007
JOB NO:	10-1073-04		

GOAL: CALCULATE THE TARGET CAPTURE VOLUME FOR THE PROPOSED DRAINAGE AREA, $A_{(3)}$

A.) DETERMINE THE "WATERSHED IMPERVIOUSNESS RATIO", i, WHICH IS EQUAL TO THE PERCENT OF IMPERVIOUS AREA IN THE BMP DRAINAGE AREA DIVIDED BY 100.
Includes all areas that will contribute runoff to proposed BMP.

$A_{(T)}$ = TOTAL BMP DRAINAGE AREA (Ac)
$A_{(IMPERVIOUS)}$ = IMPERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
$A_{(PERVIOUS)}$ = PERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
i = SITE IMPERVIOUS RATIO ($A_{IMPERVIOUS} / A_T$)

$A_{(T)}$ = **33.195** **Acres**
$A_{(IMPERVIOUS)}$ = **19.917** **Acres**
$A_{(PERVIOUS)}$ = **13.278** **Acres**

THEREFORE, i = **0.600**

B.) CALCULATE THE COMPOSITE RUNOFF COEFFICIENT, C_{BMP} FOR THE DRAINAGE AREA ABOVE USING THE FOLLOWING EQUATION:

$C_{BMP} = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$ C = **0.409**

C.) DETERMINE WHICH REGION THE DRAINAGE AREA IS LOCATED (VALLEY, MOUNTAIN OR DESERT)

THE DRAINAGE AREA IS LOCATED IN A VALLEY REGION.

D.) DETERMINE THE AREA-AVERAGED "6-HOUR MEAN STORM RAINFALL", P_6, FOR THE DRAINAGE AREA.
This is calculated by multiplying the area averaged 2-year 1-hour value by the appropriate regression coefficient from Table 1.

$P_6 = n \times P_{2YR-1HR}$
P_6 = 6-HOUR MEAN STORM RAINFALL, IN INCHES

n = **1.4807**
$P_{2YR-1HR}$ = **0.52**
P_6 = **0.770** **inches**

E.) DETERMINE THE APPROPRIATE DRAWDOWN TIME. USE THE REGRESSION CONSTANT a=1.582 FOR 24 HOURS AND a=1.963 FOR 48 HOURS.
(A 48-HOUR DRAWDOWNTIME IS RECOMMENDED FOR MOST SITE IN CALIFORNIA)

a = **1.963**

F.) CALCULATE THE "MAXIMIZED DETENTION VOLUME", P_0, USING THE FOLLOWING EQUATION:

$P_0 = a \times C_{BMP} \times P_6$

P_0 =MAXIMIZED DETENTION VOLUME, IN INCHES — P_0 = **0.618** **inches**

G.) CALCULATE THE "TARGET CAPTURE VOLUME", V_0, USING THE FOLLOWING EQUATION:

V_0 = TARGET CAPTURE VOLUME, IN ACRE-FEET

$V_0 = (P_0 \times A) / 12$

V_0 = **1.710** **acre-feet**

MULTIPLY BY 43,560 FT^2 TO GET CUBIC FEET (FT^3) — **V_0 = 74,476 ft^3**

H.) FOR THE PROPOSED BMP DRAINAGE AREA, WE HAVE CALCULATED THE TARGET CAPTURE VOLUME RUNOFF TO BE, **74,476 ft^3**. WE INTEND TO UTILIZE AN INFILTRATION BASIN IN IN ORDER TO CAPTURE AND TREAT THE CALCULATED TARGETED VOLUME.

VOLUME-BASE BMP DESIGN CALCULATIONS FOR AREA: $A_{(4)}$

***SEE THE WQMP SITE PLAN FOR BMP DRAINAGE AREAS**

PROJECT:	EDGEWATER LAKE COMMUNITY	*BY*:	E.A.J.
CLIENT:	ALLIANCE COMMERCIAL PARTNERS	*DATE*:	10/15/2007
JOB NO:	10-1073-04		

GOAL: CALCULATE THE TARGET CAPTURE VOLUME FOR THE PROPOSED DRAINAGE AREA, $A_{(4)}$

A.) DETERMINE THE "WATERSHED IMPERVIOUSNESS RATIO", i, WHICH IS EQUAL TO THE PERCENT OF IMPERVIOUS AREA IN THE BMP DRAINAGE AREA DIVIDED BY 100.

Includes all areas that will contribute runoff to proposed BMP.

$A_{(T)}$ = TOTAL BMP DRAINAGE AREA (Ac)
$A_{(IMPERVIOUS)}$ = IMPERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
$A_{(PERVIOUS)}$ = PERVIOUS AREA WITHIN BMP DRAINAGE AREA (Ac)
i = SITE IMPERVIOUS RATIO ($A_{IMPERVIOUS} / A_T$)

$A_{(T)}$ = **49.087** **Acres**
$A_{(IMPERVIOUS)}$ = **26.998** **Acres**
$A_{(PERVIOUS)}$ = **22.089** **Acres**

THEREFORE, i = **0.550**

B.) CALCULATE THE COMPOSITE RUNOFF COEFFICIENT, C_{BMP} FOR THE DRAINAGE AREA ABOVE USING THE FOLLOWING EQUATION:

$C_{BMP} = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$ C = **0.372**

C.) DETERMINE WHICH REGION THE DRAINAGE AREA IS LOCATED (VALLEY, MOUNTAIN OR DESERT)

THE DRAINAGE AREA IS LOCATED IN A VALLEY REGION.

D.) DETERMINE THE AREA-AVERAGED "6-HOUR MEAN STORM RAINFALL", P_6, FOR THE DRAINAGE AREA.

This is calculated by multiplying the area averaged 2-year 1-hour value by the appropriate regression coefficient from Table 1.

$P_6 = n \times P_{2YR\text{-}1HR}$
P_6 = 6-HOUR MEAN STORM RAINFALL, IN INCHES

n = **1.4807**
$P_{2YR\text{-}1HR}$ = **0.52**
P_6 = **0.770** **inches**

E.) DETERMINE THE APPROPRIATE DRAWDOWN TIME. USE THE REGRESSION CONSTANT a=1.582 FOR 24 HOURS AND a=1.963 FOR 48 HOURS.
(A 48-HOUR DRAWDOWNTIME IS RECOMMENDED FOR MOST SITE IN CALIFORNIA)

a = **1.963**

F.) CALCULATE THE "MAXIMIZED DETENTION VOLUME", P_0, USING THE FOLLOWING EQUATION:

$P_0 = a \times C_{BMP} \times P_6$

P_0 =MAXIMIZED DETENTION VOLUME, IN INCHES P_0 = **0.563** **inches**

G.) CALCULATE THE "TARGET CAPTURE VOLUME", V_0, USING THE FOLLOWING EQUATION:

V_0 = TARGET CAPTURE VOLUME, IN ACRE-FEET

$V_0 = (P_0 \times A) / 12$

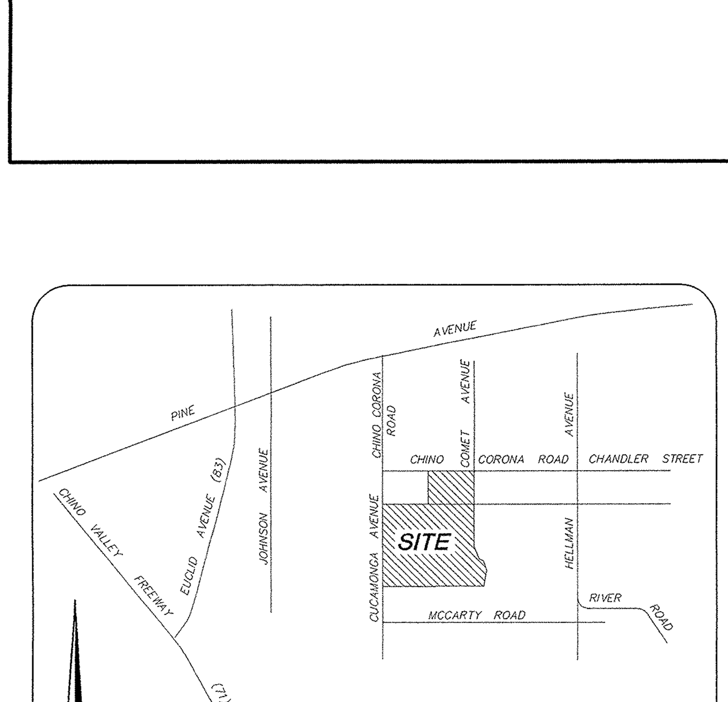
V_0 = **2.303** **acre-feet**

MULTIPLY BY 43,560 FT^2 TO GET CUBIC FEET (FT^3)

V_0 = 100,321 ft^3

H.) FOR THE PROPOSED BMP DRAINAGE AREA, WE HAVE CALCULATED THE TARGET CAPTURE VOLUME RUNOFF TO BE, **100,321 ft^3**. WE INTEND TO UTILIZE AN INFILTRATION BASIN IN IN ORDER TO CAPTURE AND TREAT THE CALCULATED TARGETED VOLUME.

Attachment E
WQMP Site Plan



VICINITY MAP

NOT TO SCALE

PRELIMINARY WQMP SITE PLAN

OPTION #5 - VORTECH UNITS AND INFILTRATION BASINS

PREPARED FOR OWNER

EDGEWATER ASSOCIATES I, LLC
165 S. UNION BLVD., SUITE 510
LAKEWOOD, CO 80228
PHONE: (303) 986-2222
FAX: (303) 986-7990
CONTACT: DONALD ROSIER

LEGEND

A=XX ACRES	DRAINAGE AREA IN ACRES
———	DRAINAGE BOUNDARY
—SD—	PROPOSED STORM DRAIN

NOTE

THE INFILTRATION BASIN SIZES ARE BASED ON ASSUMED PERCOLATION RATES OF 1 INCH/HOUR. THE FOOTPRINT OF THE BASINS WILL BE ADJUSTED ONCE THE PERCOLATION RATES ARE AVAILABLE.

HUITT-ZOLLARS
Huitt-Zollars, Inc. Irvine
430 Exchange Suite 200 Irvine, California 92602-1315
Phone (714) 734-5100 Fax (714) 734-5155

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Attachment F

Self Inspection & Record Keeping Forms

Details will be provided during final WQMP processing.

Attachment G

Source & Treatment Control BMPs

Section 4
Source Control BMPs

4.1 Introduction

This section describes specific source control Best Management Practices (BMPs) to be considered for incorporation into newly developed public and private infrastructure, as well as retrofit into existing facilities to meet stormwater management objectives.

4.2 BMP Fact Sheets

Source control fact sheets for design are listed in Table 4-1. The fact sheets detail planning methods and concepts that should be taken into consideration by developers during project design. The fact sheets are arranged in three categories: those that have to do with landscape, irrigation, and signage considerations; those that have to do with use of particular materials, those that have to do with design of particular areas.

Table 4-1 Source Control BMPs for Design

Design	
SD-10	Site Design and Landscape Planning
SD-11	Roof Runoff Controls
SD-12	Efficient Irrigation
SD-13	Storm Drain System Signs
Materials	
SD-20	Pervious Pavements
SD-21	Alternative Building Materials
Areas	
SD-30	Fueling Areas
SD-31	Maintenance Bays and Docks
SD-32	Trash Enclosures
SD-33	Vehicle Washing Areas
SD-34	Outdoor Material Storage Areas
SD-35	Outdoor Work Areas
SD-36	Outdoor Processing Areas

4.3 Fact Sheet Format

A BMP fact sheet is a short document that provides information about a particular BMP. Typically each fact sheet contains the information outlined in Figure 4-1. Supplemental information is provided if it is available. The fact sheets also contain side bar presentations with information on BMP design objectives. Completed fact sheets for each of the above activities are provided in Section 4.4.

SDxx Example Fact Sheet

Description of the BMP
Approach
Suitable Applications
Design Considerations
- Designing New Installations
- Redeveloping Existing Installations

Supplemental Information
- Examples
- Other Resources

Figure 4-1
Example Fact Sheet

4.4 BMP Fact Sheets

Source Control BMP Fact Sheets for design follow. The BMP fact sheets are individually page numbered and are suitable for photocopying and inclusion in stormwater quality management plans. Fresh copies of the fact sheets can be individually downloaded from the California Stormwater BMP Handbook website at www.cabmphandbooks.com.

Design Objectives

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

Description

Each project site possesses unique topographic, hydrologic, and vegetative features, some of which are more suitable for development than others. Integrating and incorporating appropriate landscape planning methodologies into the project design is the most effective action that can be done to minimize surface and groundwater contamination from stormwater.

Approach

Landscape planning should couple consideration of land suitability for urban uses with consideration of community goals and projected growth. Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Suitable Applications

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

Design Considerations

Design requirements for site design and landscapes planning should conform to applicable standards and specifications of agencies with jurisdiction and be consistent with applicable General Plan and Local Area Plan policies.

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Designing New Installations

Begin the development of a plan for the landscape unit with attention to the following general principles:

- Formulate the plan on the basis of clearly articulated community goals. Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.

- Map and assess land suitability for urban uses. Include the following landscape features in the assessment: wooded land, open unwooded land, steep slopes, erosion-prone soils, foundation suitability, soil suitability for waste disposal, aquifers, aquifer recharge areas, wetlands, floodplains, surface waters, agricultural lands, and various categories of urban land use. When appropriate, the assessment can highlight outstanding local or regional resources that the community determines should be protected (e.g., a scenic area, recreational area, threatened species habitat, farmland, fish run). Mapping and assessment should recognize not only these resources but also additional areas needed for their sustenance.

Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Conserve Natural Areas during Landscape Planning

If applicable, the following items are required and must be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

- Cluster development on least-sensitive portions of a site while leaving the remaining land in a natural undisturbed condition.

- Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.

- Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.

- Promote natural vegetation by using parking lot islands and other landscaped areas.

- Preserve riparian areas and wetlands.

Maximize Natural Water Storage and Infiltration Opportunities Within the Landscape Unit

- Promote the conservation of forest cover. Building on land that is already deforested affects basin hydrology to a lesser extent than converting forested land. Loss of forest cover reduces interception storage, detention in the organic forest floor layer, and water losses by evapotranspiration, resulting in large peak runoff increases and either their negative effects or the expense of countering them with structural solutions.

- Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams. Develop and implement policies and regulations to discourage the clearing, filling, and channelization of these features. Utilize them in drainage networks in preference to pipes, culverts, and engineered ditches.

- Evaluating infiltration opportunities by referring to the stormwater management manual for the jurisdiction and pay particular attention to the selection criteria for avoiding groundwater contamination, poor soils, and hydrogeological conditions that cause these facilities to fail. If necessary, locate developments with large amounts of impervious surfaces or a potential to produce relatively contaminated runoff away from groundwater recharge areas.

Protection of Slopes and Channels during Landscape Design

- Convey runoff safely from the tops of slopes.
- Avoid disturbing steep or unstable slopes.
- Avoid disturbing natural channels.
- Stabilize disturbed slopes as quickly as possible.
- Vegetate slopes with native or drought tolerant vegetation.
- Control and treat flows in landscaping and/or other controls prior to reaching existing natural drainage systems.
- Stabilize temporary and permanent channel crossings as quickly as possible, and ensure that increases in run-off velocity and frequency caused by the project do not erode the channel.
- Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion. Energy dissipaters shall be installed in such a way as to minimize impacts to receiving waters.
- Line on-site conveyance channels where appropriate, to reduce erosion caused by increased flow velocity due to increases in tributary impervious area. The first choice for linings should be grass or some other vegetative surface, since these materials not only reduce runoff velocities, but also provide water quality benefits from filtration and infiltration. If velocities in the channel are high enough to erode grass or other vegetative linings, riprap, concrete, soil cement, or geo-grid stabilization are other alternatives.
- Consider other design principles that are comparable and equally effective.

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.

Redevelopment may present significant opportunity to add features which had not previously been implemented. Examples include incorporation of depressions, areas of permeable soils, and swales in newly redeveloped areas. While some site constraints may exist due to the status of already existing infrastructure, opportunities should not be missed to maximize infiltration, slow runoff, reduce impervious areas, disconnect directly connected impervious areas.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Stormwater Management Manual for Western Washington, Washington State Department of Ecology, August 2001.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

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

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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

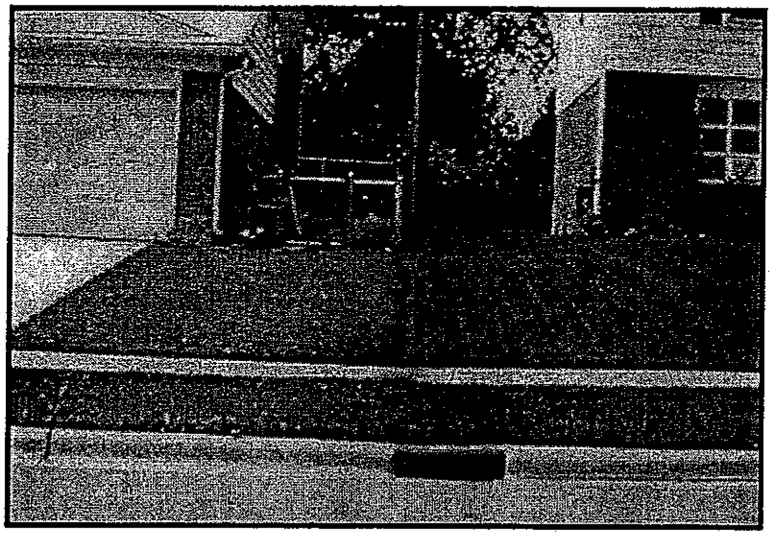
- City of Ottawa's Water Links Surface –Water Quality Protection Program
- City of Toronto Downspout Disconnection Program
- City of Boston, MA, Rain Barrel Demonstration Program

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 Objectives

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

Description

Irrigation water provided to landscaped areas may result in excess irrigation water being conveyed into stormwater drainage systems.

Approach

Project plan designs for development and redevelopment should include application methods of irrigation water that minimize runoff of excess irrigation water into the stormwater conveyance system.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

Design Considerations

Designing New Installations

The following methods to reduce excessive irrigation runoff should be considered, and incorporated and implemented where determined applicable and feasible by the Permittee:

- Employ rain-triggered shutoff devices to prevent irrigation after precipitation.
- Design irrigation systems to each landscape area's specific water requirements.
- Include design featuring flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.
- Implement landscape plans consistent with County or City water conservation resolutions, which may include provision of water sensors, programmable irrigation times (for short cycles), etc.

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- Design timing and application methods of irrigation water to minimize the runoff of excess irrigation water into the storm water drainage system.
- Group plants with similar water requirements in order to reduce excess irrigation runoff and promote surface filtration. Choose plants with low irrigation requirements (for example, native or drought tolerant species). Consider design features such as:
  - Using mulches (such as wood chips or bar) in planter areas without ground cover to minimize sediment in runoff
  - Installing appropriate plant materials for the location, in accordance with amount of sunlight and climate, and use native plant materials where possible and/or as recommended by the landscape architect
  - Leaving a vegetative barrier along the property boundary and interior watercourses, to act as a pollutant filter, where appropriate and feasible
  - Choosing plants that minimize or eliminate the use of fertilizer or pesticides to sustain growth
- Employ other comparable, equally effective methods to reduce irrigation water runoff.

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.

Other Resources

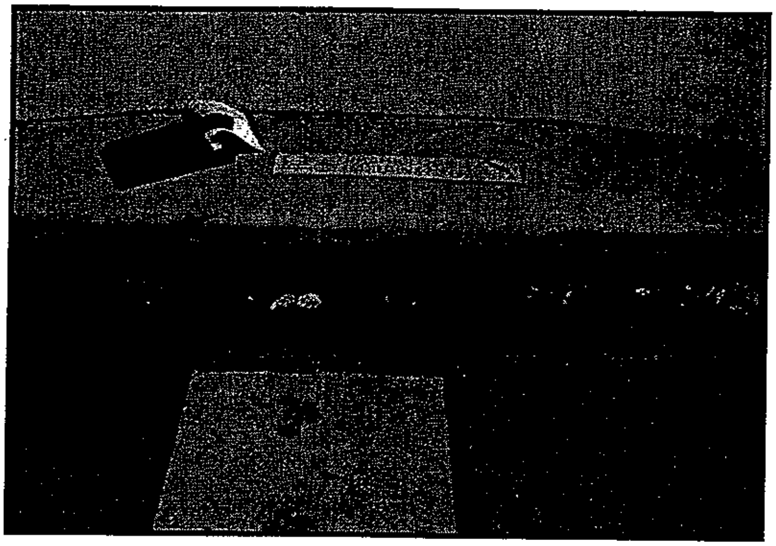
A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Storm Drain Signage



Design Objectives

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

Description

Waste materials dumped into storm drain inlets can have severe impacts on receiving and ground waters. Posting notices regarding discharge prohibitions at storm drain inlets can prevent waste dumping. Storm drain signs and stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets.

Approach

The stencil or affixed sign contains a brief statement that prohibits dumping of improper materials into the urban runoff conveyance system. Storm drain messages have become a popular method of alerting the public about the effects of and the prohibitions against waste disposal.

Suitable Applications

Stencils and signs alert the public to the destination of pollutants discharged to the storm drain. Signs are appropriate in residential, commercial, and industrial areas, as well as any other area where contributions or dumping to storm drains is likely.

Design Considerations

Storm drain message markers or placards are recommended at all storm drain inlets within the boundary of a development project. The marker should be placed in clear sight facing toward anyone approaching the inlet from either side. All storm drain inlet locations should be identified on the development site map.

Designing New Installations

The following methods should be considered for inclusion in the project design and show on project plans:

- Provide stenciling or labeling of all storm drain inlets and catch basins, constructed or modified, within the project area with prohibitive language. Examples include "NO DUMPING –

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DRAINS TO OCEAN" and/or other graphical icons to discourage illegal dumping.

- Post signs with prohibitive language and/or graphical icons, which prohibit illegal dumping at public access points along channels and creeks within the project area.

Note - Some local agencies have approved specific signage and/or storm drain message placards for use. Consult local agency stormwater staff to determine specific requirements for placard types and methods of application.

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. If the project meets the definition of "redevelopment", then the requirements stated under " designing new installations" above should be included in all project design plans.

Additional Information

Maintenance Considerations

- Legibility of markers and signs should be maintained. If required by the agency with jurisdiction over the project, the owner/operator or homeowner's association should enter into a maintenance agreement with the agency or record a deed restriction upon the property title to maintain the legibility of placards or signs.

Placement

- Signage on top of curbs tends to weather and fade.

- Signage on face of curbs tends to be worn by contact with vehicle tires and sweeper brooms.

Supplemental Information

Examples

- Most MS4 programs have storm drain signage programs. Some MS4 programs will provide stencils, or arrange for volunteers to stencil storm drains as part of their outreach program.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Pervious Pavements SD-20

Design Objectives

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

Description

Pervious paving is used for light vehicle loading in parking areas. The term describes a system comprising a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet. The surface can itself be porous such that water infiltrates across the entire surface of the material (e.g., grass and gravel surfaces, porous concrete and porous asphalt), or can be built up of impermeable blocks separated by spaces and joints, through which the water can drain. This latter system is termed 'permeable' paving. Advantages of pervious pavements is that they reduce runoff volume while providing treatment, and are unobtrusive resulting in a high level of acceptability.

Approach

Attenuation of flow is provided by the storage within the underlying structure or sub base, together with appropriate flow controls. An underlying geotextile may permit groundwater recharge, thus contributing to the restoration of the natural water cycle. Alternatively, where infiltration is inappropriate (e.g., if the groundwater vulnerability is high, or the soil type is unsuitable), the surface can be constructed above an impermeable membrane. The system offers a valuable solution for drainage of spatially constrained urban areas.

Significant attenuation and improvement in water quality can be achieved by permeable pavements, whichever method is used. The surface and subsurface infrastructure can remove both the soluble and fine particulate pollutants that occur within urban runoff. Roof water can be piped into the storage area directly, adding areas from which the flow can be attenuated. Also, within lined systems, there is the opportunity for stored runoff to be piped out for reuse.

Suitable Applications

Residential, commercial and industrial applications are possible. The use of permeable pavement may be restricted in cold regions, arid regions or regions with high wind erosion. There are some specific disadvantages associated with permeable pavement, which are as follows:

- Permeable pavement can become clogged if improperly installed or maintained. However, this is countered by the ease with which small areas of paving can be cleaned or replaced when blocked or damaged.

- Their application should be limited to highways with low traffic volumes, axle loads and speeds (less than 30 mph limit), car parking areas and other lightly trafficked or non-trafficked areas. Permeable surfaces are currently not considered suitable for adoptable roads due to the risks associated with failure on high speed roads, the safety implications of ponding, and disruption arising from reconstruction.

- When using un-lined, infiltration systems, there is some risk of contaminating groundwater, depending on soil conditions and aquifer susceptibility. However, this risk is likely to be small because the areas drained tend to have inherently low pollutant loadings.

- The use of permeable pavement is restricted to gentle slopes.

- Porous block paving has a higher risk of abrasion and damage than solid blocks.

Design Considerations

Designing New Installations

If the grades, subsoils, drainage characteristics, and groundwater conditions are suitable, permeable paving may be substituted for conventional pavement on parking areas, cul de sacs and other areas with light traffic. Slopes should be flat or very gentle. Scottish experience has shown that permeable paving systems can be installed in a wide range of ground conditions, and the flow attenuation performance is excellent even when the systems are lined.

The suitability of a pervious system at a particular pavement site will, however, depend on the loading criteria required of the pavement.

Where the system is to be used for infiltrating drainage waters into the ground, the vulnerability of local groundwater sources to pollution from the site should be low, and the seasonal high water table should be at least 4 feet below the surface.

Ideally, the pervious surface should be horizontal in order to intercept local rainfall at source. On sloping sites, pervious surfaces may be terraced to accommodate differences in levels.

Design Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and their required operational life. To provide satisfactory performance, the following criteria should be considered:

- The subgrade should be able to sustain traffic loading without excessive deformation.

- The granular capping and sub-base layers should give sufficient load-bearing to provide an adequate construction platform and base for the overlying pavement layers.

- The pavement materials should not crack of suffer excessive rutting under the influence of traffic. This is controlled by the horizontal tensile stress at the base of these layers.

There is no current structural design method specifically for pervious pavements. Allowances should be considered the following factors in the design and specification of materials:

- Pervious pavements use materials with high permeability and void space. All the current UK pavement design methods are based on the use of conventional materials that are dense and relatively impermeable. The stiffness of the materials must therefore be assessed.
- Water is present within the construction and can soften and weaken materials, and this must be allowed for.
- Existing design methods assume full friction between layers. Any geotextiles or geomembranes must be carefully specified to minimize loss of friction between layers.
- Porous asphalt loses adhesion and becomes brittle as air passes through the voids. Its durability is therefore lower than conventional materials.

The single sized grading of materials used means that care should be taken to ensure that loss of finer particles between unbound layers does not occur.

Positioning a geotextile near the surface of the pervious construction should enable pollutants to be trapped and retained close to the surface of the construction. This has both advantages and disadvantages. The main disadvantage is that the filtering of sediments and their associated pollutants at this level may hamper percolation of waters and can eventually lead to surface ponding. One advantage is that even if eventual maintenance is required to reinstate infiltration, only a limited amount of the construction needs to be disturbed, since the sub-base below the geotextile is protected. In addition, the pollutant concentration at a high level in the structure allows for its release over time. It is slowly transported in the stormwater to lower levels where chemical and biological processes may be operating to retain or degrade pollutants.

The design should ensure that sufficient void space exists for the storage of sediments to limit the period between remedial works.

- Pervious pavements require a single size grading to give open voids. The choice of materials is therefore a compromise between stiffness, permeability and storage capacity.
- Because the sub-base and capping will be in contact with water for a large part of the time, the strength and durability of the aggregate particles when saturated and subjected to wetting and drying should be assessed.
- A uniformly graded single size material cannot be compacted and is liable to move when construction traffic passes over it. This effect can be reduced by the use of angular crushed rock material with a high surface friction.

In pollution control terms, these layers represent the site of long term chemical and biological pollutant retention and degradation processes. The construction materials should be selected, in addition to their structural strength properties, for their ability to sustain such processes. In general, this means that materials should create neutral or slightly alkaline conditions and they should provide favorable sites for colonization by microbial populations.

Construction/Inspection Considerations

- Permeable surfaces can be laid without cross-falls or longitudinal gradients.
- The blocks should be lain level

- They should not be used for storage of site materials, unless the surface is well protected from deposition of silt and other spillages.
- The pavement should be constructed in a single operation, as one of the last items to be built, on a development site. Landscape development should be completed before pavement construction to avoid contamination by silt or soil from this source.
- Surfaces draining to the pavement should be stabilized before construction of the pavement.
- Inappropriate construction equipment should be kept away from the pavement to prevent damage to the surface, sub-base or sub-grade.

Maintenance Requirements

The maintenance requirements of a pervious surface should be reviewed at the time of design and should be clearly specified. Maintenance is required to prevent clogging of the pervious surface. The factors to be considered when defining maintenance requirements must include:

- Type of use
- Ownership
- Level of trafficking
- The local environment and any contributing catchments

Studies in the UK have shown satisfactory operation of porous pavement systems without maintenance for over 10 years and recent work by Imbe et al. at 9th ICUD, Portland, 2002 describes systems operating for over 20 years without maintenance. However, performance under such regimes could not be guaranteed, Table 1 shows typical recommended maintenance regimes:

Table 1 Typical Recommended Maintenance Regimes

Activity	Schedule
■ Minimize use of salt or grit for de-icing ■ Keep landscaped areas well maintained ■ Prevent soil being washed onto pavement	Ongoing
■ Vacuum clean surface using commercially available sweeping machines at the following times: - End of winter (April) - Mid-summer (July / August) - After Autumn leaf-fall (November)	2/3 x per year
■ Inspect outlets	Annual
■ If routine cleaning does not restore infiltration rates, then reconstruction of part of the whole of a pervious surface may be required. ■ The surface area affected by hydraulic failure should be lifted for inspection of the internal materials to identify the location and extent of the blockage. ■ Surface materials should be lifted and replaced after brush cleaning. Geotextiles may need complete replacement. ■ Sub-surface layers may need cleaning and replacing. ■ Removed silts may need to be disposed of as controlled waste.	As needed (infrequent) Maximum 15-20 years

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 1 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

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.

Additional Information

Cost Considerations

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 2 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

Table 2 Engineer's Estimate for Porous Pavement

Porous Pavement													
Item	Units	Price	Cycles/ Year	Quant.1 Acre WS	Total	Quant.2 Acre WS	Total	Quant.3 Acre WS	Total	Quant.4 Acre WS	Total	Quant.5 Acre WS	Total
Grading	SY	$2.00		604	$1,208	1209	$2,418	1812	$3,624	2419	$4,838	3020	$6,040
Paving	SY	$19.00		212	$4,028	424	$8,056	638	$12,084	848	$16,112	1060	$20,140
Excavation	CY	$3.60		201	$724	403	$1,451	604	$2,174	806	$2,902	1008	$3,629
Filter Fabric	SY	$1.15		700	$805	1400	$1,610	2000	$2,300	2500	$3,220	3600	$4,140
Stone Fill	CY	$16.00		201	$3,216	403	$6,448	604	$9,664	806	$12,896	1008	$16,128
Sand	CY	$7.00		100	$700	200	$1,400	300	$2,100	400	$2,800	500	$3,500
Sight Well	EA	$300.00		2	$600	3	$900	4	$1,200	7	$2,100	7	$2,100
Seeding	LF	$0.05		644	$32	1288	$64	1932	$97	2576	$129	3220	$161
Check Dam	CY	$35.00		0	$0	0	$0	0	$0	0	$0	0	$0
Total Construction Costs					$10,105		$19,929		$28,819		$40,158		$49,798
Construction Costs Amortized for 20 Years					$505		$996		$1,441		$2,008		$2,490

Annual Maintenance Expense													
Item	Units	Price	Cycles/ Year	Quant.1 Acre WS	Total	Quant.2 Acre WS	Total	Quant.3 Acre WS	Total	Quant.4 Acre WS	Total	Quant.5 Acre WS	Total
Sweeping	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Washing	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Inspection	MH	$20.00	5	5	$100	5	$100	5	$100	5	$100	5	$100
Deep Clean	AC	$450.00	0.5	1	$225	2	$450	3	$675	3.9	$878	5	$1,125
Total Annual Maintenance Expense					$3,960		$7,792		$11,851		$15,483		$19,570

Supplemental Information

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Other Resources

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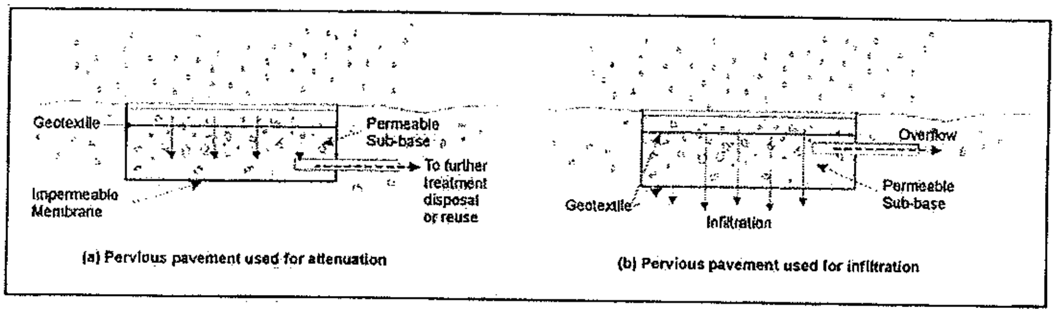
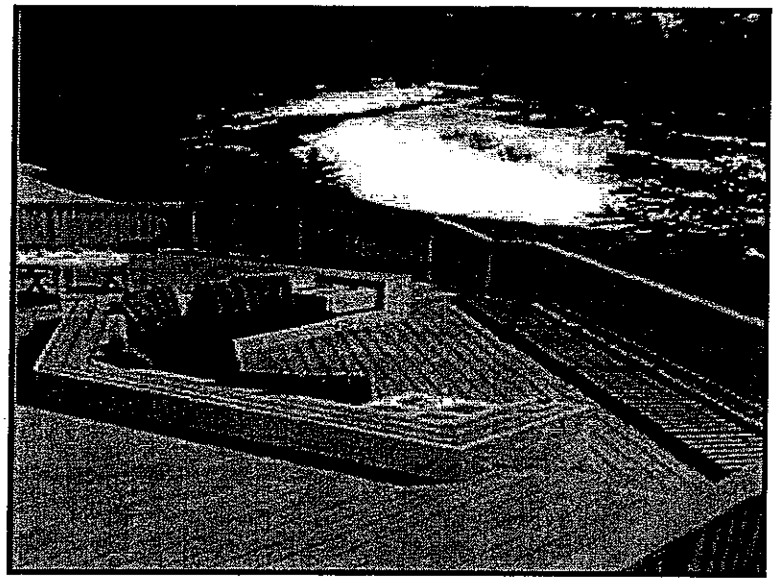


Schematics of a Pervious Pavement System

Alternative Building Materials SD-21



Design Objectives

✓ Maximize Infiltration
✓ Provide Retention
✓ Source Control
Minimize Impervious Land Coverage
Prohibit Dumping of Improper Materials
Contain Pollutant
Collect and Convey

Description

Alternative building materials are selected instead of conventional materials for new construction and renovation. These materials reduce potential sources of pollutants in stormwater runoff by eliminating compounds that can leach into runoff, reducing the need for pesticide application, reducing the need for painting and other maintenance, or by reducing the volume of runoff.

Approach

Alternative building materials are available for use as lumber for decking, roofing materials, home siding, and paving for driveways, decks, and sidewalks.

Suitable Applications

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

Design Considerations

Designing New Installations

Decking

One of the most common materials for construction of decks and other outdoor construction has traditionally been pressure treated wood, which is now being phased out. The standard treatment is called CCA, for chromated copper arsenate. The key ingredients are arsenic (which kills termites, carpenter ants and other insects), copper (which kills the fungi that cause wood to rot) and chromium (which reacts with the other ingredients to bind them to the wood). The amount of arsenic is far from trivial. A deck just 8 feet x 10 feet contains more than 1 1/3 pounds of this highly potent poison. Replacement materials include a new type of pressure treated wood, plastic and composite lumber.

There are currently over 20 products in the market consisting of plastic or plastic-wood composites. Plastic lumber is made from 100% recycled plastic, # 2 HDPE and polyethylene plastic milk jugs

CASQA California Stormwater Quality Association

and soap bottles. Plastic-wood composites are a combination of plastic and wood fibers or sawdust. These materials are a long lasting exterior weather, insect, and chemical resistant wood lumber replacement for non structural applications. Use it for decks, docks, raised garden beds and planter boxes, pallets, hand railings, outdoor furniture, animal pens, boat decks, etc.

New pressure treated wood uses a much safer recipe, ACQ, which stands for ammoniacal copper quartenary. It contains no arsenic and no chromium. Yet the American Wood Preservers Association has found it to be just as effective as the standard formula. ACQ is common in Japan and Europe.

Roofing

Several studies have indicated that metal used as roofing material, flashing, or gutters can leach metals into the environment. The leaching occurs because rainfall is slightly acidic and slowly dissolved the exposed metals. Common traditional applications include copper sheathing and galvanized (zinc) gutters.

Coated metal products are available for both roofing and gutter applications. These products eliminate contact of bare metal with rainfall, eliminating one source of metals in runoff. There are also roofing materials made of recycled rubber and plastic that resemble traditional materials.

A less traditional approach is the use of green roofs. These roofs are not just green, they're alive. Planted with grasses and succulents, low- profile green roofs reduce the urban heat island effect, stormwater runoff, and cooling costs, while providing wildlife habitat and a connection to nature for building occupants. These roofs are widely used on industrial facilities in Europe and have been established as experimental installations in several locations in the US, including Portland, Oregon. Their feasibility is questionable in areas of California with prolonged, dry, hot weather.

Paved Areas

Traditionally, concrete is used for construction of patios, sidewalks, and driveways. Although it is non-toxic, these paved areas reduce stormwater infiltration and increase the volume and rate of runoff. This increase in the amount of runoff is the leading cause of stream channel degradation in urban areas.

There are a number of alternative materials that can be used in these applications, including porous concrete and asphalt, modular blocks, and crushed granite. These materials, especially modular paving blocks, are widely available and a well established method to reduce stormwater runoff.

Building Siding

Wood siding is commonly used on the exterior of residential construction. This material weathers fairly rapidly and requires repeated painting to prevent rotting. Alternative "new" products for this application include cement-fiber and vinyl. Cement-fiber siding is a masonry product made from Portland cement, sand, and cellulose and will not burn, cup, swell, or shrink.

Pesticide Reduction

A common use of powerful pesticides is for the control of termites. Chlordane was used for many years for this purpose and is now found in urban streams and lakes nationwide. There are a number of physical barriers that can be installed during construction to help reduce the use of pesticides.

Sand barriers for subterranean termites are a physical deterrent because the termites cannot tunnel through it. Sand barriers can be applied in crawl spaces under pier and beam foundations, under slab foundations, and between the foundation and concrete porches, terraces, patios and steps. Other possible locations include under fence posts, underground electrical cables, water and gas lines, telephone and electrical poles, inside hollow tile cells and against retaining walls.

Metal termite shields are physical barriers to termites which prevent them from building invisible tunnels. In reality, metal shields function as a helpful termite detection device, forcing them to build tunnels on the outside of the shields which are easily seen. Metal termite shields also help prevent dampness from wicking to adjoining wood members which can result in rot, thus making the material more attractive to termites and other pests. Metal flashing and metal plates can also be used as a barrier between piers and beams of structures such as decks, which are particularly vulnerable to termite attack.

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.

Other Resources

There are no good, independent, comprehensive sources of information on alternative building materials for use in minimizing the impacts of stormwater runoff. Most websites or other references to "green" or "alternative" building materials focus on indoor applications, such as formaldehyde free plywood and low VOC paints, carpets, and pads. Some supplemental information on alternative materials is available from the manufacturers.

Fires are a source of concern in many areas of California. Information on the flammability of alternative decking materials is available from the University of California Forest Product Laboratory (UCFPL) website at: http://www.ucfpl.ucop.edu/WDDeckIntro.htm

Section 5
Treatment Control BMPs

5.1 Introduction

This section describes treatment control Best Management Practices (BMPs) to be considered for incorporation into newly developed public and private infrastructure, as well as retrofit into existing facilities to meet stormwater management objectives. BMP fact sheets are divided into two groups: public domain BMPs and manufactured (proprietary) BMPs. In some cases, the same BMP may exist in each group, for example, media filtration. However, treatment BMPs are typically very different between the two groups.

Brand names of manufactured BMPs are not stated. Descriptions of manufactured BMPs in this document should not be inferred as endorsement by the authors.

5.2 Treatment Control BMPs

Public domain and manufactured BMP controls are listed in Table 5-1.

Table 5-1 Treatment Control BMPs

Public Domain		Manufactured (Proprietary)	
Infiltration		**Infiltration**	
TC-10	Infiltration Trench		
TC-11	Infiltration Basin		
TC-12	Retention/Irrigation		
Detention and Settling		**Detention and Settling**	
TC-20	Wet Pond	MP-20	Wetland
TC-21	Constructed Wetland		
TC-22	Extended Detention Basin		
Biofiltration		**Biofiltration**	
TC-30	Vegetated Swale		
TC-31	Vegetated Buffer Strip		
TC-32	Bioretention		
Filtration		**Filtration**	
TC-40	Media Filter	MP-40	Media Filter
Flow Through Separation		**Flow Through Separation**	
TC-50	Water Quality Inlet	MP-50	Wet Vault
		MP-51	Vortex Separator
		MP-52	Drain Inserts
Other		**Other**	
TC-60	Multiple Systems		

5.3 Fact Sheet Format

A BMP fact sheet is a short document that gives all the information about a particular BMP. Typically, each public domain and manufactured BMP fact sheet contains the information outlined in Figure 5-1. The fact sheets also contain side bar presentations with information on BMP design considerations, targeted constituents, and removal effectiveness (if known).

Treatment BMP performance, design criteria, and other selection factors are discussed in 5.4 – 5.6 below. BMP Fact sheets are included in 5.7.

TCxx/MPxx Example Fact Sheet
Description
California Experience
Advantages
Limitations
Design and Sizing Guidelines
Performance
Siting Criteria
Design Guidelines
Maintenance
Cost
References and Sources of Additional Information

Figure 5-1
Example Fact Sheet

5.4 Comparing Performance of Treatment BMPs

With a myriad of stormwater treatment BMPs from which to choose, a question commonly asked is "which one is best". Particularly when considering a manufactured treatment system, the engineer wants to know if it provides performance that is reasonably comparable to the typical public-domain BMPs like wet ponds or grass swales. With so many BMPs, it is not likely that they perform equally for all pollutants. Thus, the question that each local jurisdiction faces is which treatment BMPs will it allow, and under what circumstances. What level of treatment is desired or reasonable, given the cost? Which BMPs are the most cost-effective? Current municipal stormwater permits specify the volume or rate of stormwater that must be treated, but not the specific level or efficiency of treatment: These permits usually require performance to the specific maximum extent practicable (MEP), but this does not translate to an easy to apply specific design criteria.

Methodology for comparing BMP performance may need to be expanded to include more than removal effectiveness. Many studies have been conducted on the performance of stormwater treatment BMPs. Several publications have provided summaries of performance (ASCE, 1998; ASCE, 2001; Brown and Schueler, 1997; Shoemaker et al., 2000; Winter, 2001). These summaries indicate a wide variation in the performance of each type of BMP, making effectiveness comparisons between BMPs problematic.

5.4.1 Variation in Performance

There are several reasons for the observed variation.

The Variability of Stormwater Quality

Stormwater quality is highly variable during a storm, from storm to storm at a site, and between sites even of the same land use. For pollutants of interest, maximum observed concentrations commonly exceed the average concentration by a factor of 100. The average concentration of a storm, known as the event mean concentration (EMC) commonly varies at a site by a factor of 5. One aspect of stormwater quality that is highly variable is the particle size distribution (PSD) of the suspended sediments. This results in variation in the settle ability of these sediments and the pollutants that are attached. For example, several performance studies of manufactured BMPs have been conducted in the upper Midwest and Northeast where deicing sand is commonly used. The sand, washed off during spring and summer storms, skews the PSD to larger sizes not commonly found in stormwater from California sites except in mountainous areas. Consequently, a lower level efficiency may be observed if the same treatment system is used in California.

Most Field Studies Monitor Too Few Storms

High variability of stormwater quality requires that a large number of storms be sampled to discern if there is a significant difference in performance among BMPs. The smaller the actual difference in performance between BMPs, the greater the number of storms that must be sampled to statistically discern the difference between them. For example, a researcher attempting to determine a difference in performance between two BMPs of 10% must monitor many more storms than if the interest is to define the difference within 50%. Given the expense and difficulty, few studies have monitored enough storms to determine the actual performance with a high level of precision.

Different Design Criteria

Performance of different systems within the same group (e.g., wet ponds) differs significantly in part because of differing design criteria for each system. This in turn can make it problematic to compare different groups of treatment BMPs to each other (e.g., wet ponds to vortex separators).

Differing Influent Concentrations and Analytical Variability

With most treatment BMPs, efficiency decreases with decreasing influent concentration. This is illustrated in Figure 5-2. Thus, a low removal efficiency may be observed during a study not because the device is inherently a poorer performer, but possibly because the influent concentrations for the site were unusually low. In addition, as the concentration of a particular constituent such as TSS approaches its analytical detection limit, the effect of the variability of the laboratory technique becomes more significant. This factor also accounts for the wide variability of observations on the left of Figure 5-2.

The variability of the laboratory results as the TSS approaches its analytical detection limit may also account for negative efficiencies at very low influent concentrations (e.g., TSS less than 10 mg/L). However, some negative efficiencies observed at higher concentrations may not necessarily be an artifact of laboratory analysis. The cause varies to some extent with the type of treatment BMP. Negative efficiencies may be due to the re-suspension of previously deposited pollutants, a change in pH that dissolves precipitated or sorbed pollutants, discharge of algae in the case of BMPs with open wet pools, erosion of unprotected basin side or bottom, and the degradation of leaves that entered the system the previous fall.

Different Methods of Calculating Efficiency

Researchers (1) have used different methods to calculate efficiency, (2) do not always indicate which method they have used, and (3) often do not provide sufficient information in their report to allow others to recalculate the efficiency using a common method.

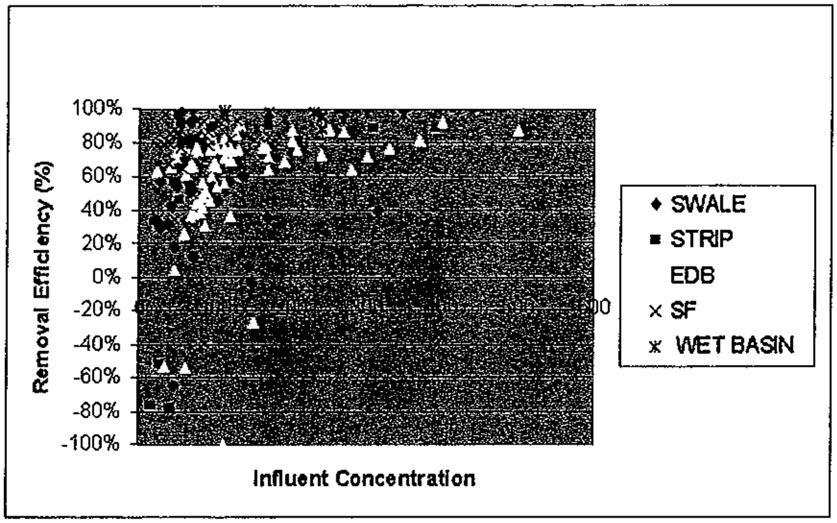


Figure 5-2
Removal Efficiency Versus Influent Concentration

One approach to quantifying BMP efficiency is to determine first if the BMP is providing treatment (that the influent and effluent mean event mean concentrations are statistically different from one another) and then examine either a cumulative distribution function of influent and effluent quality or a standard parallel probability plot. This approach is called the Effluent Probability Method. While this approach has been used in the past by EPA and ASCE, some researchers have experienced problems with the general applicability of this method. A discussion of these issues is included in Appendix B.

A second approach to comparing performance among BMPs is to compare effluent concentrations, using a box-whisker plot, the basic form of which is illustrated in Figure 5-3. The plot represents all of the data points, of one study, several studies, or of individual storms. The plots provide insight into the variability of performance within each BMP type, and possible differences in performance among the types. To explain the plot: 50% of the data points as well as the median value of all the data points is represented by the box. That is, the median falls within the 75th and 25th percentile of data (top and bottom of the box). The whisker extends to the highest point within a range of 1.5 times the difference between the first and third quartiles. Individual points beyond this range are shown as asterisks.

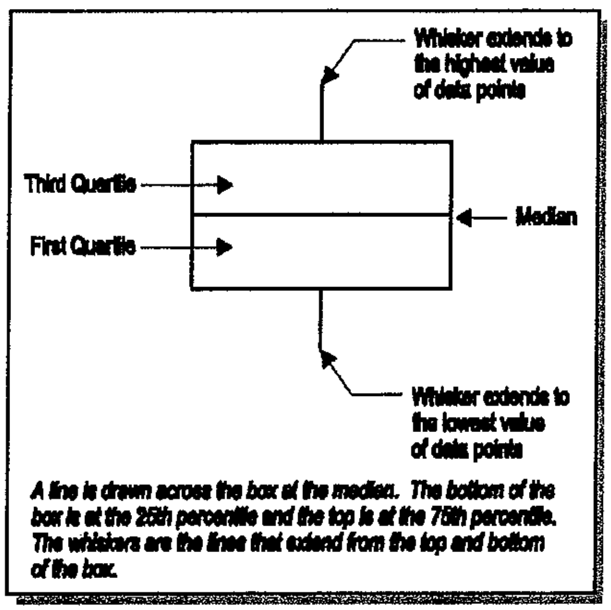


Figure 5-3
Box-Whisker Plot

Recognizing the possible effect of influent concentration on efficiency, an alternative is to compare effluent concentrations. The reasoning is that regardless of the influent concentration, a particular BMP will generate a narrower range of effluent concentrations. Figure 5-4 shows observed effluent concentrations for several different types of BMPs. These data were generated in an extensive field program conducted by the California Department of Transportation (Caltrans). As this program is the most extensive effort to date in the entire United States, the observations about performance in this Handbook rely heavily on these data. The Caltrans study is unique in that many of the BMPs were tested under reasonably similar conditions (climate, storms, freeway stormwater quality), with each type of BMP sized with the same design criteria.

An additional factor to consider when comparing BMPs is the effect of infiltration. BMPs with concrete or metal structures will have no infiltration, whereas the infiltration in earthen BMPs will vary from none to substantial. For example, in the Caltrans study, infiltration in vegetated swales averaged nearly 50%. This point is illustrated with Figure 5-4 where effluent quality of several BMPs is compared. As seen in Figure 5-4, effluent concentration for grass swales is higher than either filters or wet basins (30 vs. 10 to 15 mg/L), suggesting that swales in comparison are not particularly effective. However, surface water entering swales may infiltrate into the ground, resulting in a loading reduction (flow times concentration) that is similar to those BMPs with minimal or no infiltration.

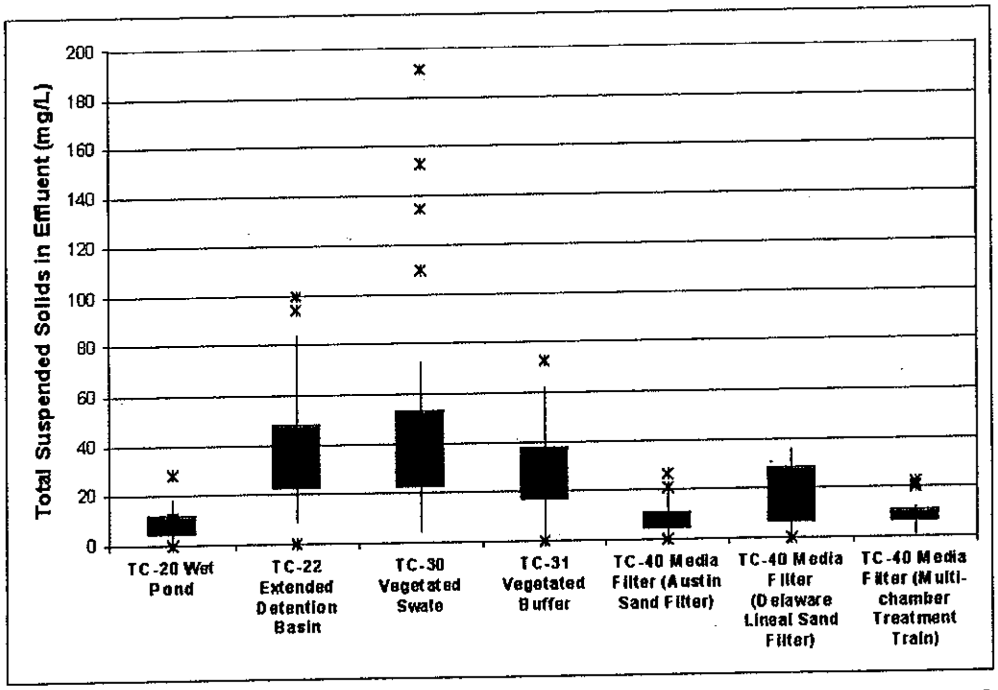


Figure 5-4
Observed Effluent Concentrations for Several Different Public Domain BMPs

With equation shown below, it is possible using the data from Figure 5-4 to estimate different levels of loading reduction as a function of the fraction of stormwater that is infiltrated.

$$EEC = (1-I)(EC) + (I)(GC)$$

Where:

EEC = the effective effluent concentration

I = fraction of stormwater discharged by infiltration

EC = the median concentration observed in the effluent

GC = expected concentration of stormwater when it reaches the groundwater

To illustrate the use of the equation above, the effect of infiltration is considered on the effective effluent concentration of TSS from swales. From Figure 5-4, the median effluent concentration for swales is about 30 mg/L. Infiltration of 50% is assumed with an expected concentration of 5 mg/L when the stormwater reaches the groundwater. This gives:

$$EEC = (1-0.5)(30) + (0.5)(5) = 17.5 \text{ mg/L}.$$

The above value can be compared to other BMPs that may directly produce a lower effluent concentration, but do not exhibit infiltration, such as concrete wet vaults.

5.4.2 Other Issues Related to Performance Comparisons

A further consideration related to performance comparisons is whether or not the treatment BMP removes dissolved pollutants. Receiving water standards for most metals are based on the dissolved fraction; the form of nitrogen or phosphorus of most concern as a nutrient is the dissolved fraction.

The common practice of comparing the performance of BMPs using TSS may not be considered sufficient by local governments and regulatory agencies, as there is not always a strong, consistent relationship between TSS and the pollutants of interest, particularly those identified in the 303d list for specific water bodies in California. These pollutants frequently include metals, nitrogen, nutrients (but often nutrients without specifying nitrogen or phosphorus), indicator bacteria (i.e., fecal coliform), pesticides, and trash. Less commonly cited pollutants include sediment, PAHs, PCBs, and dioxin. With respect to metals, typically, only the general term is used. In some cases, a specific metal is identified. The most commonly listed metals are mercury, copper, lead, selenium, zinc, and nickel. Less frequently listed metals are cadmium, arsenic, silver, chromium, molybdenum, and thallium. Commonly, only the general term "metals" is indicated for a water body without reference to a particular metal.

It is desirable to know how each of the treatment BMPs performs with respect to the removal of the above pollutants. Unfortunately, the performance data are non-existent or very limited for many of the cited pollutants, particularly trash, PAHs, PCBs, dioxin, mercury, selenium, and pesticides. Furthermore, the concentrations of these constituents are very low, often below the detection limit. This prevents the determination of which BMPs are most effective. However, with the exception of trash and possibly dioxin, these pollutants readily sorb to sediments in stormwater, and therefore absent data at this time can be considered to be removed in proportion to the removal of TSS (i.e., sediment.) Therefore, in general, those treatment systems that are most effective at removing TSS will be most effective at removing pollutants noted above.

While there is little data on the removal of trash, those treatment BMPs that include a basin such as a wet pond or vault, or extended detention basin should be similarly effective at removing trash as long as the design incorporates a means of retaining the floating trash in the BMP. Whether or not manufactured products that are configured as a basin (e.g., round vaults or vortex separators) are as effective as public domain BMPs is unknown. However, their ability to retain floating debris may be limited by the fact that many of these products are relatively small and therefore may have limited storage capacity. Only one manufactured BMP is specifically designed to remove floating debris.

There are considerable amounts of performance data for zinc, copper, and lead, with a less substantial database for nickel, cadmium, and chromium. An exception is high-use freeways where metals in general are at higher concentrations than residential and commercial properties. Lead sorbs easily to the sediments in stormwater, with typically only 10% in the dissolved phase. Hence, its removal is generally in direct proportion to the removal of TSS. In contrast, zinc, copper, and cadmium are highly soluble with 50% or more in the dissolved phase. Hence, two treatment BMPs may remove TSS at the same level, but if one is capable of removing dissolved metals, it provides better treatment overall for the more soluble metals.

5.4.3 Comparisons of Treatment BMPs for Nitrogen, Zinc, Bacteria, and TSS

Presented in Figures 5-5 through 5-8 are comparisons of the effluent concentrations produced by several types of treatment BMPs for nitrogen, zinc, and fecal coliform, respectively (TSS is represented in Figure 5-4). Graphs for other metals are provided in Appendix C. These data are from the Caltrans study previously cited. Total and the dissolved effluent concentrations are shown for zinc. (Note that while box-whisker plots are used here to compare BMPs, other methodologies, such as effluent cumulative probability distribution plots, are used by others.)

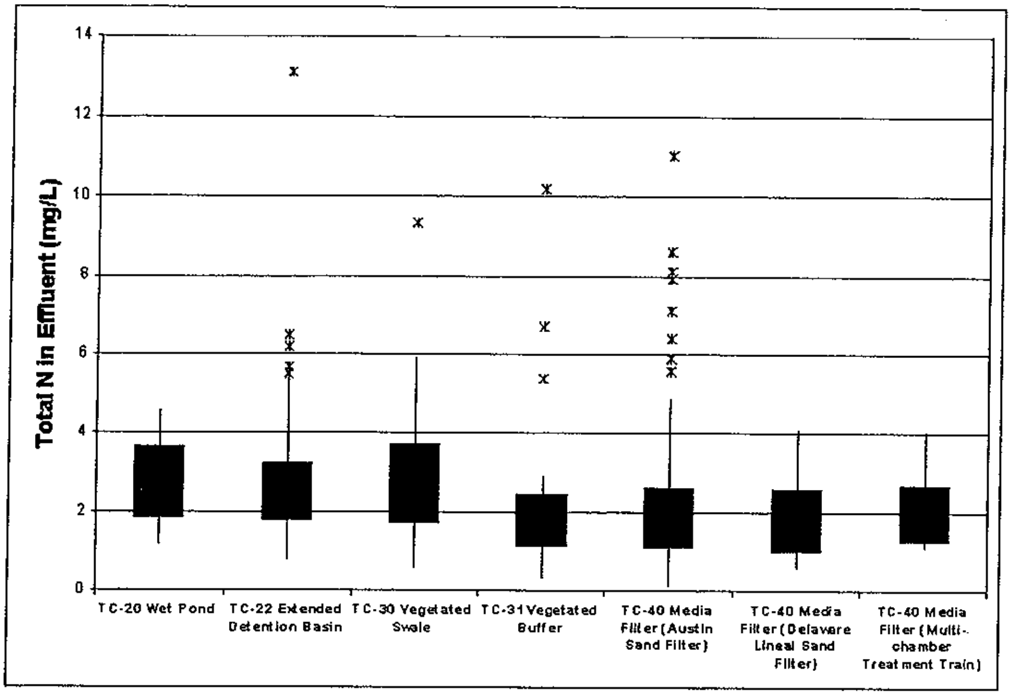


Figure 5-5
Total Nitrogen in Effluent

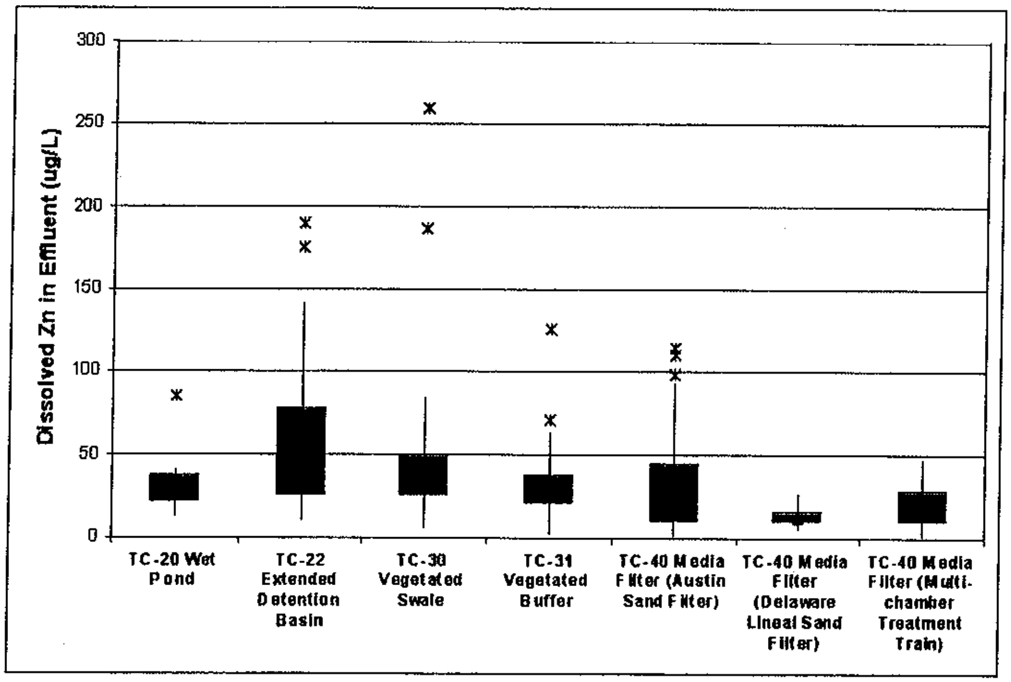


Figure 5-6
Total Dissolved Zinc in Effluent

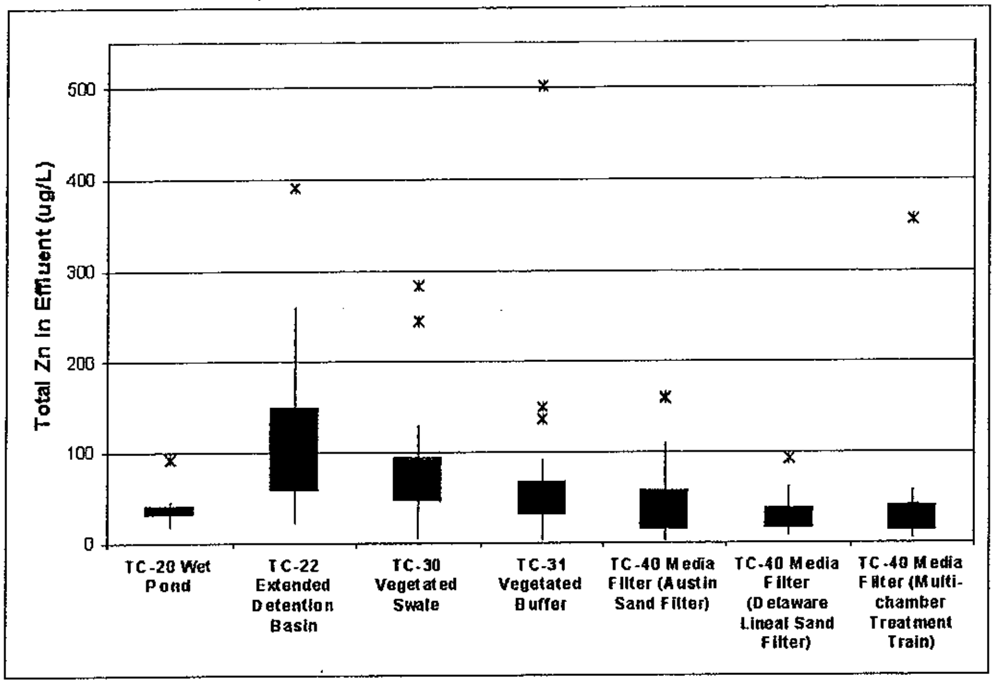


Figure 5-7
Total Zinc in Effluent

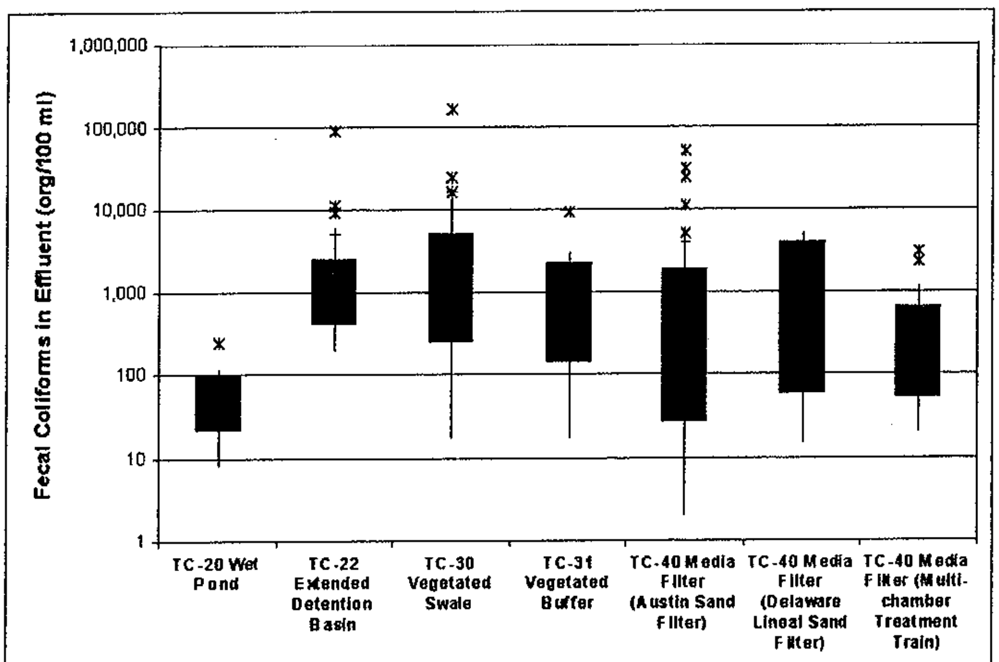


Figure 5-8
Total Fecal Coliforms in Effluent

While a figure is provided for fecal coliform, it is important to stress that the performance comparisons between BMPs is problematic. Some California BMP studies have shown excellent removal of fecal coliform through constructed wetlands and other BMPs. However, BMP comparisons are complicated by the fact that several BMPs attract wildlife and pets, thereby elevating bacteria levels. As bacteria sorb to the suspended sediments, a significant fraction may be removed by settling or filtration. A cautionary note regarding nitrogen: when comparing nitrogen removal between treatment systems it is best to use the parameter total nitrogen. It consists of Total Kjeldahl Nitrogen – TKN (organic nitrogen plus ammonia) plus nitrate. Comparing TKN removal rates is misleading in that in some treatment systems the ammonia is changed to nitrate but not removed. Examination of the performance data of many systems shows that while TKN may decrease dramatically, the nitrate concentration increases correspondingly. Hence, the overall removal of nitrogen is considerably lower than implied from looking only at Kjeldahl Nitrogen.

5.4.4 General Performance of Manufactured BMPs

An important question is how the performance of manufactured treatment BMPs compares to those in the public domain, illustrated previously in Figures 5-4 through 5-8. Figure 5-9 (and Figure 5-10 in log format) presents box-whisker plots of the removal of TSS for the manufactured systems. Data are presented for five general types of manufactured BMPs: wet vaults, drain inserts, constructed wetlands, media filters, and vortex separators. The figures indicate wide ranges in effluent concentrations, reflecting in part the different products and design criteria within each type. Comparing Figures 5-4 and 5-9 suggests that manufactured products may perform as well as the less effective publicdomain BMPs such as swales and extended detention basins (excluding the additional benefits of infiltration with the latter). Manufactured wetlands may perform as well as the most effective publicdomain BMPs; however, the plot presented in Figure 5-9 for the manufactured wetlands represents only five data points. It should be noted that each type of BMP illustrated in Figure 5-9 contains data from more than one product. Performance of particular products within that grouping may not perform as well as even the least effective publicdomain BMPs. This observation is implied by the greater spread within some boxes in Figure 5-9, for example, manufactured wet vaults and vortex separators.

Product performance within each grouping of manufactured BMPs vary as follows:

- Filters – TSS effluent concentrations range from 2 to 280 mg/L, with a median value of 29 mg/L
- Inserts - TSS effluent concentrations range from 4 to 248 mg/L with a median value of 27 mg/L
- Wetlands – TSS effluent concentrations vary little, and have a median value of 1.2 mg/L
- Vaults – TSS effluent concentrations range from 1 to 467 mg/L, with a median value of 36 mg/L
- Vortex – TSS effluent concentrations range from 13 to 359 mg/L, with a median value of 32 mg/L

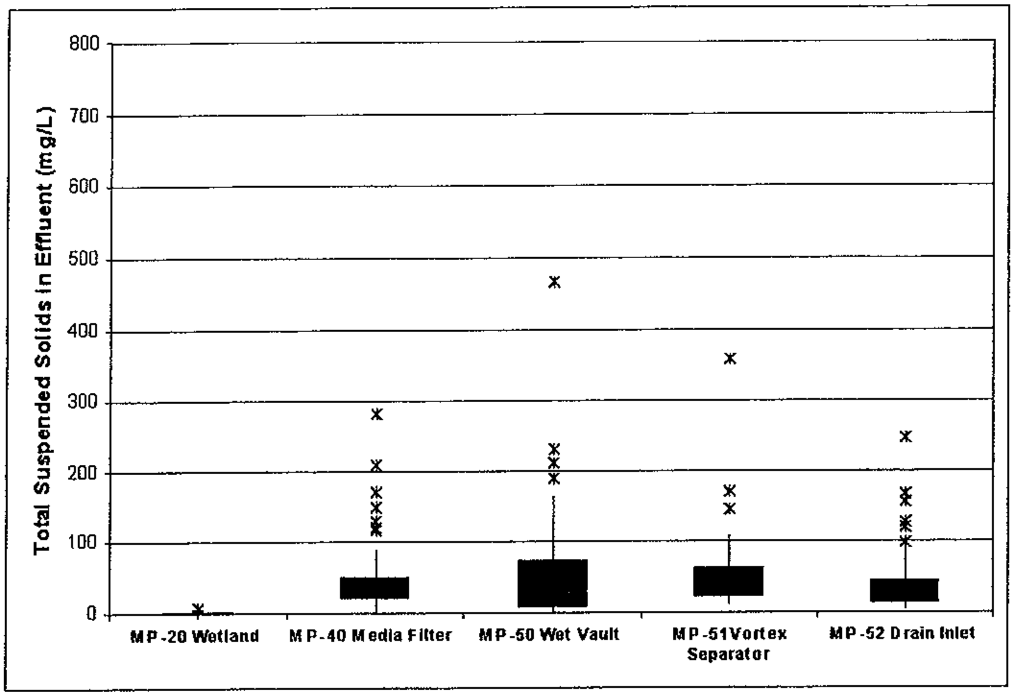


Figure 5-9
Total Suspended Solids in Effluent

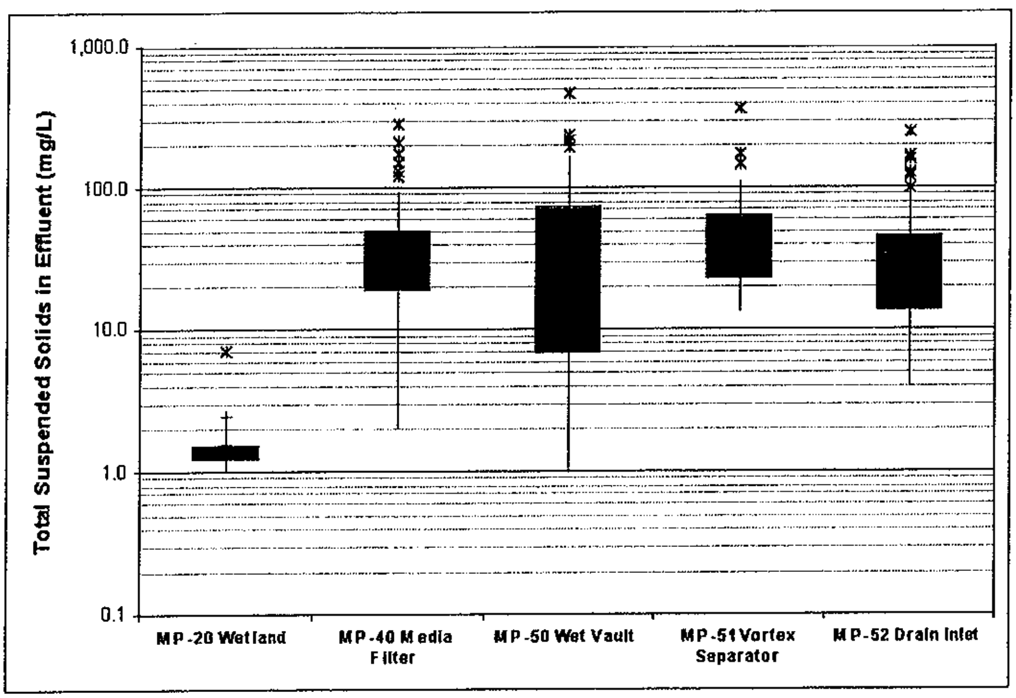


Figure 5-10
Total Suspended Solids in Effluent (log-format)

As noted earlier, performance of particular products in a grouping may be due to different design criteria within the group. For example, wet vault products differ with respect to the volume of the permanent wet pool to the design event volume; filter products differ with respect to the type of media.

5.4.5 Technology Certification

This Handbook does not endorse proprietary products, although many are described. It is left to each community to determine which proprietary products may be used, and under what circumstances. When considering a proprietary product, it is strongly advised that the community consider performance data, but only performance data that have been collected following a widely accepted protocol. Protocols have been developed by the American Society of Civil Engineering (ASCE BMP Data Base Program), and by the U.S.Environmental Protection Agency (Environmental Technology Certification Program). The local jurisdiction should ask the manufacturer of the product to submit a report that describes the product and protocol that was followed to produce the performance data.

It can be expected that subsequent to the publishing of this Handbook, new public-domain technologies will be proposed (or design criteria for existing technologies will be altered) by development engineers. As with proprietary products, it is advised that new public-domain technologies be considered only if performance data are available and have been collected following a widely accepted protocol.

5.5 BMP Design Criteria for Flow and Volume

Many municipal stormwater discharge permits in California contain provisions such as Standard Urban Stormwater Mitigation Plans, Stormwater Quality Urban Impact Mitigation Plans, or Provision C.3 New and Redevelopment Performance Standards, commonly referred to as SUSMPs, SQUIMPs, or C.3 Provisions, respectively. What these and similar provisions have in common is that they require many new development and redevelopment projects to capture and then infiltrate or treat runoff from the project site prior to being discharged to storm drains. These provisions include minimum standards for sizing these treatment control BMPs. Sizing standards are prescribed for both volume-based and flow-based BMPs.

A key point to consider when developing, reviewing, or complying with requirements for the sizing of treatment control BMPs for stormwater quality enhancement is that BMPs are most efficient and economical when they target small, frequent storm events that over time produce more total runoff than the larger, infrequent storms targeted for design of flood control facilities. The reason for this can be seen by examination of Figure 5-11 and Figure 5-12.

Figure 5-11 shows the distribution of storm events at San Jose, California where most storms produce less than 0.50 in. of total rainfall. Figure 5-12 shows the distribution of rainfall intensities at San Jose, California, where most storms have intensities of less than 0.25 in/hr. The patterns at San Jose, California are typical of other locations throughout the state. Figures 5-11 and 5-12 show that as storm sizes increase, the number of events decrease. Therefore, when BMPs are designed for increasingly larger storms (for example, storms up to 1 in. versus storms of up to 0.5 in.), the BMP size and cost increase dramatically, while the number of additional treated storm events are small. Table 5-2 shows that doubling the design storm depth from 0.50 in. to 1.00 in. only increases the number of events captured by 23%. Similarly, doubling the design rainfall intensity from 0.25 in/hr to 0.50 in/hr only increases the number of events captured by 7%.

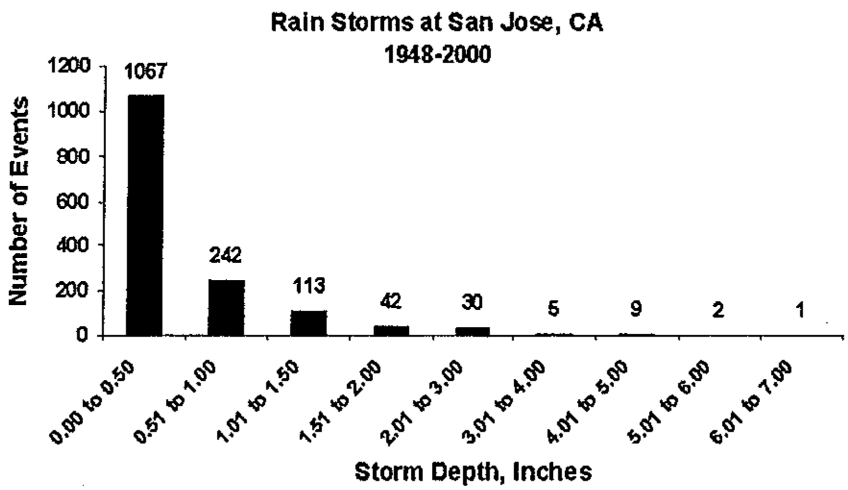


Figure 5-11
Rain Storms at San Jose, CA

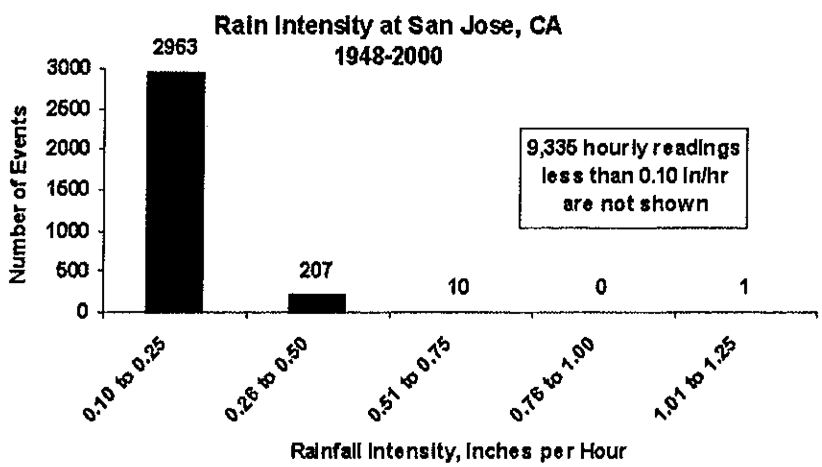


Figure 5-12
Rain Intensity at San Jose, CA

Table 5-2 Incremental Design Criteria VS Storms Treated at San Jose, CA			
Proposed BMP Design Target	**Number of Historical Events in Range**	**Incremental Increase in Design Criteria**	**Incremental Increase in Storms Treated**
Storm Depth 0.00 to 0.50 in.	1,067	+100%	+23%
Storm Depth 0.51 to 1.00 in.	242		
Rainfall Intensity 0.10 to 0.25 in/hr	2,963	+100%	+7%
Rainfall Intensity 0.26 to 0.50 in/hr	207		

Due to economies of scale, doubling the capture and treatment requirements for a BMP are not likely to double the cost of many BMPs, but the incremental cost per event will increase, making increases beyond a certain point generally unattractive. Typically, design criteria for water quality control BMPs are set to coincide with the "knee of the curve," that is, the point of inflection where the magnitude of the event increases more rapidly than number of events captured. Figure 5-13 shows that the "knee of the curve" or point of diminishing returns for San Jose, California is in the range of 0.75 to 1.00 in. of rainfall. In other words, targeting design storms larger than this will produce gains at considerable incremental cost. Similar curves can be developed for rainfall intensity and runoff volume.

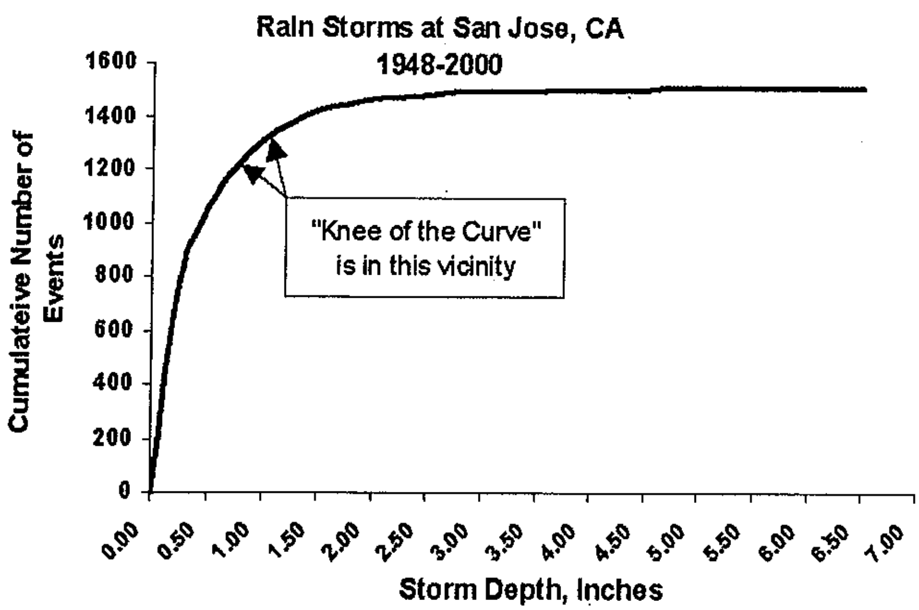


Figure 5-13
Rain Storms at San Jose, CA

It is important to note that arbitrarily targeting large, infrequent storm events can actually reduce the pollutant removal capabilities of some BMPs. This occurs when outlet structures, detention times, and drain down times are designed to accommodate unusually large volumes and high flows. When BMPs are over-designed, the more frequent, small storms that produce the most annual runoff pass quickly through the over-sized BMPs and therefore receive inadequate treatment. For example, a detention basin might normally be designed to capture 0.5 in. of runoff and to release that runoff over 48 hrs, providing a high level of sediment removal. If the basin were to be oversized to capture 1.0 in. of runoff and to release that runoff over 48 hrs, a more common 0.5 inch runoff event entering basin would drain in approximately 24 hrs, meaning the smaller, more frequent storm that is responsible for more total runoff would receive less treatment than if the basin were designed for the smaller event. Therefore, efficient and economical BMP sizing criteria are usually based on design criteria that correspond to the "knee of the curve" or point of diminishing returns.

5.5.1 Volume-Based BMP Design

Volume-based BMP design standards apply to BMPs whose primary mode of pollutant removal depends on the volumetric capacity of the BMP. Examples of BMPs in this category include detention basins, retention basins, and infiltration. Typically, a volume-based BMP design criteria calls for the capture and infiltration or treatment of a certain percentage of the runoff from the project site, usually in the range of the 75th to 85th percentile average annual runoff volume. The 75th to 85th percentile capture range corresponds to the "knee of the curve" for many sites in California for sites whose composite runoff coefficient is in the 0.50 to 0.95 range.

The following are examples of volume-based BMP design standards from current municipal stormwater permits. The permits require that volume-based BMPs be designed to capture and then to infiltrate or treat stormwater runoff equal to one of the following:

- Eighty (80) percent of the volume of annual runoff, determined in accordance with the methodology set forth in Appendix D of the California Storm Water Best Management Practices Handbook (Stormwater Quality Task Force, 1993), using local rainfall data.

- The maximized stormwater quality capture volume for the area, based on historical rainfall records, determined using the formula and volume capture coefficients set forth in Urban Runoff Quality Management (WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87, (1998), pages 175-178).

The reader is referred to the municipal stormwater program manager for the jurisdiction processing the new development or redevelopment project application to determine the specific requirements applicable to a proposed project.

California Stormwater BMP Handbook Approach

The volume-based BMP sizing methodology included in the first edition of the *California Storm Water Best Management Practice Handbook* (Stormwater Quality Task Force, 1993) has been included in this second edition of the handbook and is the method recommended for use.

The California Stormwater BMP Handbook approach is based on results of a continuous simulation model, the STORM model, developed by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers (COE-HEC, 1977). The Storage, Treatment, Overflow, Runoff Model (STORM) was applied to long-term hourly rainfall data at numerous sites throughout California, with sites selected throughout the state representing a wide range of municipal stormwater permit areas, climatic areas, geography, and topography. STORM translates rainfall into runoff, then routes the runoff through detention storage. The volume-based BMP sizing curves resulting from the STORM model provide a range of options for choosing a BMP sizing curve appropriate to sites in most areas of the state. The volume-based BMP sizing curves are included in Appendix D. Key model assumptions are also documented in Appendix D.

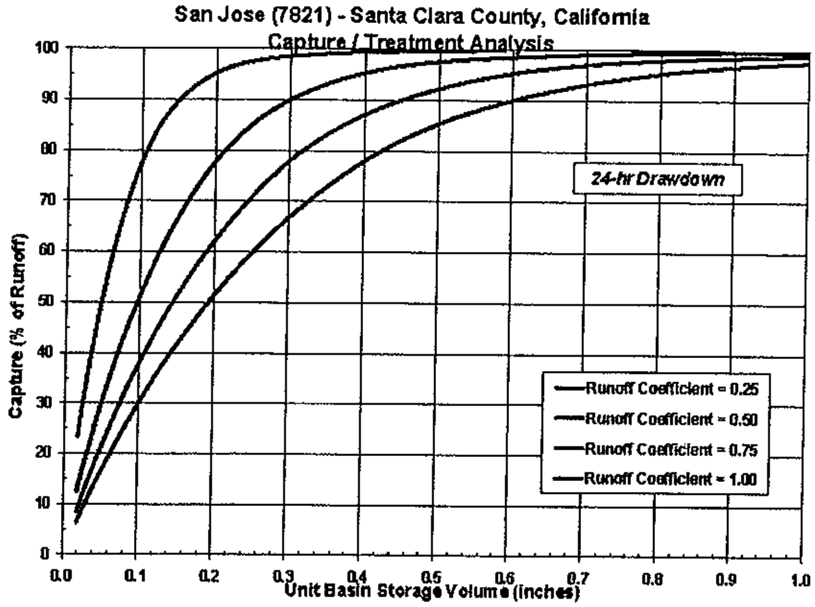


Figure 5-14
Capture/Treatment Analysis at San Jose, CA

The California Stormwater BMP Handbook approach is simple to apply, and relies largely on commonly available information about a project. The following steps describe the use of the BMP sizing curves contained in Appendix D.

1. Identify the "BMP Drainage Area" that drains to the proposed BMP. This includes all areas that will contribute runoff to the proposed BMP, including pervious areas, impervious areas, and off-site areas, whether or not they are directly or indirectly connected to the BMP.

2. Calculate the composite runoff coefficient "C" for the area identified in Step 1.

3. Select a capture curve representative of the site and the desired drain down time using Appendix D. Curves are presented for 24-hour and 48-hour draw down times. The 48-hour curve should be used in most areas of California. Use of the 24-hour curve should be limited

to drainage areas with coarse soils that readily settle and to watersheds where warming may be detrimental to downstream fisheries. Draw down times in excess of 48 hours should be used with caution, as vector breeding can be a problem after water has stood in excess of 72 hours.

4. Determine the applicable requirement for capture of runoff (Capture, % of Runoff).

5. Enter the capture curve selected in Step 3 on the vertical axis at the "Capture, % Runoff" value identified in Step 4. Move horizontally to the right across capture curve until the curve corresponding to the drainage area's composite runoff coefficient "C" determined in Step 2 is intercepted. Interpolation between curves may be necessary. Move vertically down from this point until the horizontal axis is intercepted. Read the "Unit Basin Storage Volume" along the horizontal axis. If a local requirement for capture of runoff is not specified, enter the vertical axis at the "knee of the curve" for the curve representing composite runoff coefficient "C." The "knee of the curve" is typically in the range of 75 to 85% capture.

6. Calculate the required capture volume of the BMP by multiplying the "BMP Drainage Area" from Step 1 by the "Unit Basin Storage Volume" from Step 5 to give the BMP volume. Due to the mixed units that result (e.g., ac-in., ac-ft) it is recommended that the resulting volume be converted to cubic feet for use during design.

Urban Runoff Quality Management Approach

The volume-based BMP sizing methodology described in *Urban Runoff Quality Management* (WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87, (1998), pages 175-178) has been included in this edition of the handbook as an alternative to the California Stormwater BMP Handbook approach described above. The Urban Runoff Quality Management Approach is suitable for planning level estimates of the size of volume-based BMPs (WEF/ASCE, 1998, page 175).

The Urban Runoff Quality Management approach is similar to the California Stormwater BMP Handbook approach in that it is based on the translation of rainfall to runoff. The Urban Runoff Quality Management approach is based on two regression equations. The first regression equation relates rainfall to runoff. The rainfall to runoff regression equation was developed using 2 years of data from more than 60 urban watersheds nationwide. The second regression equation relates mean annual runoff-producing rainfall depths to the "Maximized Water Quality Capture Volume" which corresponds to the "knee of the cumulative probability curve". This second regression was based on analysis of long-term rainfall data from seven rain gages representing climatic zones across the country. The Maximized Water Quality Capture Volume corresponds to approximately the 85th percentile runoff event, and ranges from 82 to 88%.

The two regression equations that form the Urban Runoff Quality Management approach are as follows:

$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

$$P_o = (a \bullet C) \bullet P_6$$

Where

C = runoff coefficient

i = watershed imperviousness ratio which is equal to the percent total imperviousness divided by 100

P_o = Maximized Detention Volume, in watershed inches

a = regression constant, a=1.582 and a=1.963 for 24 and 48 hour draw down, respectively

P_6 = mean annual runoff-producing rainfall depths, in watershed inches, Table #-1. See Appendix D.

The Urban Runoff Quality Management Approach is simple to apply. The following steps describe the use of the approach.

1. Identify the "BMP Drainage Area" that drains to the proposed BMP. This includes all areas that will contribute runoff to the proposed BMP, including pervious areas, impervious areas, and off-site areas, whether or not they are directly or indirectly connected to the BMP.
2. Calculate the "Watershed Imperviousness Ratio" (i), which is equal to the percent of total impervious area in the "BMP Drainage Area" divided by 100.
3. Calculate the "Runoff Coefficient" (C) using the following equation:

   $$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

4. Determine the "Mean Annual Runoff" (P6) for the "BMP Drainage Area" using Table #-1 in Appendix D.
5. Determine the "Regression Constant" (a) for the desired BMP drain down time. Use a=1.582 for 24 hrs and a=1.963 for 48 hr draw down.
6. Calculate the "Maximized Detention Volume" (Po) using the following equation:

   $$P_o = (a \bullet C) \bullet P_6$$

7. Calculate the required capture volume of the BMP by multiplying the "BMP Drainage Area" from Step 1 by the "Maximized Detention Volume" from Step 6 to give the BMP volume. Due to the mixed units that result (e.g., ac-in., ac-ft) it is recommended that the resulting volume be converted to ft^3 for use during design.

5.5.2 Flow-Based BMP Design

Flow-based BMP design standards apply to BMPs whose primary mode of pollutant removal depends on the rate of flow of runoff through the BMP. Examples of BMPs in this category include swales, sand filters, screening devices, and many proprietary products. Typically, a flow-based BMP design criteria calls for the capture and infiltration or treatment of the flow runoff produced by rain events of a specified magnitude.

The following are examples of flow-based BMP design standards from current municipal stormwater permits. The permits require that flow-based BMPs be designed to capture and then to infiltrate or treat stormwater runoff equal to one of the following:

- 10% of the 50-yr peak flow rate (Factored Flood Flow Approach)
- The flow of runoff produced by a rain event equal to at least two times the 85th percentile hourly rainfall intensity for the applicable area, based on historical records of hourly rainfall depths (California Stormwater BMP Handbook Approach)
- The flow of runoff resulting from a rain event equal to at least 0.2 in/hr intensity (Uniform Intensity Approach)

The reader is referred to the municipal stormwater program manager for the jurisdiction processing the new development or redevelopment project application to determine the specific requirements applicable to a proposed project.

The three typical requirements shown above all have in common a rainfall intensity element. That is, each criteria is based treating a flow of runoff produced by a rain event of specified rainfall intensity.

In the first example, the Factored Flood Flow Approach, the design rainfall intensity is a function of the location and time of concentration of the area discharging to the BMP. The intensity in this case is determined using Intensity-Duration-Frequency curves published by the flood control agency with jurisdiction over the project or available from climatic data centers. This approach is simple to apply when the 50-yr peak flow has already been determined for either drainage system design or flood control calculations.

In the second example, the California Stormwater BMP Handbook Approach (so called because it is recommended in this handbook), the rainfall intensity is a function of the location of the area discharging to the BMP. The intensity in this case can be determined using the rain intensity cumulative frequency curves developed for this Handbook based on analysis of long-term hourly rainfall data at numerous sites throughout California, with sites selected throughout the state representing a wide range of municipal stormwater permit areas, climatic areas, geography, and topography. These rain intensity cumulative frequency curves are included in Appendix D. This approach is recommended as it reflects local conditions throughout the state. The flow-based design criteria in some municipal permits require design based on two times the 85^{th} percentile hourly rainfall intensity. The factor of two included in these permits appears to be provided as a factor of safety: therefore, caution should be exercised when applying additional factors of safety during the design process so that over design can be avoided.

In the third example, the Uniform Intensity Approach, the rainfall intensity is specified directly, and is not a function of the location or time of concentration of the area draining to the BMP. This approach is very simple to apply, but it is not reflective of local conditions.

The three example flow-based BMP design criteria are easy to apply and can be used in conjunction with the Rational Formula, a simplified, easy to apply formula that predicts flow rates based on rainfall intensity and drainage area characteristics. The Rational Formula is as follows:

$$Q = CiA$$

where

Q = flow in ft^3/s

i = rain intensity in in/hr

A = drainage area in acres

C = runoff coefficient

The Rational Formula is widely used for hydrologic calculations, but it does have a number of limitations. For stormwater BMP design, a key limitation is the ability of the Rational Formula to predict runoff from undeveloped areas where runoff coefficients are highly variable with storm intensity and antecedent moisture conditions. This limitation is accentuated when predicting runoff from frequent, small storms used in stormwater quality BMP design because many of the runoff coefficients in common use were developed for predicting runoff for drainage design where larger, infrequent storms are of interest. Table 5-3 provides some general guidelines on use of the Rational Equation.

Table 5-3 Use of Rational Formula for Stormwater BMP Design

	Composite Runoff Coefficient, "C"			
BMP Drainage Area (Acres)	0.00 to 0.25	0.26 to 0.50	0.51 to 0.75	0.76 to 1.00
0 to 25	Caution	Yes	Yes	Yes
26 to 50	High Caution	Caution	Yes	Yes
51 to 75	Not Recommended	High Caution	Caution	Yes
76 to 100	Not Recommended	High Caution	Caution	Yes

In summary, the Rational Formula, when used with commonly tabulated runoff coefficients in undeveloped drainage areas, will likely result in predictions higher than will be experienced under actual field conditions. However, given the simplicity of the equation, its use remains practical and is often the standard method specified by local agencies. In general, use of alternative formulas for predicting BMP design flows based on the intensity criteria above is acceptable if the formula is approved by the local flood control agency or jurisdiction where the project is being developed.

The following steps describe the approach for application of the flow-based BMP design criteria:

1. Identify the "BMP Drainage Area" that drains to the proposed BMP. This includes all areas that will contribute runoff to the proposed BMP, including pervious areas, impervious areas, and off-site areas, whether or not they are directly or indirectly connected to the BMP.

2. Determine rainfall intensity criteria to apply and the corresponding design rainfall intensity.

   a. *Factored Flood Flow Approach*: Determine the time of concentration for "BMP Drainage Area" using procedures approved by the local flood control agency or using standard hydrology methods. Identify an Intensity-Duration-Frequency Curve representative of the drainage area (usually available from the local flood control agency or climatic data center). Enter the Intensity-Duration-Frequency Curve with the time of concentration and read the rainfall intensity corresponding to the 50-yr return period rainfall event. This intensity is the "Design Rainfall Intensity."

   b. *California Stormwater BMP Handbook Approach*: Select a rain intensity cumulative frequency curve representative of the "BMP Drainage Area." See Appendix D. Read the rainfall intensity corresponding to the cumulative probability specified in the criteria, usually 85%. Multiply the intensity by the safety factor specified in the criteria, usually 2, to get the "Design Rainfall Intensity."

   c. *Uniform Intensity Approach*: The "Design Rainfall Intensity" is the intensity specified in the criteria, usually 0.2 in/hr.

3. Calculate the composite runoff coefficient" "C" for the "BMP Drainage Area" identified in Step 1.

4. Apply the Rational Formula to calculate the "BMP Design Flow"

   a. *Factored Flood Flow Approach*: Using the "BMP Drainage Area" from Step 1, the "Design Rainfall Intensity" from Step 2a, and "C" from Step 3, apply the Rational Formula and multiply the result by 0.1. The result is the "BMP Design Flow."

   b. *California Stormwater BMP Handbook Approach*: Using the "BMP Drainage Area" from Step 1, the "Design Rainfall Intensity" from Step 2b, and "C" from Step 3, apply the Rational Formula. The result is the "BMP Design Flow."

   c. *Uniform Intensity Approach*: Using the "BMP Drainage Area" from Step 1, the "Design Rainfall Intensity" from Step 2c, and "C" from Step 3, apply the Rational Formula. The result is the "BMP Design Flow."

5.5.3 Combined Volume-Based and Flow-Based BMP Design

Volume-based BMPs and flow-based BMPs do not necessarily treat precisely the same stormwater runoff. For example, an on-line volume-based BMP such as a detention basin will treat the design runoff volume and is essentially unaffected by runoff entering the basin at an extremely high rate, say from a very short, but intense storm that produces the design volume of runoff. However, a flow-based BMP might be overwhelmed by the same short, but intense storm if the storm intensity results in runoff rates that exceed the flow-based BMP design flow rate. By contrast, a flow-based BMP such as a swale will treat the design flow rate of runoff and is essentially unaffected by the duration of the design flow, say from a long, low intensity storm. However, a volume-based detention basin subjected to this same rainfall and runoff event will begin to provide less treatment or will go into bypass or overflow mode after the design runoff volume is delivered.

Therefore, there may be some situations where designers need to consider both volume-based and flow-based BMP design criteria. An example of where both types of criteria might apply is an off-line detention basin. For an off-line detention basin, the capacity of the diversion structure could be designed to comply with the flow-based BMP design criteria while the detention basin itself could be designed to comply with the volume-based criteria.

When both volume-based and flow based criteria apply, the designer should determine which of the criteria apply to each element of the BMP system, and then size the elements accordingly.

5.6 Other BMP Selection Factors

Other factors that influence the selection of BMPs include cost, vector control issues, and endangered species issues. Each of these is discussed briefly below.

5.6.1 Costs

The relative costs for implementing various public domain and manufactured BMPs based on flow and volume parameters are shown in Tables 5-4 and 5-5 below:

Table 5-4 Economic Comparison Matrix - Flow

BMP	Cost/cfs
Strip	$$
Swale	$$
Wet Vault	Not available
Media Filter	$$$$
Vortex	Not available
Drain Insert	Not available

Table 5-5 Economic Comparison Matrix - Volume

BMP	Cost/acre-ft
Austin Sand Filter Basin	$$$$
Delaware Lineal Sand Filter	$$$$
Extended Detention Basin (EDB)	$$
Multi Chamber Treatment Train (MCTT)	$$$$
Wet Basin	$$$$
Manufactured Wetland	Not available
Infiltration Basin	$
Wet Pond and Constructed Wetland	$$$$

5.6.2 Vector Breeding Considerations

The potential of a BMP to create vector breeding habitat and/or harborage should be considered when selecting BMPs. Mosquito and other vector production is a nuisance and public health threat. Mosquitoes can breed in standing water almost immediately following a BMP installation and may persist at unnaturally high levels and for longer seasonal periods in created habitats. BMP siting, design, construction, and maintenance must be considered in order to select a BMP that is least conducive to providing habitat for vectors. Tips for minimizing vector-breeding problems in the design and maintenance of BMPs are presented in the BMP fact sheets. Certain BMPs, including ponds and wetlands and those designed with permanent water sumps, vaults, and/or catch basins (including below ground installations), may require routine inspections and treatments by local mosquito and vector control agencies to suppress vector production.

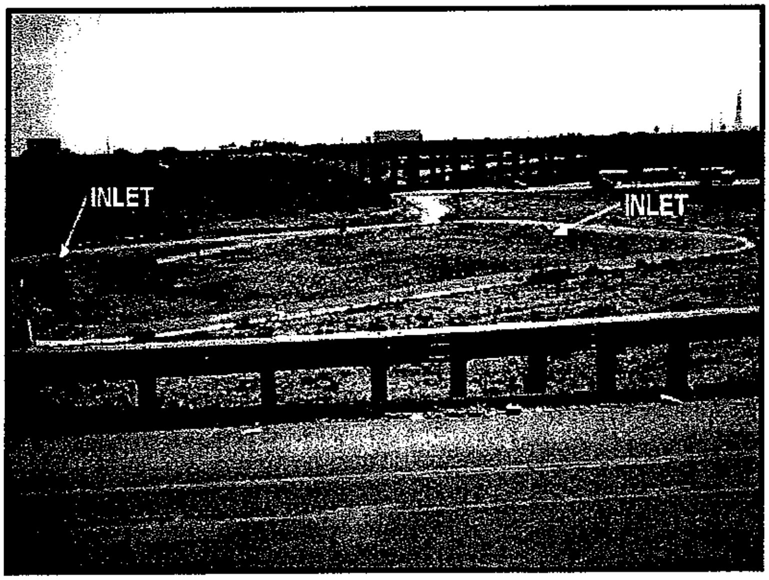
5.6.3 Threatened and Endangered Species Considerations

The presence or potential presence of threatened and endangered species should also be considered when selecting BMPs. Although preservation of threatened endangered species is crucial, treatment BMPs are not intended to supplement or replace species habitat except under special circumstances. The presence of threatened or endangered species can hinder timely and routine maintenance, which in turn can result in reduced BMP performance and an increase in vector production. In extreme cases, jurisdictional rights to the treatment BMP and surrounding land may be lost if threatened or endangered species utilize or become established in the BMP.

When considering BMPs where there is a presence or potential presence of threatened or endangered species, early coordination with the California Department of Fish and Game and the U.S. Fish and Wildlife service is essential. During this coordination, the purpose and the long-term operation and maintenance requirements of the BMPs need to be clearly established through written agreements or memorandums of understanding. Absent firm agreements or understandings, proceeding with BMPs under these circumstances is not recommended.

5.7 BMP Fact Sheets

BMP fact sheets for public domain and manufactured BMPs follow. The BMP fact sheets are individually page numbered and are suitable for photocopying and inclusion in stormwater quality management plans. Fresh copies of the fact sheets can be individually downloaded from the Caltrans Stormwater BMP Handbook website at www.cabmphandbooks.com.



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.

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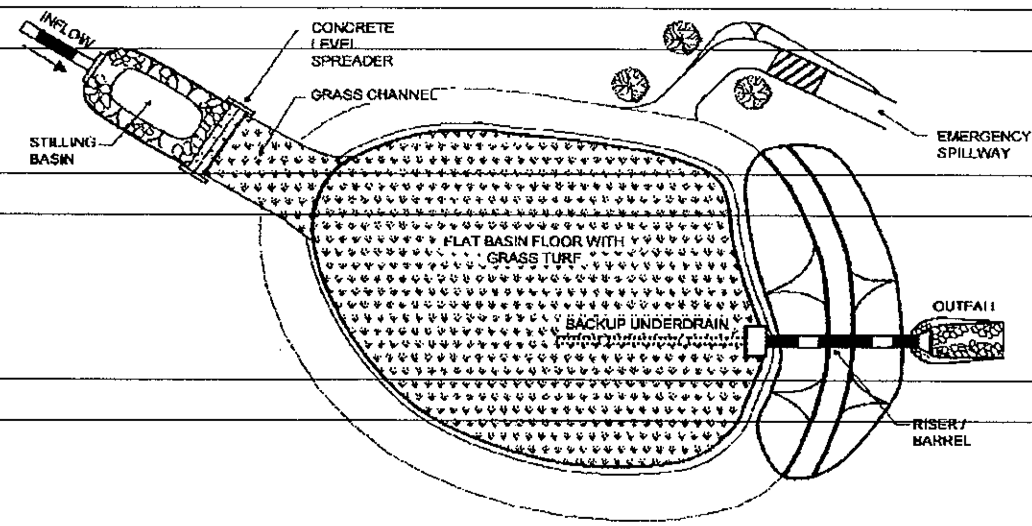
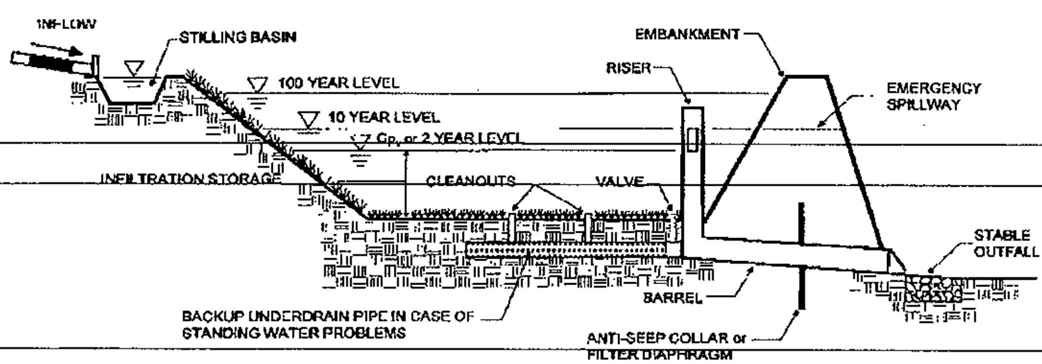


PLAN VIEW



PROFILE

Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated 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, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

Targeted Constituents

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

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

CASQA
California Stormwater Quality Association

- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.
- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data

Study	TSS	TP	TN	NO_3	Metals	Bacteria	Type
	Removal Efficiencies (% Removal)						
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large 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.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. 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.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per ft^2, which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd³	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd²	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f]	Yd²	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]	Yd²	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	--	--	--	--	--	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	--	--	--	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right)$ x swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC, 1991)

Component	Unit Cost	Swale Size (Depth and Top Width)		Comment
		1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	
Lawn Mowing	$0.85 / 1,000 ft^2/ mowing	$0.14 / linear foot	$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	$9.00 / 1,000 ft^2/ year	$0.18 / linear foot	$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	$0.10 / linear foot / year	$0.10 / linear foot	$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	$0.30 / yd^2	$0.01 / linear foot	$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	$0.15 / linear foot / year, plus $25 / inspection	$0.15 / linear foot	$0.15 / linear foot	Inspect four times per year
Total	--	**$0.58 / linear foot**	**$ 0.75 / linear foot**	–

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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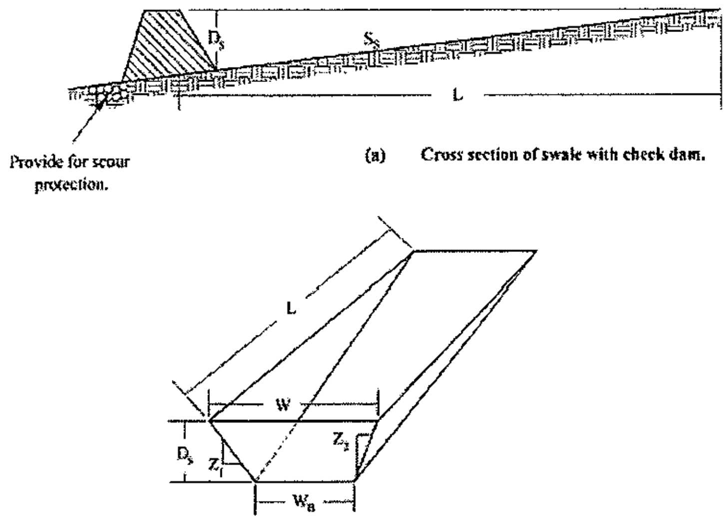

(a) Cross section of swale with check dam.

(b) Dimensional view of swale impoundment area.

Notation:

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

Description

Vortex separators: (alternatively, swirl concentrators) are gravity separators, and in principle are essentially wet vaults. The difference from wet vaults, however, is that the vortex separator is round, rather than rectangular, and the water moves in a centrifugal fashion before exiting. By having the water move in a circular fashion, rather than a straight line as is the case with a standard wet vault, it is possible to obtain significant removal of suspended sediments and attached pollutants with less space. Vortex separators were originally developed for combined sewer overflows (CSOs), where it is used primarily to remove coarse inorganic solids. Vortex separation has been adapted to stormwater treatment by several manufacturers.

California Experience

There are currently about 100 installations in California.

Advantages

- May provide the desired performance in less space and therefore less cost.
- May be more cost-effective pre-treatment devices than traditional wet or dry basins.
- Mosquito control may be less of an issue than with traditional wet basins.

Limitations

- As some of the systems have standing water that remains between storms, there is concern about mosquito breeding.
- It is likely that vortex separators are not as effective as wet vaults at removing fine sediments, on the order 50 to 100 microns in diameter and less.
- The area served is limited by the capacity of the largest models.
- As the products come in standard sizes, the facilities will be oversized in many cases relative to the design treatment storm, increasing the cost.
- The non-steady flows of stormwater decreases the efficiency of vortex separators from what may be estimated or determined from testing under constant flow.
- Do not remove dissolved pollutants.
- A loss of dissolved pollutants may occur as accumulated organic

Design Considerations

- Service Area
- Settling Velocity
- Appropriate Sizing
- Inlet Pipe Diameter

Targeted Constituents

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

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

CASQA California Stormwater Quality Association

matter (e.g., leaves) decomposes in the units.

Design and Sizing Guidelines

The stormwater enters, typically below the effluent line, tangentially into the basin, thereby imparting a circular motion in the system. Due to centrifugal forces created by the circular motion, the suspended particles move to the center of the device where they settle to the bottom. There are two general types of vortex separation: free vortex and dampened (or impeded) vortex. Free vortex separation becomes dampened vortex separation by the placement of radial baffles on the weir-plate that impede the free vortex-flow pattern

It has been stated with respect to CSOs that the practical lower limit of vortex separation is a particle with a settling velocity of 12 to 16.5 feet per hour (0.10 to 0.14 cm/s). As such, the focus for vortex separation in CSOs has been with settleable solids generally 200 microns and larger, given the presence of the lighter organic solids. For inorganic sediment, the above settling velocity range represents a particle diameter of 50 to 100 microns. Head loss is a function of the size of the target particle. At 200 microns it is normally minor but increases significantly if the goal is to remove smaller particles.

The commercial separators applied to stormwater treatment vary considerably with respect to geometry, and the inclusion of radial baffles and internal circular chambers. At one extreme is the inclusion of a chamber within the round concentrator. Water flows initially around the perimeter between the inner and outer chambers, and then into the inner chamber, giving rise to a sudden change in velocity that purportedly enhances removal efficiency. The opposite extreme is to introduce the water tangentially into a round manhole with no internal parts of any kind except for an outlet hood. Whether the inclusion of chambers and baffles gives better performance is unknown. Some contend that free vortex, also identified as swirl concentration, creates less turbulence thereby increasing removal efficiency. One product is unique in that it includes a static separator screen.

- Sized is based on the peak flow of the design treatment event as specified by local government.
- If an in-line facility, the design peak flow is four times the peak of the design treatment event.
- If an off-line facility, the design peak flow is equal to the peak of the design treatment event.
- Headloss differs with the product and the model but is generally on the order of one foot or less in most cases.

Construction/Inspection Considerations

No special considerations.

Performance

Manufacturer's differ with respect to performance claims, but a general statement is that the manufacturer's design and rated capacity (cfs) for each model is based on and believed to achieve an aggregate reduction of 90% of all particles with a specific gravity of 2.65 (glacial sand) down to 150 microns, and to capture the floatables, and oil and grease. Laboratory tests of two products support this claim. The stated performance expectation therefore implies that a lesser removal efficiency is obtained with particles less than 150 microns, and the lighter, organic settleables. Laboratory tests of one of the products found about 60% removal of 50 micron sand at the expected average operating flow rate

Experience with the use of vortex separators for treating combined sewer overflows (CSOs), the original application of this technology, suggests that the lower practical limit for particle removal are particles with a settling velocity of 12 feet per hour (Sullivan, 1982), which represents a particle diameter of 100 to 200 microns, depending on the specific gravity of the particle. The CSO experience therefore seems consistent with the limited experience with treating stormwater, summarized above

Traditional treatment technologies such as wet ponds and extended detention basins are generally believed to be more effective at removing very small particles, down to the range of 10 to 20 microns. Hence, it is intuitively expected that vortex separators do not perform as well as the traditional wet and dry basins, and filters. Whether this matters depends on the particle size distribution of the sediments in stormwater. If the distribution leans towards small material, there should be a marked difference between vortex separators and, say, traditional wet vaults. There are little data to support this conjecture

In comparison to other treatment technologies, such as wet ponds and grass swales, there are few studies of vortex separators. Only two of manufactured products currently available have been field tested. Two field studies have been conducted. Both achieved in excess of 80% removal of TSS. However, the test was conducted in the Northeast (New York state and Maine) where it is possible the stormwater contained significant quantities of deicing sand. Consequently, the influent TSS concentrations and particle size are both likely considerably higher than is found in California stormwater. These data suggest that if the stormwater particles are for the most part fine (i.e., less than 50 microns), vortex separators will not be as efficient as traditional treatment BMPs such as wet ponds and swales, if the latter are sized according to the recommendations of this handbook.

There are no equations that provide a straightforward determination of efficiency as a function of unit configuration and size. Design specifications of commercial separators are derived from empirical equations that are unique and proprietary to each manufacturer. However, some general relationships between performance and the geometry of a separator have been developed. CSO studies have found that the primary determinants of performance of vortex separators are the diameters of the inlet pipe and chamber with all other geometry proportional to these two.

Sullivan et al. (1982) found that performance is related to the ratios of chamber to inlet diameters, D_2/D_1, and height between the inlet and outlet and the inlet diameter, H_1/D_1, shown in Figure 3. The relationships are: as D_2/D_1 approaches one, the efficiency decreases; and, as the H_1/D_1 ratio decreases, the efficiency decreases. These relationships may allow qualitative comparisons of the alternative designs of manufacturers. Engineers who wish to apply these concepts should review relevant publications presented in the References.

Siting Criteria

There are no particularly unique siting criteria. The size of the drainage area that can be served by vortex separators is directly related to the capacities of the largest models.

Additional Design Guidelines

Vortex separators have two capacities if positioned as in-line facilities, a treatment capacity and a hydraulic capacity. Failure to recognize the difference between the two may lead to significant under sizing; i.e., too small a model is selected. This observation is relevant to three of the five products. These three technologies all are designed to experience a unit flow rate of about 24 gallons/square foot of separator footprint at the peak of the design treatment event. This is the horizontal area of the separator zone within the container, not the total footprint of the unit. At this unit flow rate, laboratory tests by these manufacturers have established that the performance will meet the general claims previously described. However, the units are sized to handle 100 gallons/square foot at the peak of the hydraulic event. Hence, in selecting a particular model the design engineer must be certain to match the peak flow of the design event to the stated treatment capacity, not the hydraulic capacity. The former is one-fourth the latter. If the unit is positioned as an off-line facility, the model selected is based on the capacity equal to the peak of the design treatment event.

Maintenance

Maintenance consists of the removal of accumulated material with an eductor truck. It may be necessary to remove and dispose the floatables separately due to the presence of petroleum product.

Maintenance Requirements

Remove all accumulated sediment, and litter and other floatables, annually, unless experience indicates the need for more or less frequent maintenance.

Cost

Manufacturers provide costs for the units including delivery. Installation costs are generally on the order of 50 to 100 % of the manufacturer's cost. For most sites the units are cleaned annually.

Cost Considerations

The different geometry of the several manufactured separators suggests that when comparing the costs of these systems to each other, that local conditions (e.g., groundwater levels) may affect the relative cost-effectiveness.

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Attachment H

Educational Material

STORMWATER Pollution Prevention

LANDSCAPE MAINTENANCE

San Bernardino County Stormwater Program

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San Bernardino County Stormwater Program
825 East Third Street · Room 127
San Bernardino, CA 94215-0835

STORMWATER Pollution Prevention

Stormwater Management Practices for Commercial Landscape Maintenance

Yard waste, sediments, and toxic lawn/garden chemicals used in commercial landscape maintenance often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates local waterways, making them unsafe for people and wildlife. Following these best management practices will prevent pollution, comply with regulations and protect public health.

Recycle Yard Waste

Recycle leaves, grass clippings and other yard waste. Do not blow, sweep, rake or hose yard waste into the street. Try grasscycling - the natural recycling of grass by leaving clippings on the lawn when mowing. Grass clippings will quickly decompose, returning valuable nutrients to the soil. Further information can be obtained at www.ciwmb.ca.gov/Organics.

Use Fertilizers, Herbicides and Pesticides Safely

Fertilizers, herbicides and pesticides are often carried into the storm drain system by sprinkler runoff. Use of natural, non-toxic alternatives to the traditional fertilizers, herbicides and pesticides is highly recommended. If you must use chemical fertilizers, herbicides, or pesticides:

- Spot apply pesticides and herbicides, rather than blanketing entire areas.
- Avoid applying near curbs and driveways, and never apply before a rain.
- Apply fertilizers as needed, when plants can best use it, and when the potential for it being carried away by runoff is low.

Recycle Hazardous Waste

Pesticides, fertilizers, herbicides and motor oil contaminate landfills and should be disposed of through a Hazardous Waste Facility, which accepts these types of materials. For information on proper disposal call, (909) 386-8401.

Use Water Wisely

Conserve water and prevent runoff by controlling the amount of water and direction of sprinklers. Sprinklers should be on long enough to allow water to soak into the ground but not so long as to cause runoff. Periodically inspect, fix leaks and realign sprinkler heads. Plant native vegetation to reduce the need of water, fertilizers, herbicides, and pesticides.

Prevent Erosion

Erosion washes sediments, debris and toxic runoff into the storm drain system, polluting waterways.

- Prevent erosion and sediment runoff by using ground cover, berms and vegetation down-slope to capture runoff.
- Avoid excavation or grading during wet weather.

Store Materials Safely

Keep landscaping materials and debris away from the street, gutter and storm drains. On-site stockpiles of materials must be covered with plastic sheeting to protect from rain, wind and runoff.

To report illegal dumping or for more information on stormwater pollution prevention, call:

1 (800) CLEANUP

or visit our websites:

www.co.san-bernardino.ca.us/flood/npdes

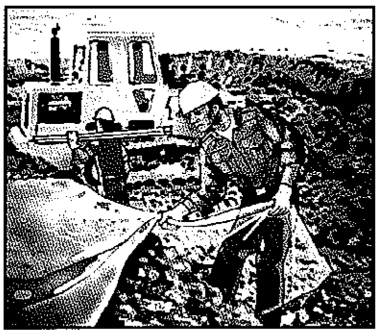
www.1800cleanup.org

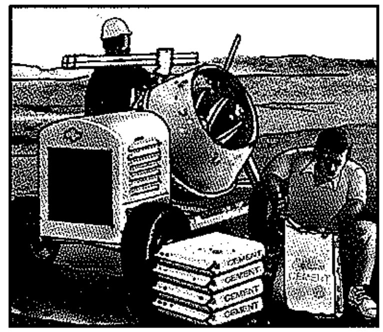
STORMWATER

Pollution Prevention

FRESH CONCRETE & MORTAR APPLICATION

Cement wash, sediment, vehicle fluids, dust and hazardous debris from construction sites often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these best management practices to prevent pollution and protect public health.





Storing Materials

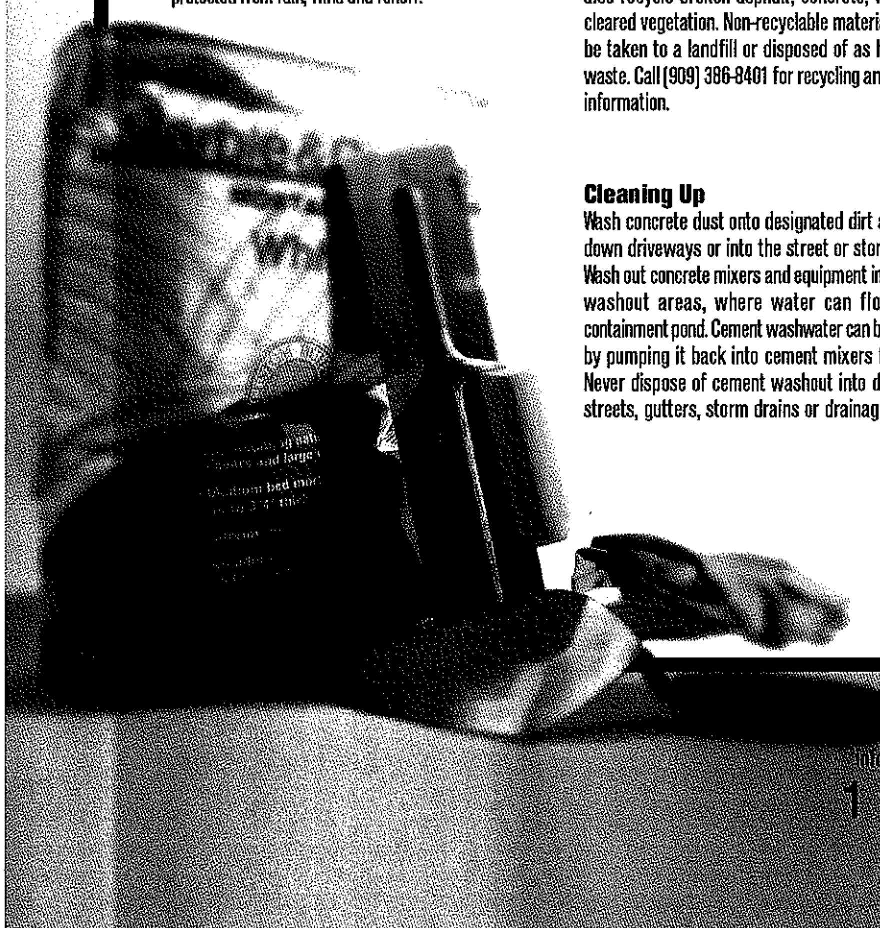
Keep construction materials and debris away from the street, gutter and storm drains. Secure open bags of cement and cover exposed stockpiles of soil, sand or gravel and excavated material with plastic sheeting, protected from rain, wind and runoff.

Ordering Materials & Recycling Waste

Reduce waste by ordering only the amounts of materials needed for the job. Use recycled or recyclable materials whenever possible. When breaking up paving, recycle the pieces at a crushing company. You can also recycle broken asphalt, concrete, wood, and cleared vegetation. Non-recyclable materials should be taken to a landfill or disposed of as hazardous waste. Call (909) 386-8401 for recycling and disposal information.

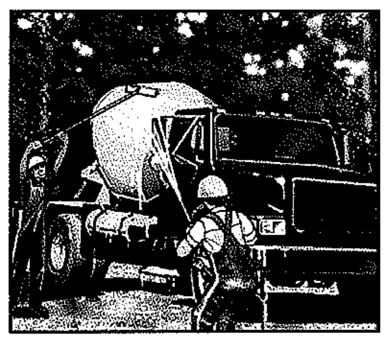
During Construction

Schedule excavation and grading during dry weather. Prevent mortar and cement from entering the street and storm drains by placing erosion controls. Setup small mixers on tarps or drop cloths, for easy cleanup of debris. Never bury waste material. Recycle or dispose of it as hazardous waste.



Cleaning Up

Wash concrete dust onto designated dirt areas, not down driveways or into the street or storm drains. Wash out concrete mixers and equipment in specified washout areas, where water can flow into a containment pond. Cement washwater can be recycled by pumping it back into cement mixers for reuse. Never dispose of cement washout into driveways, streets, gutters, storm drains or drainage ditches.



To report illegal dumping or for more information on stormwater pollution prevention, call:

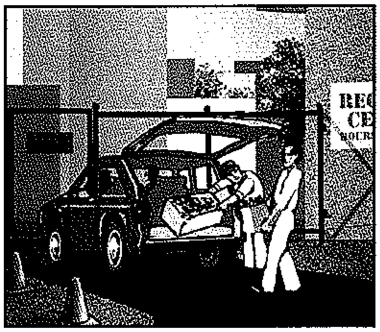
1 (800) CLEANUP

www.1800cleanup.org

STORMWATER Pollution Prevention

HOME & GARDEN

Yard waste and household toxics like paints and pesticides often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these simple tips to prevent pollution and protect your health.



Recycle Household Hazardous Waste

Household products like paint, pesticides, solvents and cleaners are too dangerous to dump and too toxic to trash. Take them to be recycled at a convenient household hazardous waste collection facility. Call (800) CLEANUP for the facility in your area.

Disposing of Yard Waste

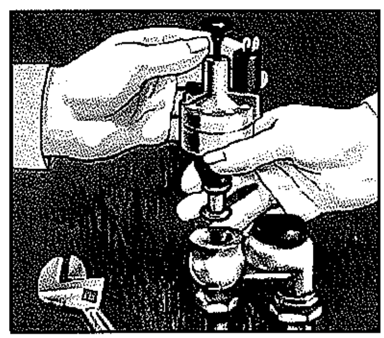
Recycle leaves, grass clippings and other yard waste, instead of blowing, sweeping or hosing into the street. Try grasscycling, leaving grass clippings on your lawn instead of using a grass catcher. The clippings act as a natural fertilizer, and because grass is mostly water, it also irrigates your lawn, conserving water.

Use Fertilizers & Pesticides Safely

Fertilizers and pesticides are often carried into the storm drain system by sprinkler runoff. Try using organic or non-toxic alternatives. If you use chemical fertilizers or pesticides, avoid applying near curbs and driveways and never apply before a rain.

Planting in the Yard

Produce less yard waste and save water by planting low maintenance, drought-tolerant trees and shrubs. Using drip irrigation, soaker hoses or micro-spray systems for flower beds and vegetation can also help reduce your water bill and prevent runoff.



Use Water Wisely

Cut your water costs and prevent runoff by controlling the amount of water and direction of sprinklers. The average lawn needs about an inch of water a week, including rainfall, or 10 to 20 minutes of watering. A half-inch per week is enough for fall and spring. Sprinklers should be on long enough to allow water to soak into the ground but not so long as to cause runoff.

To report illegal dumping or for more information on stormwater pollution prevention, call:

1 (800) CLEANUP

www.1800cleanup.org

English side

Spanish side

Item: Fertilizer tip card **Actual size:** 4.125" x 5.5" **Advertiser:** San Bernardino County Storm Water Program
Agency: Industrial Strength Advertising **Date:** 9/10/03

Paint Tips to Prevent Pollution

Washing a paint brush or dumping rinse water in the gutter allows toxic chemicals to flow into the San Bernardino County storm drain system, and they do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these simple tips to prevent pollution and protect your health:

- Use water-based paints whenever possible. They are less toxic than oil-based paints and easier to clean up. Look for products labeled "latex" or "cleans with water."
- Don't clean brushes or rinse paint containers in the street, gutter or near a storm drain. Clean water-based paints in the sink and oil-based paints with thinner.
- Recycle leftover paint at a household hazardous waste collection facility. Call (800) 253-2687.

To report illegal dumping or for more information on Stormwater pollution prevention, call:

1 (800) CLEANUP

www.1800cleanup.org

English side

Consejos de Prevención Para la Contaminación de Pintura.

Lavar las brochas de pintura o arrojar agua sucia en el desagüe acaba por llegar a los drenajes del Condado de San Bernardino y terminando en el Rio de Santa Ana. Esto contamina el agua que tomamos, haciendola peligorsa para la gente y la vida salvaje. Sigue estas practicas para prevenir la contaminación y protejer la salud publica:

- Usa pinturas de agua cuando sea posible. Son menos toxicas que las pinturas de aceite y mas faciles para limpiar. Busca los productos "latex" or "cleans with water".
- Nunca laves las brochas ni los contenedores de pintura en la calle, coladeras o desagües. Las de pintura de agua límpialas en el labavo y las de pintura de aceite con thiner.
- Recicla la pintura que sobra en un lugar de colección de materiales peligrosos. Llama al (800) 253-2687.

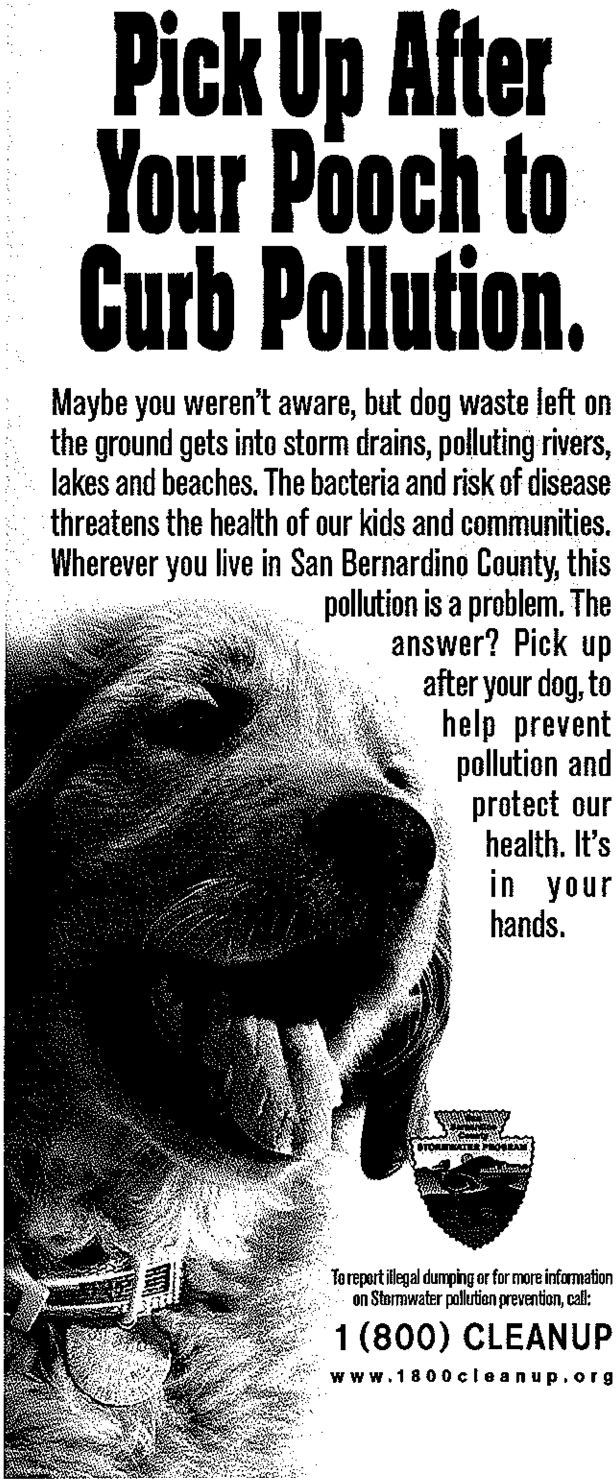
Para reportar actividadas ilegales u obtener más información de la prevención de contaminación llamar al:

1 (800) CLEANUP

www.1800cleanup.org

Spanish side

Item: Paint tip card **Actual size:** 4.125" x 5.5" **Advertiser:** San Bernardino County Storm Water Program
Agency: Industrial Strength Advertising **Date:** 9/10/03



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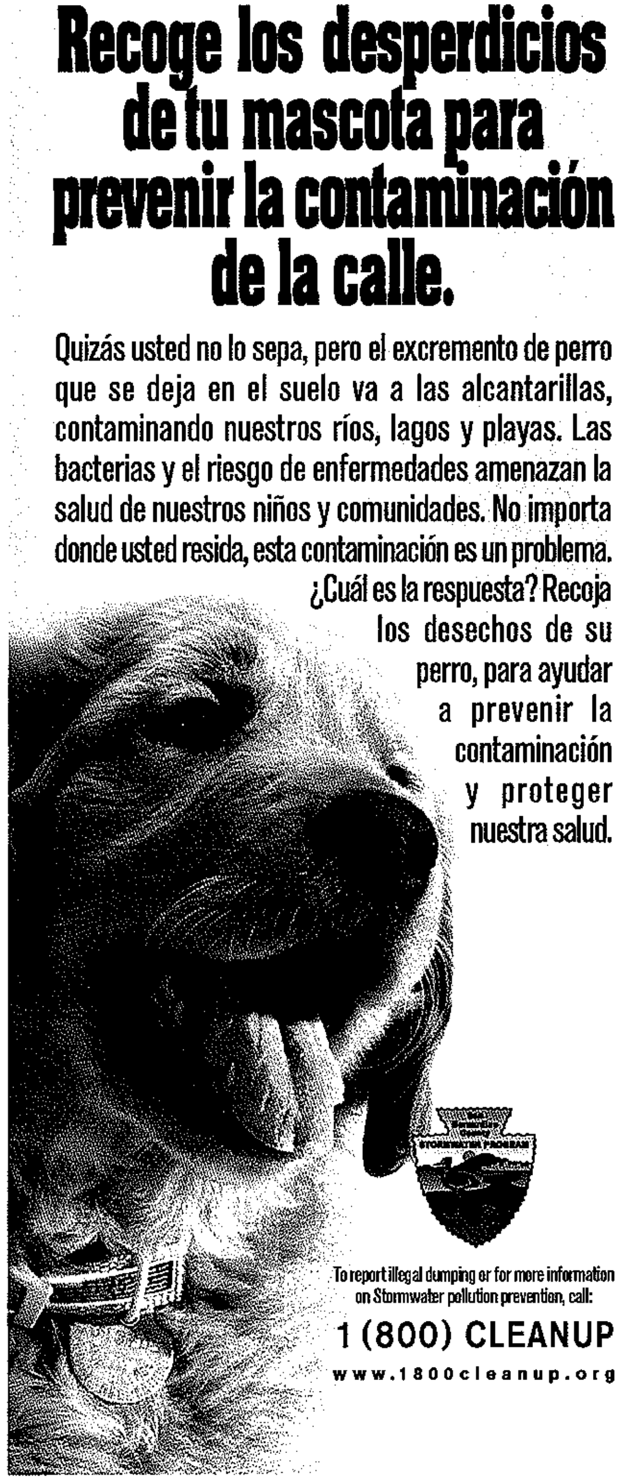
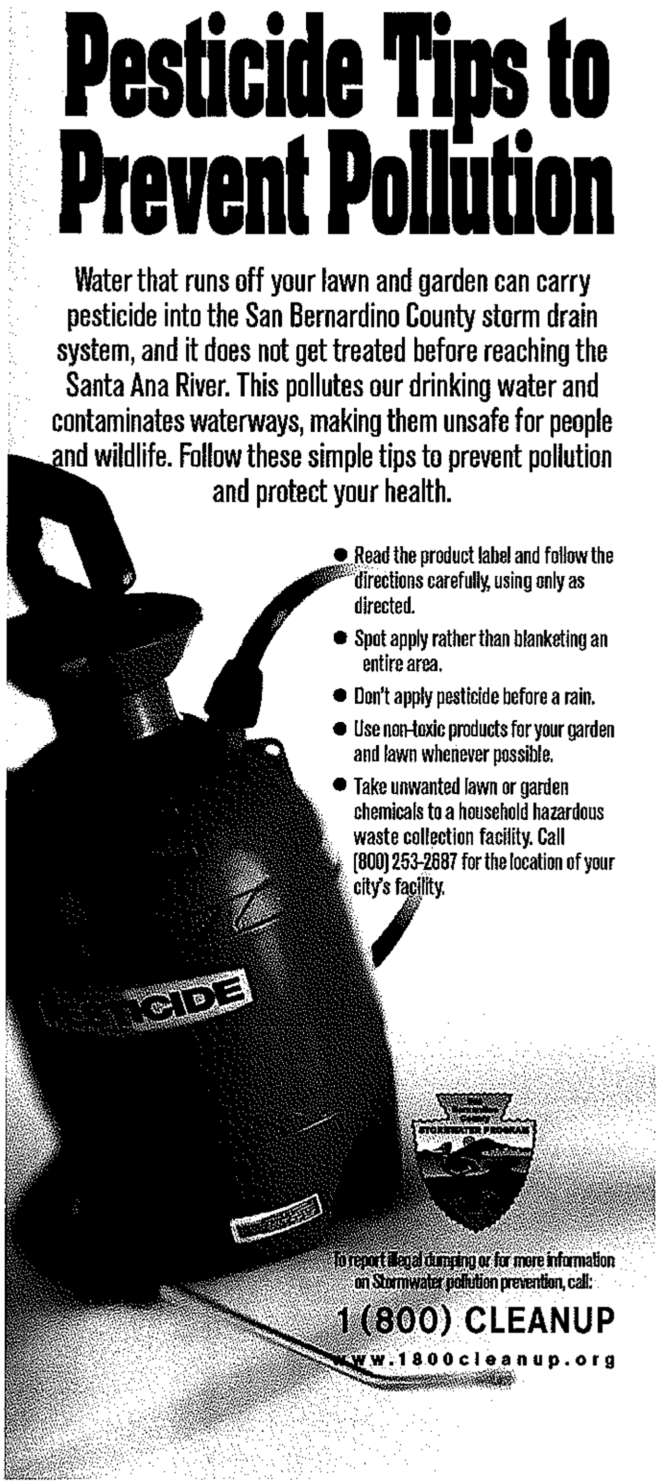


Spanish side

Item: Dog waste bill insert **Actual size:** 3.625" x 8.5" **Advertiser:** San Bernardino County Storm Water Program
Agency: Industrial Strength Advertising **Date:** 9/10/03



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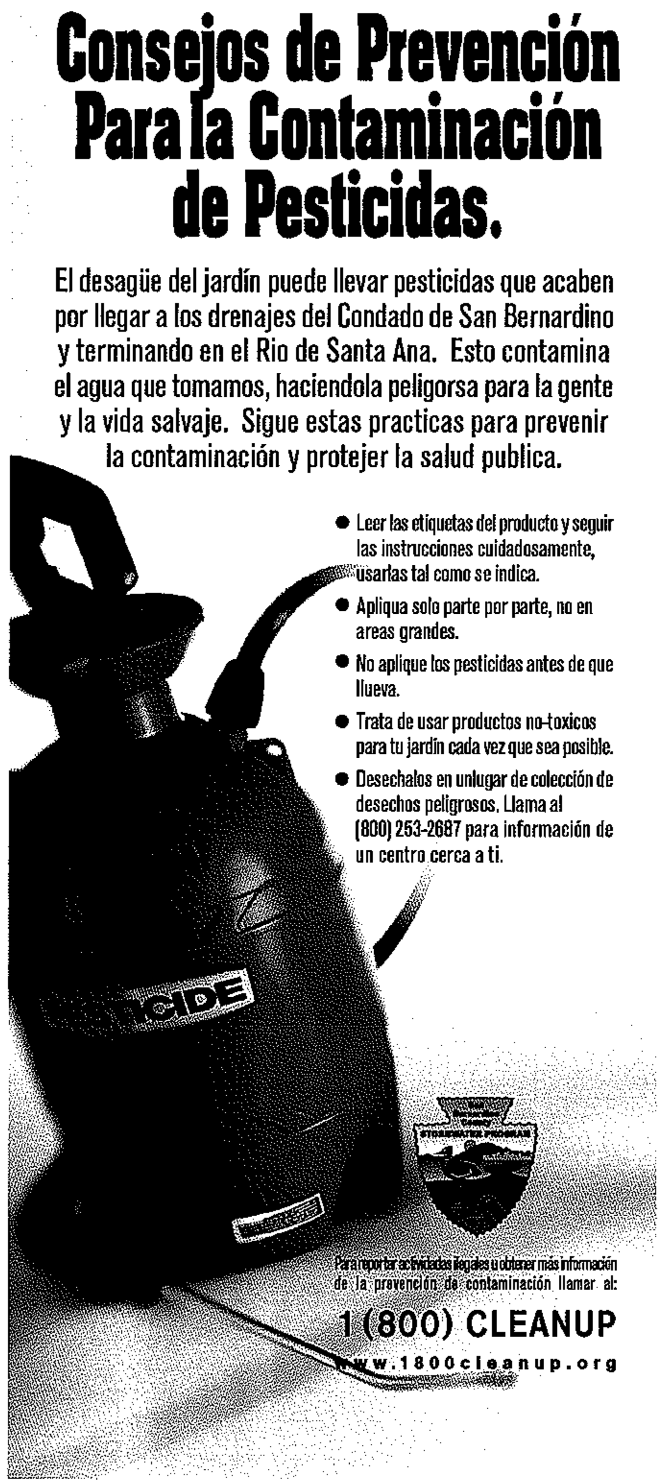

Spanish side

Item: Pesticide bill insert **Actual size:** 3.625" x 8.5" **Advertiser:** San Bernardino County Storm Water Program
Agency: Industrial Strength Advertising **Date:** 8/29/03

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STORMWATER

Pollution Prevention

CARPET CLEANING ACTIVITIES

San Bernardino County Stormwater Program
825 East Third Street · Room 127
San Bernardino, CA 94215-0835

STORMWATER

Pollution Prevention

Stormwater Management Practices for Carpet Cleaning Activities

Toxic chemicals and discharged waste water from carpet, drapery, furniture and window cleaning often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates local waterways, making them unsafe for people and wildlife. Following these best management practices will prevent pollution, comply with regulations and protect public health.

These guidelines apply even if the cleaning products are labeled "nontoxic" or "biodegradable". Although these products may be less harmful to the environment, they can still have harmful effects if they enter the storm drain untreated.

Dispose of Wastewater Properly

Wastewater from cleaning equipment must be discharged into a sink, toilet, or other drain connected to the sanitary sewer system within sanitary sewer discharge limits, hauled off and disposed of properly, or may be discharged to a pervious area, for example, a lawn area, as long as it does not overflow into the street, gutter, parking lot or storm drain. Wastewater should never be discharged into a street, gutter, parking lot or storm drain.

Filter Wastewater

Carpet cleaning wastewater should be filtered before discharging it to the sanitary sewer since fibers and other debris in the wastewater can clog pipes. The filtered material can be disposed of in the garbage, provided that the waste is not contaminated with hazardous pollutants.

To report illegal dumping or for more information on stormwater pollution prevention, call:

1 (800) CLEANUP

or visit our websites:

www.co.san-bernardino.ca.us/flood/npdes

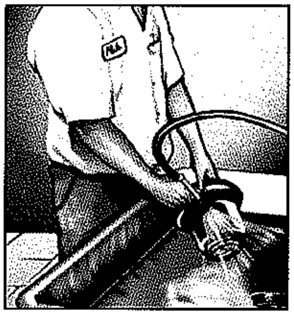
www.1800cleanup.org

STORMWATER

Pollution Prevention

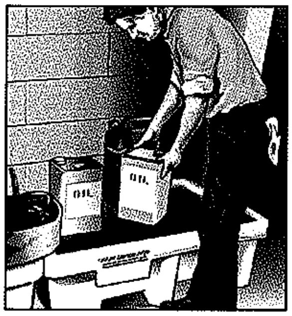
AUTO MAINTENANCE

Oil, grease, anti-freeze and other toxic automotive fluids often make their way into the San Bernardino County storm drain system, and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these best management practices to prevent pollution and protect public health.



Cleaning Auto Parts

Scrape parts with a wire brush or use a bake oven rather than liquid cleaners. Arrange drip pans, drying racks and drain boards so that fluids are directed back into the parts washer or the fluid holding tank. Do not wash parts or equipment in a shop sink, parking lot, driveway or street.



Storing Hazardous Waste

Keep your liquid waste segregated. Many fluids can be recycled via hazardous waste disposal companies if they are not mixed. Store all materials under cover with spill containment or inside to prevent contamination of rainwater runoff.

Metal Grinding and Polishing

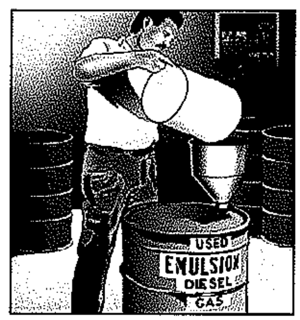
Keep a bin under your lathe or grinder to capture metal filings. Send uncontaminated filings to a scrap metal recycler for reclamation. Store metal filings in a covered container or indoors.

Preventing Leaks and Spills

Place drip pans underneath to capture fluids. Use absorbent cleaning agents instead of water to clean work areas.

Cleaning Spills

Use dry methods for spill cleanup (sweeping, absorbent materials). Follow your hazardous materials response plan, as filed with your local fire department or other hazardous materials authority. Be sure that all employees are aware of the plan and are capable of implementing each phase. To report serious toxic spills, call 911.



Proper Disposal of Hazardous Waste

Recycle used motor oil and oil filters, anti-freeze and other hazardous automotive fluids, batteries, tires and metal filings collected from grinding or polishing auto parts. Contact a licensed hazardous waste hauler. For more recycling information, call (909) 386-8401.

To report illegal dumping or for more information on stormwater pollution prevention, call:

1 (800) CLEANUP

www.1800cleanup.org

STORMWATER
Pollution Prevention

HOME REPAIR & REMODELING

Paints, solvents, adhesives and other toxic substances used in home repair and remodeling often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these simple tips to prevent pollution and protect your health.

Construction Projects

Keep construction debris away from the street, gutter and storm drains. Schedule grading and excavation projects for dry weather. Cover excavated material and stockpiles of soil, sand or gravel, protected from rain, wind and runoff. Prevent erosion by planting fast-growing annual and perennial grass, which can shield and bind soil.

Recycle Household Hazardous Waste

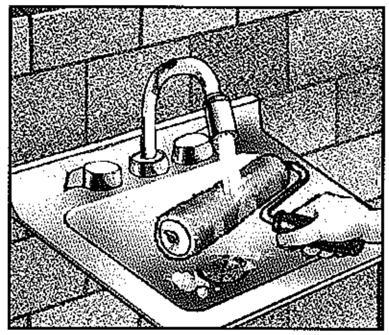
Household cleaners, paint and other home improvement products like wallpaper and tile adhesives are too toxic to trash. Recycle them instead, at a convenient household hazardous waste collection facility. Call (800) CLEANUP for the facility in your area.

Landscaping & Gardening

Avoid applying fertilizers or pesticide near curbs and driveways, and store covered, protected from rain, wind and runoff. Try using organic or non-toxic alternatives. Reduce runoff and lower your water bill by using drip irrigation, soaker hoses or micro-spray systems. Recycle leaves instead of blowing, sweeping or raking them into the street, gutter or storm drain.

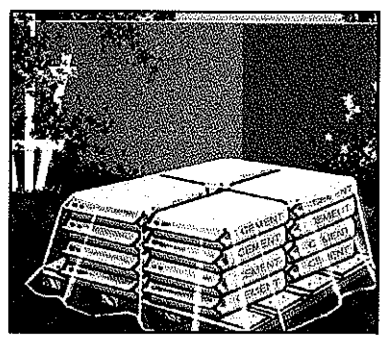
Paint Removal

Paint stripping residue, chips and dust from marine paints and paints containing lead or tributyl tin are hazardous wastes. Sweep them up instead of hosing into the street and dispose of them safely at a household hazardous waste collection facility.



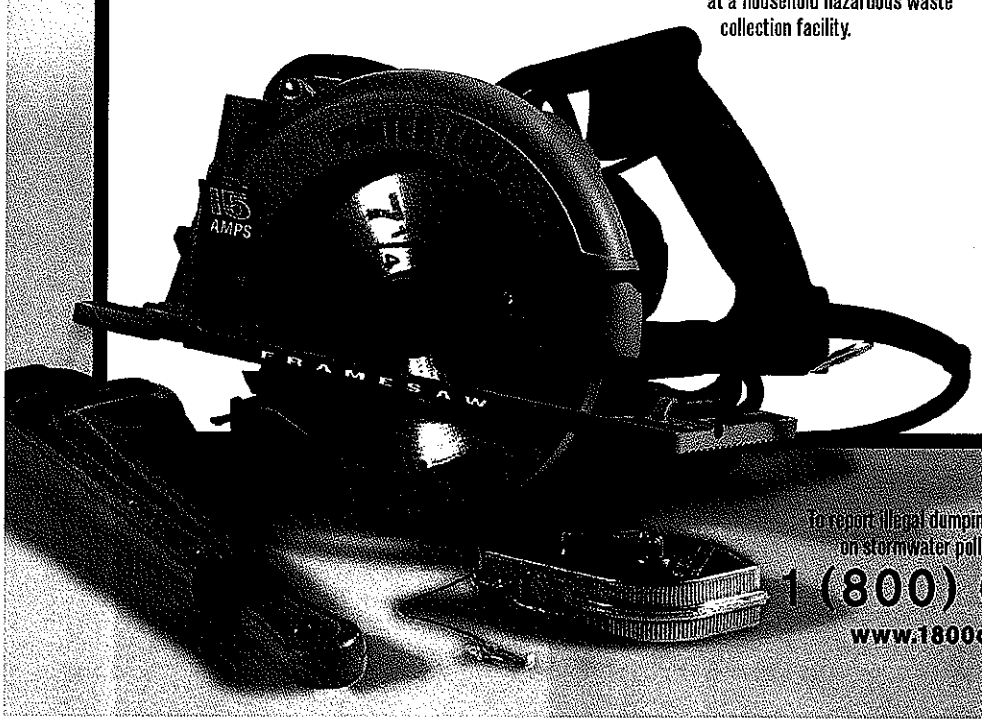
Painting Cleanup

Avoid cleaning brushes or rinsing paint containers in the street, gutter or near a storm drain. Clean water-based paints in the sink. Clean oil-based paints with thinner, which you can filter and reuse. Recycle leftover paint at a household hazardous waste collection facility, save it for touch ups or give it to someone who can use it, like a theatre group, school, city or community organization.



Concrete and Masonry

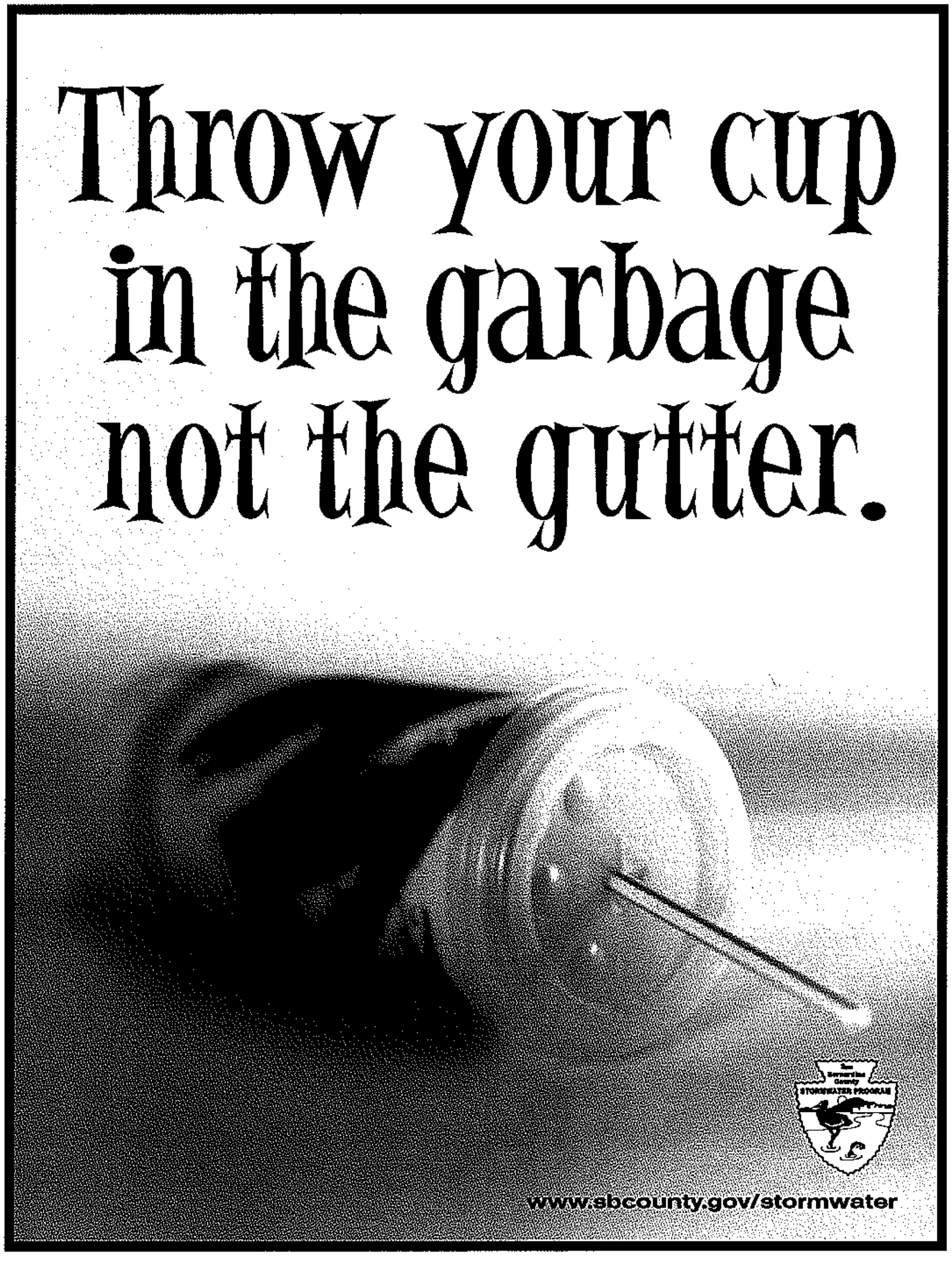
Store bags of cement and plaster away from gutters and storm drains, and cover them to protect against rain, wind and runoff. Sweep or scoop up cement washout or concrete dust instead of hosing into driveways, streets, gutters or storm drains.



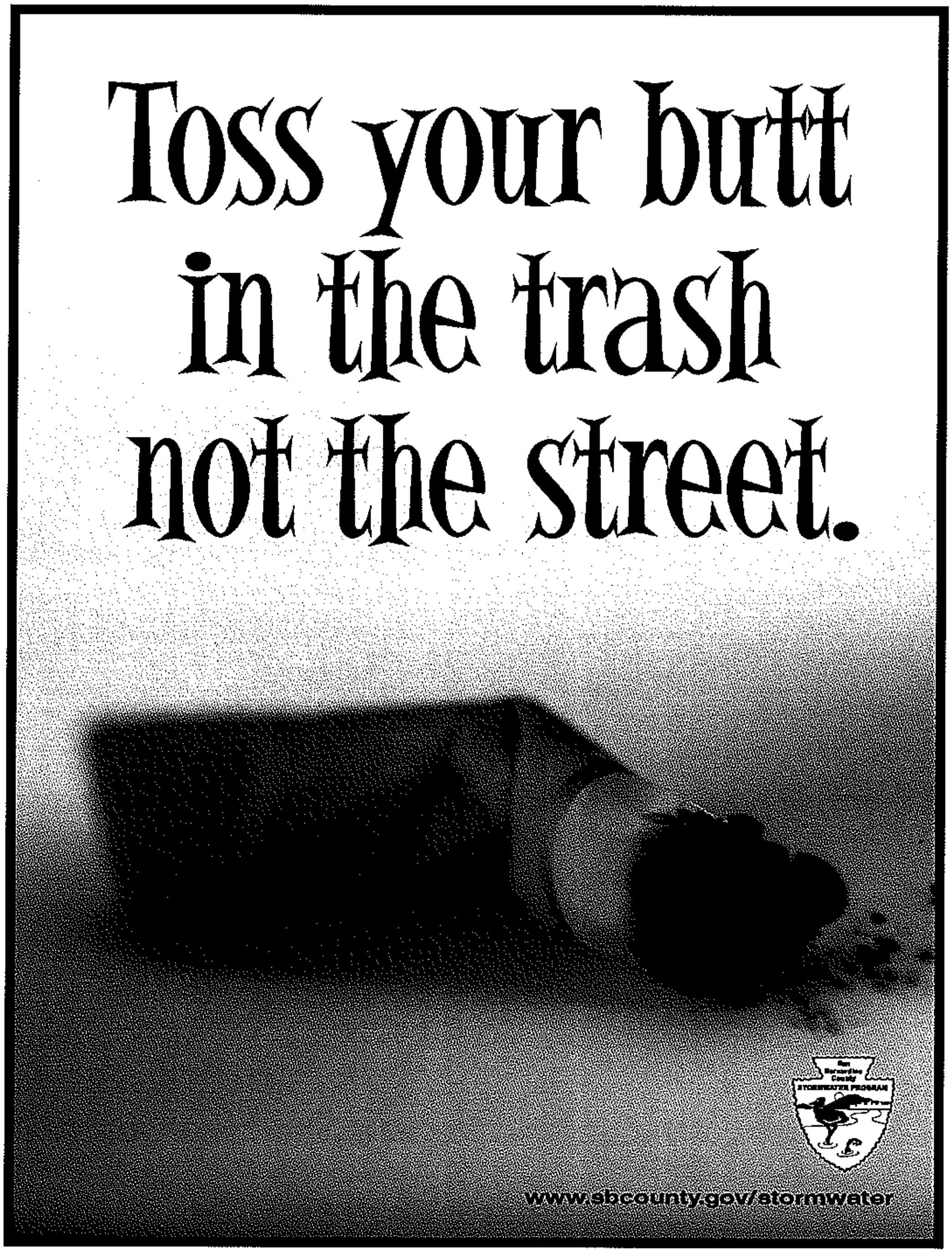
To report illegal dumping or for more information on stormwater pollution prevention, call:

1 (800) CLEANUP

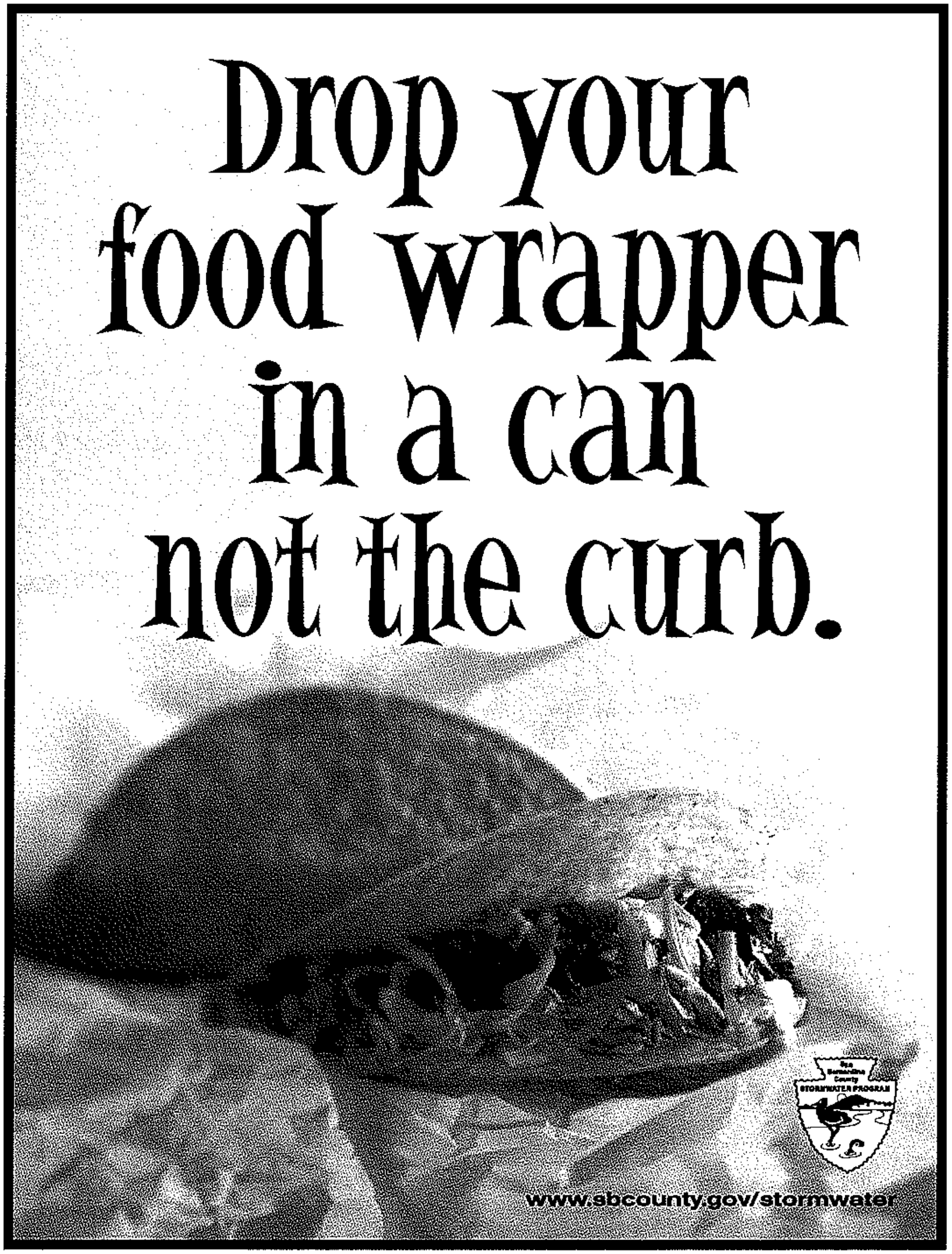
www.1800cleanup.org



Ad code: SBST-04-06 **Ad title:** Soda Cup **Size:** 3 col. (5.69") x 7.5" **Publ:** San Ber Sun, Inland Bulletin
Advertiser: San Bernardino County Storm Water Program **Agency:** Industrial Strength Advertising **Date:** 6/3/04



Ad code: SBST-04-07 **Ad title:** Cigarette Butt **Size:** 3 col. (5.69") x 7.5" **Publ:** San Ber Sun, Inland Bulletin
Advertiser: San Bernardino County Storm Water Program **Agency:** Industrial Strength Advertising **Date:** 6/7/04



Ad code: SBST-04-08 **Ad title:** Tacos **Size:** 3 col. (5.69") x 7.5" **Publ:** San Ber Sun, Inland Bulletin
Advertiser: San Bernardino County Storm Water Program **Agency:** Industrial Strength Advertising **Date:** 6/7/04

Attachment I

Educational material for Vortech Units

Details will be provided during final WQMP processing.

Vortechs® System

The proven stormwater treatment leader

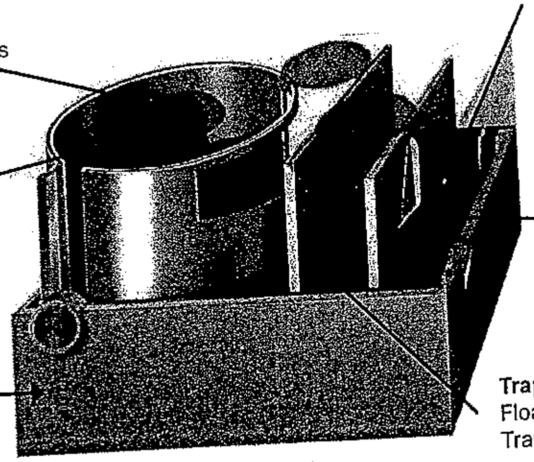
Vortechnics®
A CONTECH Company

Get proven, reliable stormwater treatment every time.

The Vortechs® System is the proven stormwater solution chosen by engineers, contractors, regulators, developers and conservation organizations to meet water quality challenges and to ensure that urban runoff is as clean as possible.

The EPA award-winning design efficiently removes contaminated sediment, floating hydrocarbons, and debris from stormwater. The Vortechs® System's swirl-concentrator and flow controls work together to eliminate turbulence and to provide positive removal efficiencies throughout the full range of operation. With the most comprehensive lab, field and third-party testing in the industry, the Vortechs® System delivers proven results and site-specific solutions for all applications and rainfall conditions.

Vortechs® System Features and Benefits



Best standalone treatment technology on the market.

The pollutants targeted by most stormwater regulations are sediment, hydrocarbons and debris. While other technologies are useful in removing some of these pollutants, the Vortechs® System is the best standalone solution for addressing all of the target pollutants. Other technologies have inherent design limitations that can compromise treatment efficiency, diminish flow rate capacity and/or obstruct maintenance access. For more than 15 years, Vortechs® Systems have proven their versatility and adaptability on more than 4,000 successful installations in North America.

·dvantages of the Vortechs® System

- ·s Full Range of Flows
- F ·ntenance
- ·ent Needs Residential ·ites
- Shallow System Profile
- Customizable Design
- Optimizes Surface Use of Real Estate on High Value Sites
- Easy Installation
- 20-Year Warranty
- Performance Verified Through Lab, Field and Third-Party Testing

Committed to Clean Water™

,7.907.8676 or visit us at www.vortechnics.com

Vortechs® System

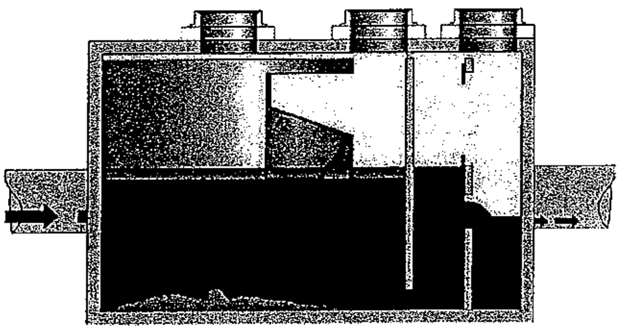
The proven stormwater treatment leader

Vortechnics®
A CONTECH Company

Vortechs® System Operation

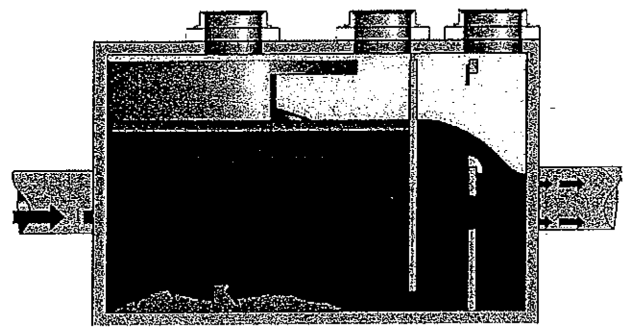
Visit www.vortechnics.com to see an animated Vortechs® System in action!

Low Intensity Storm



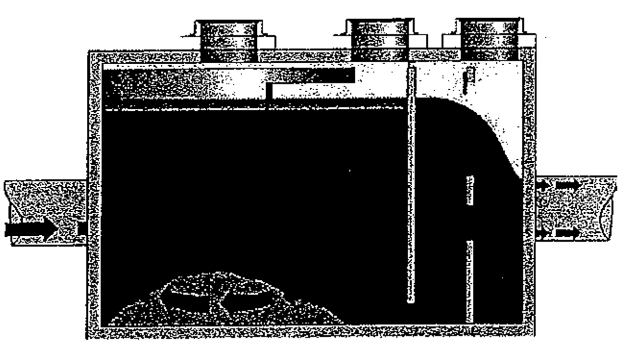
Most storm events (85 percent) do not exceed the two-month storm intensity. During this low intensity storm flow, the water level within the Vortechs® System will rise above the top of the inlet pipe, reducing inflow velocity and turbulence. Oil and fine sediments are usually washed off paved surfaces during these events, and the Vortechs® System treatment efficiencies are in the 80 to 90 percent range for typical urban runoff sediment.

Medium Intensity Storm



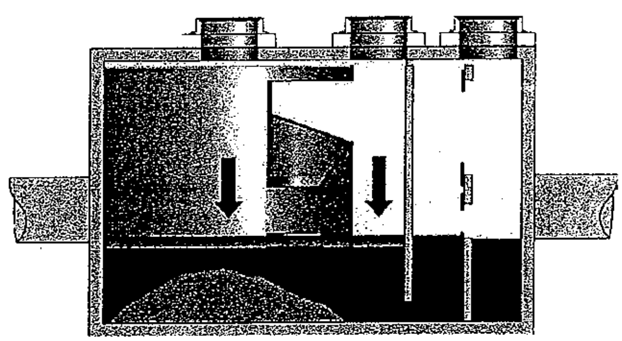
During a medium intensity storm, which occurs with a frequency of one to two years, remaining oil washes off pavement, and larger sediment particles and debris are now transported into the Vortechs® System. As flow increases, the water level rises above the low flow control and the tank begins to fill. With the inlet submerged, the oily layer is above the influent flow path, preventing re-entrainment of floating pollutants. Swirling action increases at this stage, which increases sediment removal rates.

High Intensity Storm



High intensity storms are infrequent, and storm flows have sufficient energy to wash off the largest sediment particles and pieces of debris. When the high flow control approaches full discharge within the Vortechs® System, storm drains are flowing at peak capacity. The Vortechs® System can accommodate flows up to the specified design storm (i.e. 10-year storm). Treatment efficiencies remain constant during this phase.

Storm Subsidence



Treated runoff is decanted out of the Vortechs® System at a controlled rate, restoring the water level to a low, dry-weather volume. This reveals a conical pile of accumulated sediment in the center of the grit chamber. Besides facilitating inspection and cleaning, the low water level significantly reduces maintenance costs by reducing pump-out volume.

Learn More! Call 877.907.8676 or visit us at www.vortechnics.com

Committed to Clean Water™

Vortechs® System: a System Sized for Every Application

When you specify a Vortechs® System, the Vortechnics team will customize the design to fit your site's unique parameters and provide you with an effective, cost-efficient solution.

Each Vortechs® System is custom designed based on:

- » Removal Efficiency Goals
- » Drainage Area
- » Regional Rainfall Intensity Distribution
- » Design Flow
- » Site Runoff Coefficient and Time of Concentration
- » Anticipated Pollutant Characteristics

Vortechs® System Sizing Methodology: the Rational Rainfall Method™

Differences in local climate and topography make every site unique, so it is important to take these factors into consideration when choosing a stormwater treatment system. Therefore Vortechnics developed the Rational Rainfall Method™ to accurately design each Vortechs® System. The sizing methodology combines site-specific information, including local historical precipitation records, with laboratory-generated performance data corroborated by third-party field studies, ensuring accurate long-term performance.

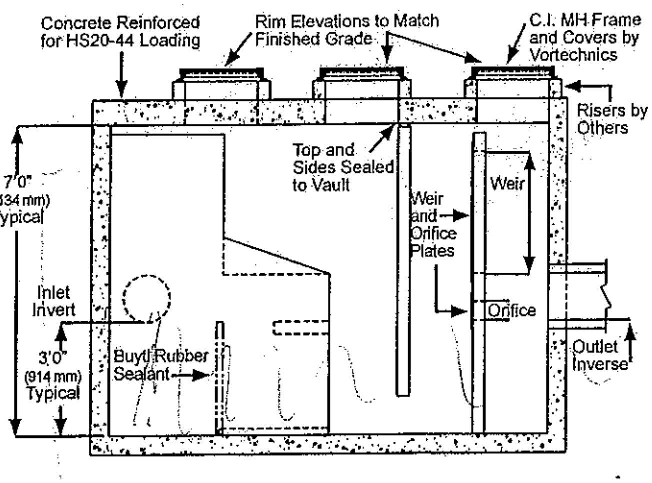
Short duration rain gauge records from across the United States and Canada were analyzed by Vortechnics to determine the percent of the total annual rainfall that fell at a range of intensities. One trend was consistent at all sites: the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for a specific site, are translated into flow rates using the Rational Rainfall Method™. Based on the flow rates calculated for each intensity, an operating rate within a proposed Vortechs® System is determined. Finally, a removal efficiency is selected for each operating rate based on anticipated pollutant characteristics and on full-scale laboratory tests. The relative removal efficiencies at each operating rate are summed to produce a net annual pollutant removal efficiency estimate.

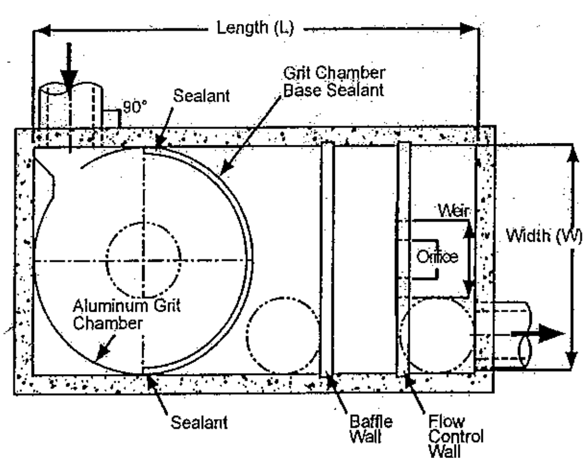
Vortechnics typically selects a system size that will provide an 80 percent annual total suspended solids (TSS) load reduction based on laboratory-generated performance curves for 50-micron sediment particles, however the Rational Rainfall Method™ can accommodate other removal efficiencies or particle sizes. It can also be used to estimate annual hydrocarbon load reductions.

Once a system size is established, the internal elements of the system are designed based on information provided by the site engineer. Flow control sizes and shapes, sump depth, spill storage capacity, sediment storage volume and inlet and outlet orientation are determined for each system. In addition, bypass weir calculations are made for offline systems.

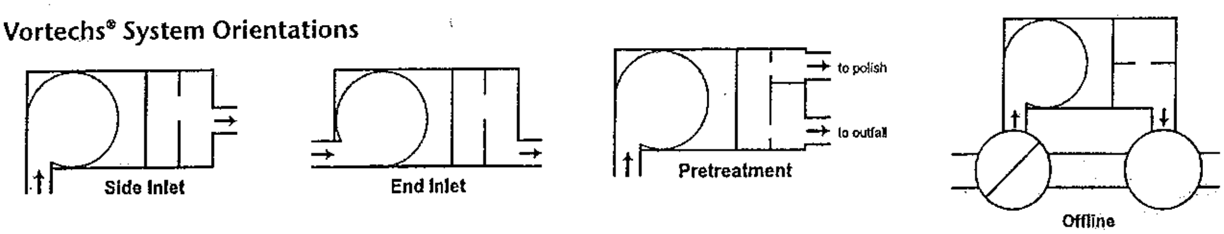
Typical Vortechs® System Elevation View



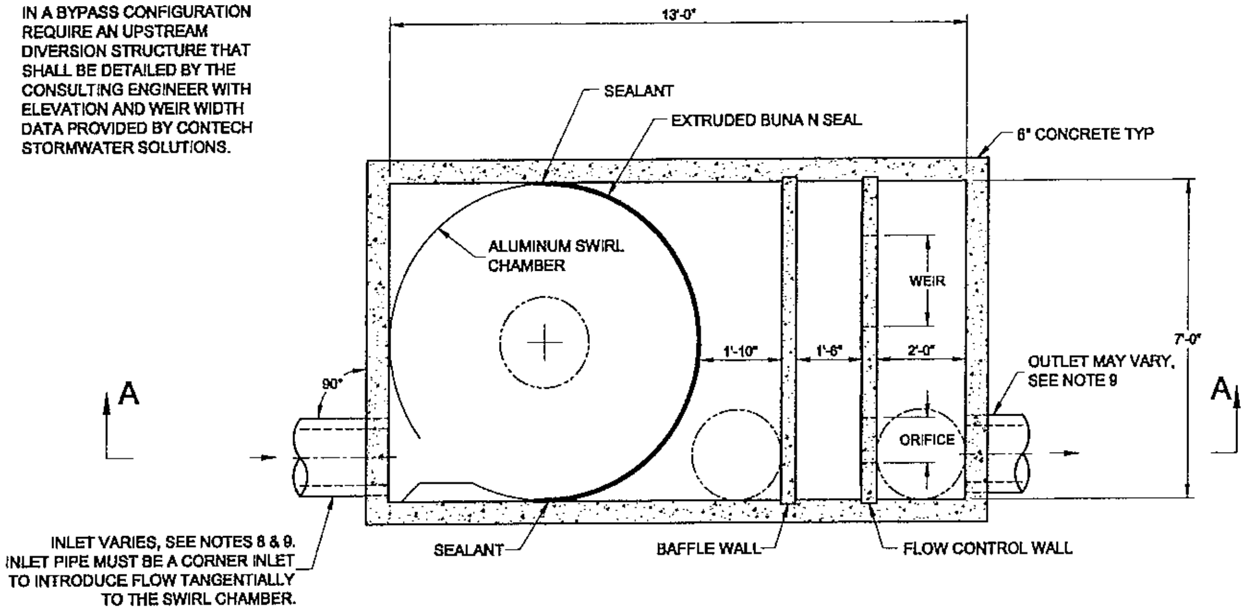
Typical Vortechs® System Plan View



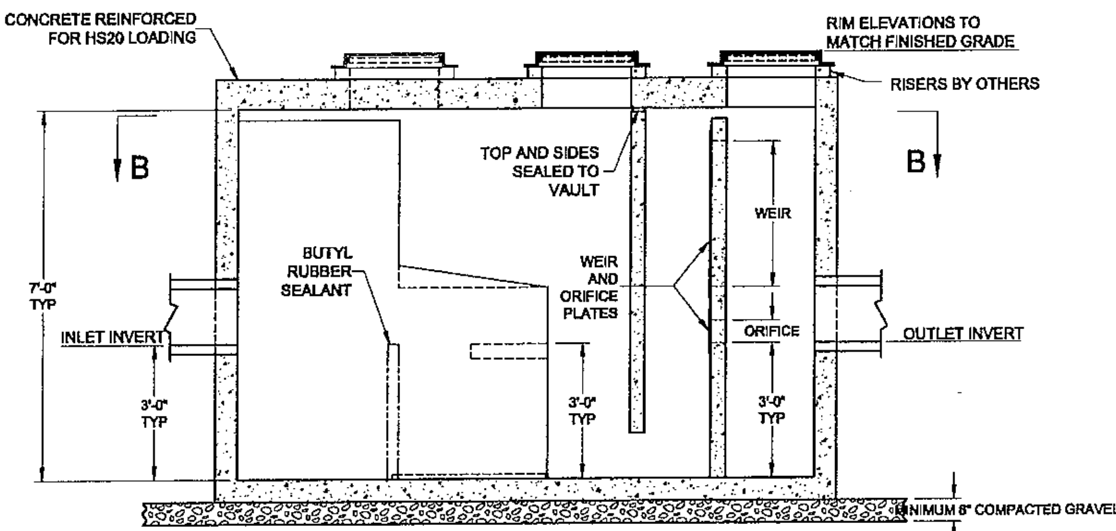
Vortechs® System Orientations



NOTE:
VORTECHS SYSTEMS INSTALLED IN A BYPASS CONFIGURATION REQUIRE AN UPSTREAM DIVERSION STRUCTURE THAT SHALL BE DETAILED BY THE CONSULTING ENGINEER WITH ELEVATION AND WEIR WIDTH DATA PROVIDED BY CONTECH STORMWATER SOLUTIONS.



PLAN VIEW B - B



SECTION A - A

NOTES:
1. STORMWATER TREATMENT SYSTEM (SWTS) SHALL HAVE:
   PEAK TREATMENT CAPACITY: 8.5 CFS
   SEDIMENT STORAGE: 3.25 CU YD
   SEDIMENT CHAMBER DIA: 7' MIN
2. SWTS SHALL BE CONTAINED IN ONE RECTANGULAR STRUCTURE
3. SWTS REMOVAL EFFICIENCY SHALL BE DOCUMENTED BASED ON PARTICLE SIZE
4. SWTS SHALL RETAIN FLOATABLES AND TRAPPED SEDIMENT UP TO AND INCLUDING PEAK TREATMENT CAPACITY
5. SWTS INVERTS IN AND OUT ARE TYPICALLY AT THE SAME ELEVATION
6. SWTS SHALL NOT BE COMPROMISED BY EFFECTS OF DOWNSTREAM TAILWATER
7. SWTS SHALL HAVE NO INTERNAL COMPONENTS THAT OBSTRUCT MAINTENANCE ACCESS
8. INLET PIPE MUST BE PERPENDICULAR TO THE STRUCTURE
9. PIPE ORIENTATION MAY VARY; SEE SITE PLAN FOR SIZE AND LOCATION
10. PURCHASER SHALL NOT BE RESPONSIBLE FOR ASSEMBLY OF UNIT
11. MANHOLE FRAMES AND PERFORATED COVERS SUPPLIED WITH SYSTEM, NOT INSTALLED
12. PURCHASER TO PREPARE EXCAVATION AND PROVIDE CRANE FOR OFF-LOADING AND SETTING AT TIME OF DELIVERY
13. VORTECHS SYSTEMS BY CONTECH STORMWATER SOLUTIONS; PORTLAND, OR (800)548-4667; SCARBOROUGH, ME (877) 907-8676; ELKRIDGE, MD (866) 740-3318.

PROPRIETARY INFORMATION - NOT TO BE USED FOR CONSTRUCTION PURPOSES

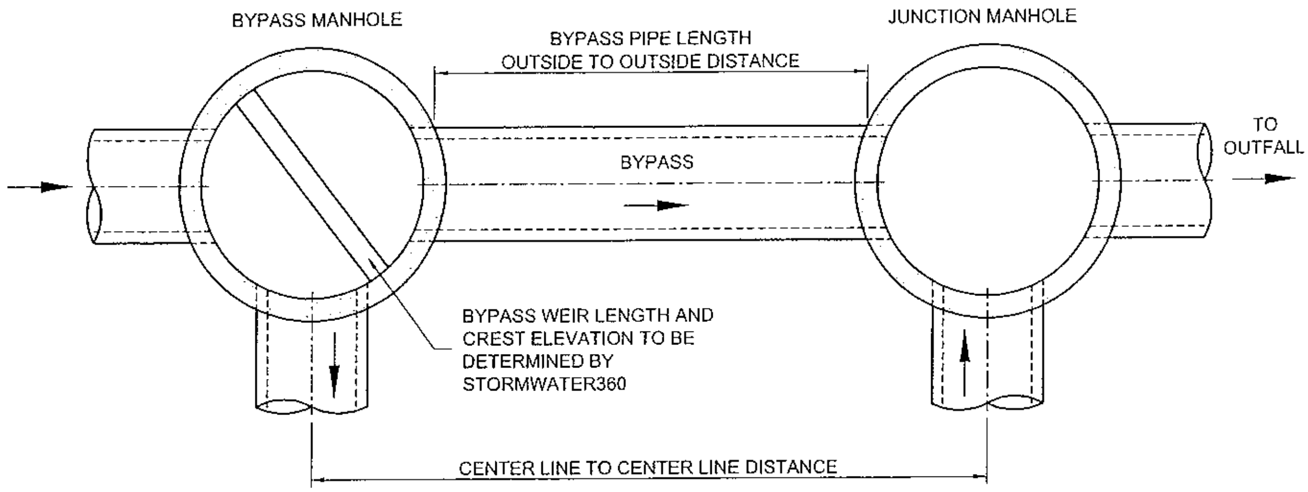
CONTECH® STORMWATER SOLUTIONS
contechstormwater.com

STANDARD DETAIL
STORMWATER TREATMENT SYSTEM
VORTECHS® MODEL 5000

U.S. PATENT No. 5,759,415

DATE: 4/5/06	SCALE: NONE	FILE NAME: STD5k	DRAWN: GMC	CHECKED: NDG

FOR INFORMATIONAL PURPOSES ONLY
NOT INTENDED AS A CONSTRUCTION DOCUMENT
-BYPASS AND JUNCTION STRUCTURES NOT SUPPLIED BY CONTECH STORMWATER SOLUTIONS-



NOTE: BYPASS AND JUNCTION MANHOLE DIAMETERS ARE ASSUMED BASED ON THE TREATMENT CAPACITY OF THE VORTECHS SYSTEM. THESE DIAMETERS MAY CHANGE DEPENDING ON SPECIFIC SITE CONDITIONS. CONTACT YOUR CONTECH STORMWATER SOLUTIONS DESIGN ENGINEER.

Vortechs Model Size	Vortechs Dims		Recommended Pipe Size	Typical Bypass Manhole	Typical Junction Manhole	Approximate Center Line to Center Line Distance	Approximate Bypass Pipe Length Outside to Outside
	Length	Width					
1000	9'-0"	3'-0"	Ø10"	4'-0"Ø	4'-0"Ø	7'-6"	3'-6"
2000	10'-0"	4'-0"	Ø12"	4'-0"Ø	4'-0"Ø	8'-5"	4'-5"
3000	11'-0"	5'-0"	Ø15"	5'-0"Ø	4'-0"Ø	9'-3"	4'-9"
4000	12'-0"	6'-0"	Ø15"	5'-0"Ø	4'-0"Ø	10'-3"	5'-9"
5000	13'-0"	7'-0"	Ø18"	6'-0"Ø	5'-0"Ø	11'-2"	5'-8"
7000	14'-0"	8'-0"	Ø18"	6'-0"Ø	5'-0"Ø	12'-2"	6'-8"
9000	15'-0"	9'-0"	Ø21"	6'-0"Ø	6'-0"Ø	11'-10"	5'-10"
11000	16'-0"	10'-0"	Ø24"	6'-0"Ø	6'-0"Ø	12'-8"	6'-8"
16000	18'-0"	12'-0"	Ø27"	6'-0"Ø	6'-0"Ø	14'-7"	8'-7"

CONTECH® STORMWATER SOLUTIONS
contechstormwater.com

TYPICAL BYPASS & JUNCTION MANHOLE LAYOUT
WITH SPECIFICATIONS TABLE FOR
VORTECHS® STORMWATER TREATMENT SYSTEM

DATE: 4/7/06	SCALE: NONE	FILE NAME: TYPTBLVXBPR	DRAWN: GMC	CHECKED: NDG

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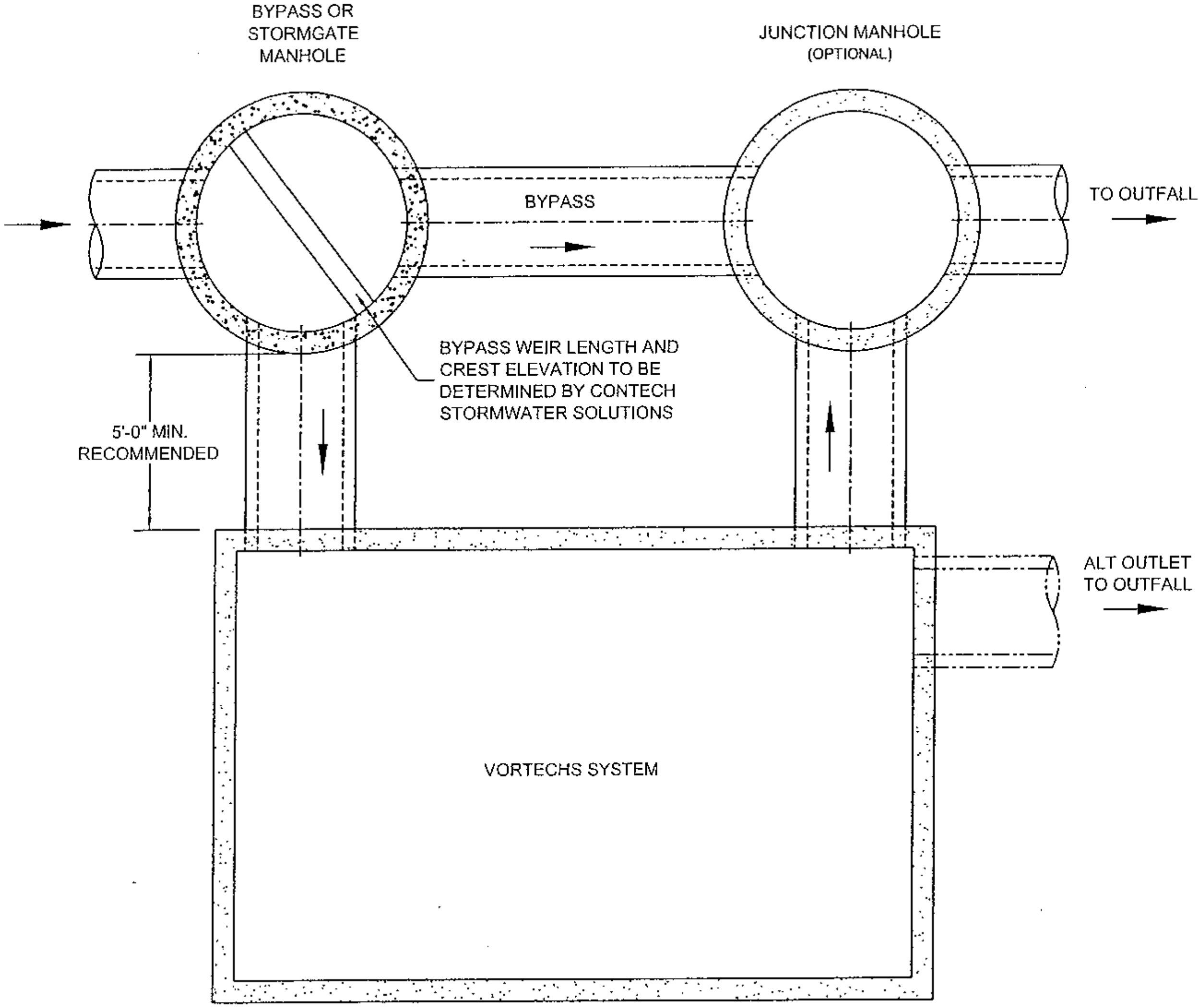
- BYPASS AND JUNCTION STRUCTURES NOT SUPPLIED BY CONTECH STORMWATER SOLUTIONS -

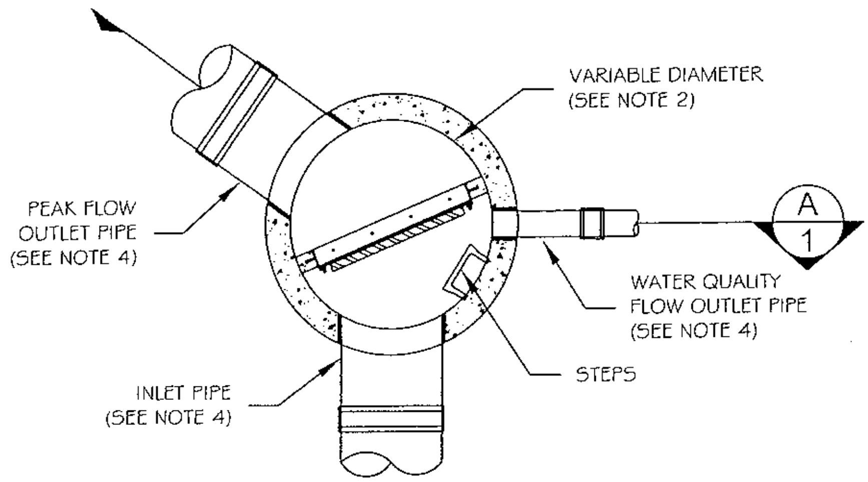


ACTUAL ORIENTATION AND LAYOUT MAY VARY
DUE TO SITE SPECIFIC CONSIDERATIONS

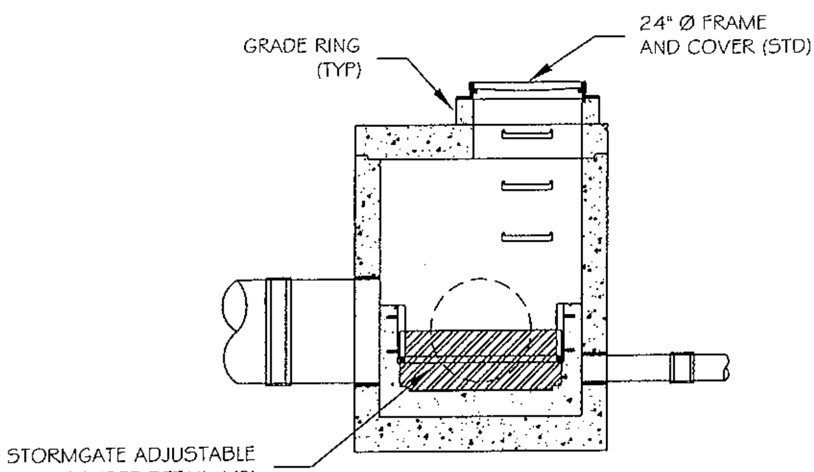
CONTECH® STORMWATER SOLUTIONS
contechstormwater.com

TYPICAL BYPASS LAYOUT
VORTECHS® STORMWATER TREATMENT SYSTEM

DATE: 6/15/06	SCALE: NONE	FILE NAME: TYPVXBPLOR	DRAWN: GMC	CHECKED: NDG



STORMGATE MANHOLE - PLAN VIEW 1/1



STORMGATE MANHOLE - SECTION VIEW A/1

CONTECH STORMWATER SOLUTIONS
contechstormwater.com

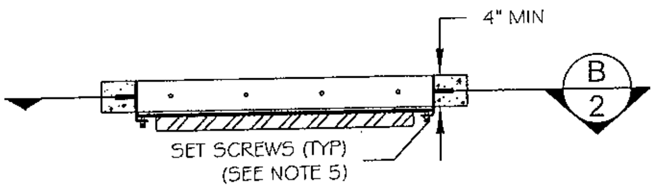
STORMGATE MANHOLE HIGH FLOW BYPASS
PLAN AND SECTION VIEWS
STANDARD DETAIL

DATE: 04/04/06	SCALE: NONE	FILE NAME: SG-MH-DTL	DRAWN: MJW	CHECKED: ARG

DRAWING 1
1/2

GENERAL NOTES

1) STORMGATE BY CONTECH STORMWATER SOLUTIONS; PORTLAND, OR (800) 548-4667; SCARBOROUGH, ME (877) 907-8676; LINTHICUM, MD (866) 740-3318.
2) PRECAST MANHOLE TO BE CONSTRUCTED IN ACCORDANCE WITH ASTM C478. DETAIL DRAWING REFLECTS DESIGN INTENT ONLY. ACTUAL DIMENSIONS AND CONFIGURATION OF STRUCTURE WILL BE SHOWN ON PRODUCTION SHOP DRAWING.
3) STRUCTURE AND ACCESS COVERS TO MEET AASHTO H-20 LOAD RATING.
4) INLET AND OUTLET PIPING TO BE SPECIFIED BY ENGINEER AND PROVIDED BY CONTRACTOR. PRECAST STORMGATE MANHOLE EQUIPPED WITH EITHER CORED OPENINGS OR KNOCKOUTS AT INLET AND OUTLET LOCATIONS.
5) CONTRACTOR TO ADJUST WEIR TO DESIGN ELEVATION SPECIFIED IN DATA TABLE BELOW. DO NOT EXCEED 5.0 FT-LBS TORQUE WHEN TIGHTENING SCREWS ON WEIR FRAME. SEAL WEIR TO FRAME WITH RTV SILICONE SEALANT AFTER FINAL ADJUSTMENT.



WEIR DETAIL - PLAN VIEW 1/2

STORMGATE MANHOLE DATA

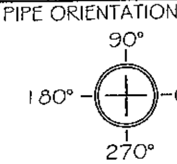
STRUCTURE ID	XXX
WATER QUALITY FLOW RATE (cfs)	X.XX
PEAK FLOW RATE, Qpeak (cfs)	X.XX
MANHOLE DIAMETER (48", 60", 72")	XX"
RIM ELEVATION	XXX.XX'

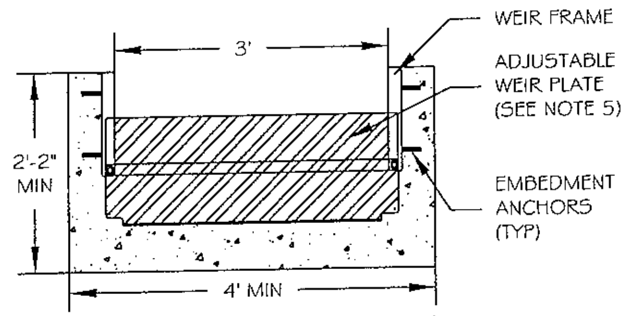
PIPE DATA:	I.E.	ORIENTATION	MATERIAL	DIAMETER
INLET PIPE	XXX.XX'	XX°	XXX	XX"
WATER QUALITY FLOW OUTLET PIPE	XXX.XX'	XX°	XXX	XX"
PEAK FLOW OUTLET PIPE	XXX.XX'	XX°	XXX	XX"

ORIFICE TYPE (PIPE, CAP, PLATE)	XXXXX
ORIFICE DIAMETER (in)	XX"
WEIR CREST ELEVATION	XXX.XX'
WEIR WALL ELEVATION	XXX.XX'
HEAD OVER WEIR, H (ft)	X.XX'
WSE at Qpeak	XXX.XX'
WEIR ORIENTATION	XX°
FLOOR ELEVATION	XXX.XX'

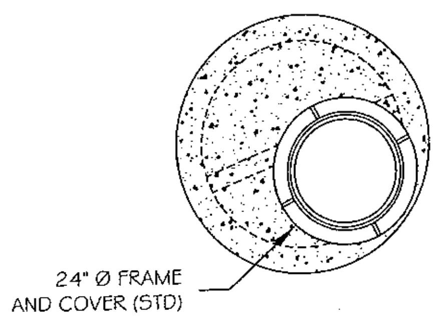
NOTES/SPECIAL REQUIREMENTS:

PIPE ORIENTATION KEY:





WEIR DETAIL - SECTION VIEW B/2



STORMGATE MANHOLE- TOP VIEW 2/2

CONTECH® STORMWATER SOLUTIONS INC.

contechstormwater.com

STORMGATE MANHOLE HIGH FLOW BYPASS
TOP VIEW, WEIR DETAIL, DATA AND NOTES
STANDARD DETAIL

DRAWING 2 — 2/2

DATE: 04/04/06 | SCALE: NONE | FILE NAME: SG-MH-DTL | DRAWN: MJW | CHECKED: ARG

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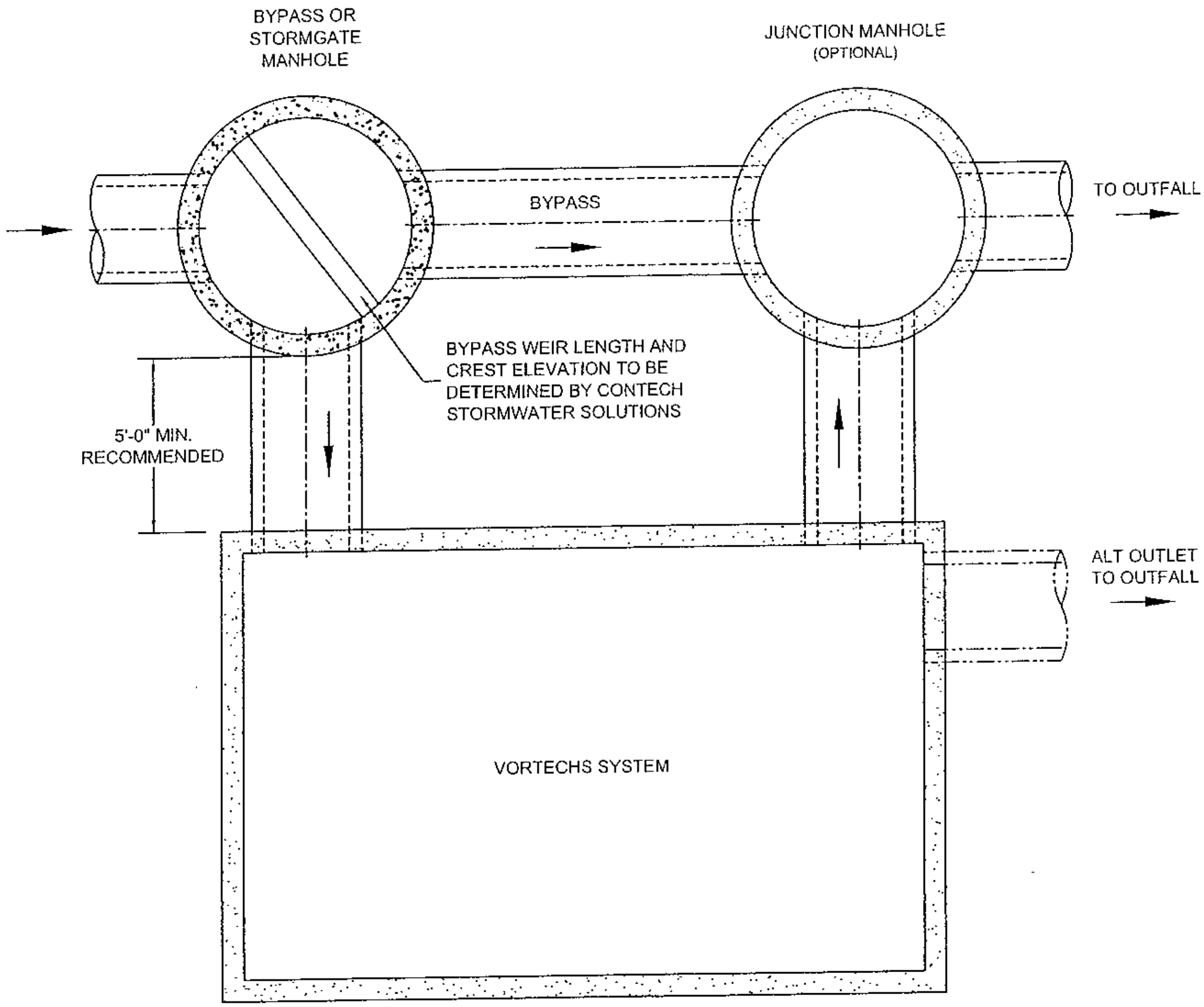


ACTUAL ORIENTATION AND LAYOUT MAY VARY
DUE TO SITE SPECIFIC CONSIDERATIONS

CONTECH® STORMWATER SOLUTIONS
contechstormwater.com

TYPICAL BYPASS LAYOUT
VORTECHS® STORMWATER TREATMENT SYSTEM

DATE: 6/15/06	SCALE: NONE	FILE NAME: TYPVXBPLOR	DRAWN: GMC	CHECKED: NDG

CONTECH® STORMWATER SOLUTIONS INC.

Hydrodynamic Separation

Hydrodynamic Separation Products

High performance hydrodynamic separation products are reliable, easy to install, and offer proven stormwater pollutant removal. Discover the advantages of hydrodynamic separation whether you're looking for a stand-alone treatment device or a treatment train.

Target Pollutants

- Total suspended solids larger than 50 microns
- Free oil and grease
- Trash and debris
- Sediment

Applications

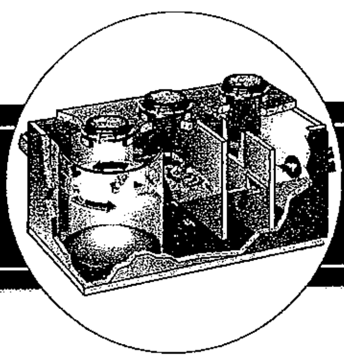
- Commercial, municipal, residential and industrial sites
- High-density and single-family residential sites
- Maintenance, transportation and port facilities
- Parking lots
- Arterial roads
- Freeways

Why Hydrodynamic Separation?

- Removes sediment, floatables, free oil and grease
- Widely accepted for effective solids removal
- Small footprint for treated flow rate
- Delivers treatment with minimal headloss
- Documented performance through lab and independent field testing
- Underground, traffic-rated BMPs maximize land use

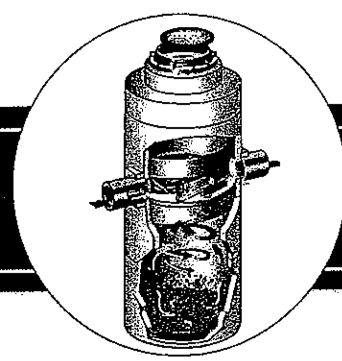
About CONTECH Stormwater Solutions

When you select CONTECH Stormwater Solutions, you'll get much more than stormwater management products. You'll have dedicated, knowledgeable engineers and technical experts to help you select the right technology to meet your regulations. Our organization is committed to preserving water resources by providing customized, site-specific stormwater treatment solutions. And, every product is backed by the most comprehensive lab, field and independent testing in the industry. As one of the four divisions of CONTECH Construction Products – Stormwater, Bridge, Earth Stabilization, and Drainage – we bring you the most comprehensive portfolio of solutions in the industry. Every day. Every site.



Vortechs®

- High performance hydrodynamic separation widely accepted for solids removal makes permitting easier
- Removes a wide range of pollutants – including sediment, trash, free oil and grease – cost effectively
- Treats peak flows without bypassing
- Proven performance verified through third-party testing
- Shallow system profile and unique horizontal design makes installation easier and less expensive
- Flexible design fits multiple site constraints and accommodates a wide range of treatment options



VortSentry®

- Compact design is ideal for congested sites
- Houses an internal bypass and treatment in one structure
- Lightweight design eases installation
- Unobstructed maintenance access typically does not require confined space entry

www.contechstormwater.com

CONTECH®
STORMWATER SOLUTIONS INC.

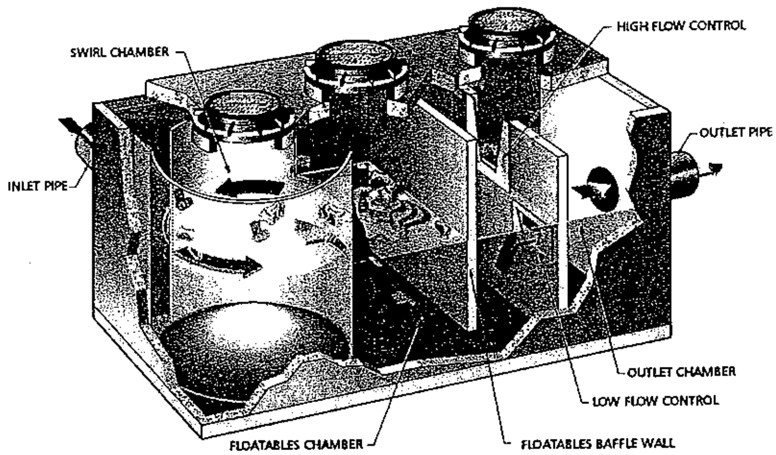
Vortechs®

High flow hydrodynamic separation

The Vortechs system is a high-performance hydrodynamic separator that removes sediment, particles, free oil and grease. The design allows for easy inspection and unobstructed maintenance access.

Each Vortechs system can be designed in accordance with local regulations or by using the Rational Rainfall Method™. This method combines site-specific information, including local historical precipitation records and laboratory-generated performance data (corroborated by third-party field studies) to ensure accurate long-term performance. It can also be used to estimate annual hydrocarbon load reductions.

A typical system is sized to provide an 80% load reduction based on laboratory-verified removal efficiencies for varying particle size distributions such as 50-micron sediment particles.

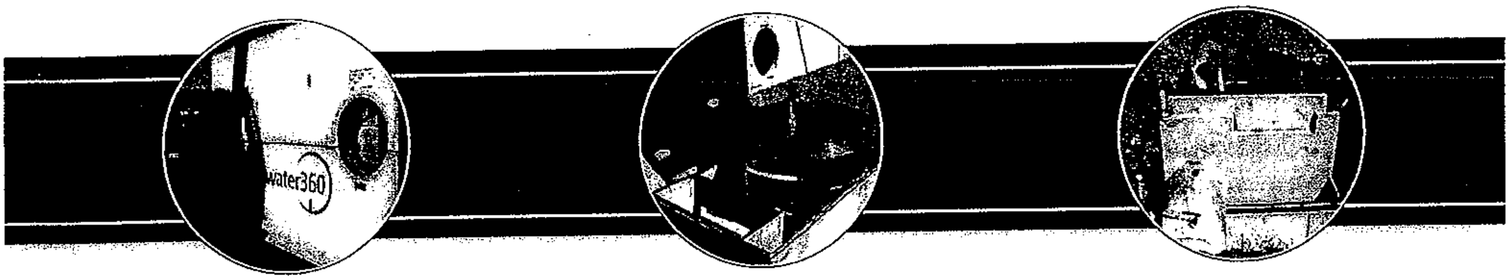


How does it work?

Water enters the swirl chamber at a tangent, inducing a gentle swirling flow pattern and enhancing gravitational separation. Sinking pollutants stay in the swirl chamber while floating pollutants are stopped at the baffle wall. Flow rates are controlled through the system by the low flow control, which reduces inflow velocity. In most applications the Vortechs system is designed to operate at the low flow rate, since this accounts for 80% of the annual runoff volume at most sites.

During larger storms, the water level rises above the low flow control and begins to flow through the high flow control. The layer of floating pollutants is elevated above the influent pipe, preventing re-entrainment. Swirling action increases in intensity in relation to the storm, which helps maintain high sediment removal rates. When the storm drain is flowing at peak capacity, the water surface in the system approaches the top of the high flow control. The Vortechs system will be sized large enough so that previously captured pollutants are retained in the system even during these infrequent events.

As a storm subsides, treated runoff decants out of the Vortechs system at a controlled rate, restoring the water level to a dry-weather level equal to the invert of the inlet and outlet pipe. Besides facilitating inspection and cleaning, the low water level significantly reduces maintenance costs by reducing pump-out volume.



Vortechs®

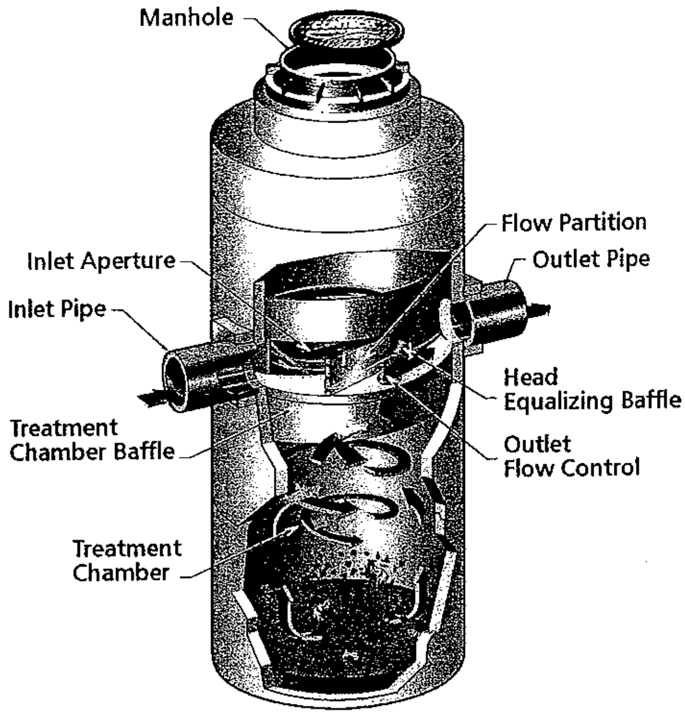
- Proven performance speeds approval process
- Rational Rainfall Method predicts optimal size
- Flow controls reduce inflow velocity and increase residence time
- Unobstructed access simplifies maintenance
- Shallow system profile reduces site excavation
- Very low headloss

VortSentry®

Hydrodynamic separation with internal bypass

The VortSentry® is a hydrodynamic separator with a small footprint that makes it an effective treatment option for projects where space is at a premium and efficiency is critical. The internal bypass ensures treatment chamber velocities remain low, which improves performance and eliminates the risk of resuspension.

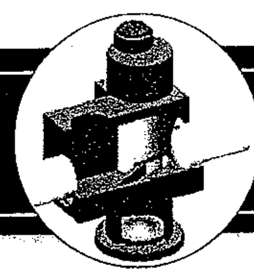
In addition to stand-alone applications, the VortSentry® is an ideal pretreatment device. The system is housed inside a lightweight concrete manhole structure for easy installation (often without the use of a crane) and unobstructed maintenance access.



How does it work?

Stormwater runoff enters the unit tangentially to promote a gentle swirling motion in the treatment chamber. As polluted water circles within the chamber, settleable solids fall into the sump and are retained. Buoyant debris and oil and grease rise to the surface and are separated from the water as it flows under the baffle wall. Treated water exits the treatment chamber through a flow control orifice located behind the baffle wall.

During low-flow conditions all runoff is diverted into the treatment chamber by the flow partition. At higher flow rates, a portion of the runoff spills over the flow partition and is diverted around the treatment chamber, filling the head equalization chamber. This collapses the head differential between the treatment chamber and the outlet, resulting in a relatively constant flow rate in the treatment chamber even with a substantial increase in total flow through the system. This further reduces the potential for resuspension or washout of captured pollutants.



VortSentry®

- Internal bypass and treatment in one structure
- Compact manhole design
- Unobstructed maintenance access
- Round, lightweight construction

VortSentry® High-Flow (HF) model

- Allows a greater bypass flow through the system while maintaining the same level of treatment
- Accommodates pipe diameter up to 72 inches (1800 mm)

Available models

Use this table to identify the appropriate model for your site. Engineers in our Technical Sales department are available to assist with your project.

Vortechs Model	Swirl Chamber Diameter		Internal Length		Peak Treatment Flow		Sediment Storage	
	ft	m	ft	m	cfs	l/s	yd³	m³
1000	3	0.9	9	2.7	1.6	45	0.7	0.5
2000	4	1.2	10	3.0	2.8	80	1.2	0.9
3000	5	1.5	11	3.4	4.5	130	1.8	1.4
4000	6	1.8	12	3.7	6.0	170	2.4	1.8
5000	7	2.1	13	4.0	85	240	3.2	2.5
7000	8	2.4	14	4.3	11	310	4.0	3.1
9000	9	2.7	15	4.6	14	400	4.8	3.7
11000	10	3.0	16	4.9	17.5	500	5.6	4.3
16000	12	3.7	18	5.5	25	710	7.1	5.4

VortSentry Model	Diameter		Typical Depth (below invert)		80% Water Quality Flow[1]		Max. Size Inlet/Outlet		Sediment Storage	
	ft	m	ft	m	cfs	l/s	in	mm	yd³	m³
VS30	3	0.9	5.5	1.7	0.26	7.40	12	300	0.8	0.6
VS40	4	1.2	6.7	2.0	0.58	16.4	18	460	1.4	1.1
VS50	5	1.5	7.6	2.3	1.07	30.3	18	460	2.2	1.7
VS60	6	1.8	8.5	2.6	1.77	50.1	24	600	3.1	2.4
VS70	7	2.1	9.4	2.9	2.70	76.5	30	750	4.3	3.3
VS80	8	2.4	10.2	3.1	3.90	110	36	600	5.6	4.3
VS40 HF	4	1.2	7.5	2.3	0.58	16.4	36	900	1.4	1.1
VS50 HF	5	1.5	8.5	2.6	1.07	30.3	42	1050	2.2	1.7
VS60 HF	6	1.8	9.3	2.8	1.77	50.1	48	1200	3.1	2.4
VS70 HF	7	2.1	10.5	3.2	2.70	76.5	60	1500	4.3	3.3
VS80 HF	8	2.4	11.0	3.4	3.90	110	60	1500	5.6	4.3

[1] Treatment flows based on 80% removal of OK110 silica sand. Note: Larger models may be available in your area.

Support & Maintenance

Our goal: to remove stormwater pollutants

- Drawings and specifications are available at contechstormwater.com.
- Design support is available from our Technical Sales Engineers, to provide site-specific solutions.
- Full maintenance services are available to maximize performance and ensure long-term product viability.

CONTECH® STORMWATER SOLUTIONS INC.

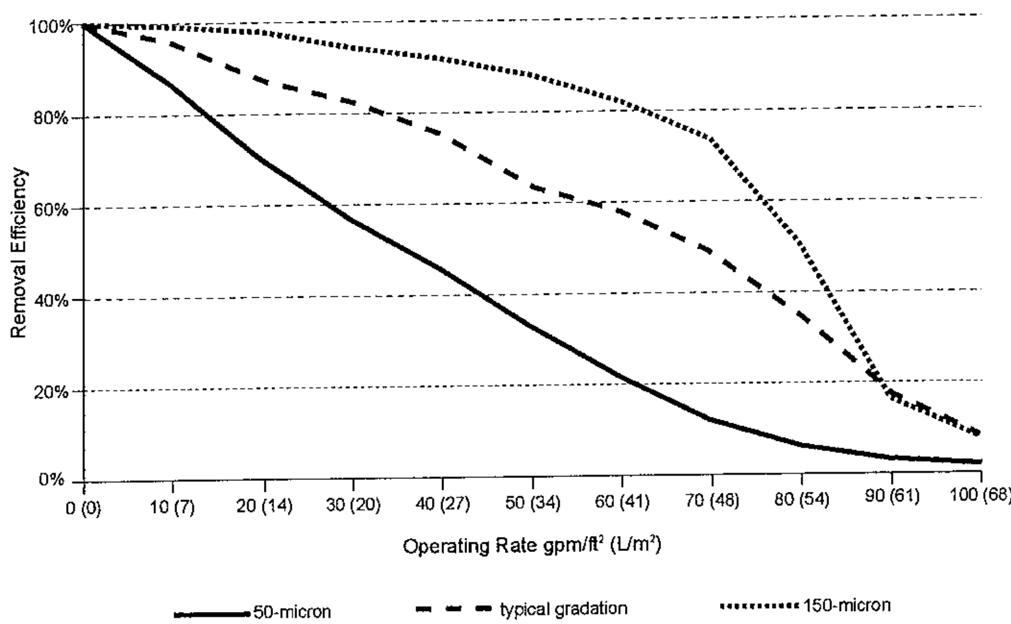
Filtration | Hydrodynamic Separation | Screening | Oil/Water Separation | Flow Control

MK-1009

Vortechs® System Performance: Removal Efficiencies for Selected Particle Gradations

These performance curves are based on laboratory tests using a full scale Vortechs® model 2000. The testing protocol used is summarized on the following page. The 150-micron curve demonstrates the results of tests using particles that passed through a 100-mesh sieve and were retained on a 150-mesh sieve. The 50-micron curve is based on tests of particles passing through a 200-mesh sieve and retained on a 400-mesh sieve. A gradation with an average particle size (d_{50}) of 80 microns, containing particles ranging from 38–500 microns in diameter was used to represent typical stormwater solids.

Vortechs® System Removal Efficiencies for Selected Particle Gradations



As the graph clearly shows, CONTECH Stormwater Solutions systems maintain positive total suspended solids (TSS) removal efficiencies over the full range of operating rates. This allows the system to effectively treat all runoff from large, infrequent design storms, as well as runoff from more frequent low-intensity storms. CONTECH Stormwater Solutions systems are designed to treat peak flows from 1.6 cfs (45 L/s) up to 25 cfs (710 L/s) without bypassing. However, external bypasses can be configured to convey peak flows around the system if treatment capacity is exceeded. The CONTECH Stormwater Solutions system can be configured to direct low flows from the last chamber of the system to polishing treatment when more stringent water quality standards are imposed. In all configurations, high removal efficiencies are achieved during the lower intensity storms, which constitute the majority of annual rainfall volume.

CONTECH Stormwater Solutions systems are sized based on flow rate rather than volume, which allows effective treatment of runoff from the entire storm, including high-intensity flows. This design basis addresses the deficiencies of conventional volume-based BMPs, which capture the first half or whole inch of runoff but may bypass prematurely, allow resuspension of previously captured pollutants, and/or wash out at higher flow rates. For more information about the CONTECH Stormwater Solutions Inc. sizing methodology, please refer to Technical Bulletin No. 3.

Technical Bulletin 1

Laboratory Quality Control Brief

The following protocol contains standard operating procedures for Total Suspended Solids (TSS) testing in the CONTECH Stormwater Solutions laboratory. These guidelines were followed in the creation of the preceding performance curves.

Sediment Source

Sediment samples are sorted according to ASTM Special Technical Publication 477 B, which establishes sieve analysis procedures. U.S. Standard Sieves in a Gilson SS-15 sieve shaker are used to separate particles to the various fractions required for our tests. To ensure uniformity of those fractions, an unsorted sample is sieved until less than 1% of that sample passes through the sieve in one minute. All sediment recovered after a test is dried and re-sieved according to this procedure before reuse. Unless otherwise specified, mineral sediments with a density of 2.65 g/cm^3 are used.

Flow Calibration and Regulations

Flow calibration is accomplished by calculating the head at the baffle wall required to produce a given flow rate through the orifice and the weir in the flow control wall. Flow is regulated by a 12-inch butterfly valve located upstream of the CONTECH Stormwater Solutions system. In order to simulate field conditions, flow rates are changed gradually to avoid flow surges through the system. The test flow rate is set by observing the head in the CONTECH Stormwater Solutions system and adjusting the regulating valve accordingly. Before any samples are collected, the valve must remain fixed for a period equal to half of the detention time so that flow equalizes throughout the system. Each test group is planned so that flow rates increase incrementally in consecutive tests.

Sediment Metering

All sediment is injected into the inlet pipe via a ¼-inch flexible hose using a Watson Marlow 5058 peristaltic metering pump. For TSS tests, a known gradation of sediment and water are combined in approximately a ½ pound/gallon ratio in a holding tank and homogenized by a mixing propeller powered by a ⅓ horsepower motor. The mixer is activated at least five minutes before testing commences and runs continuously throughout the test. The metering pump is activated for a period of time equal to at least half of the detention time of the CONTECH Stormwater Solutions system at the test flow rate, before the first influent sample is taken. The pump must run continuously until the last effluent sample is taken.

Sample Collection

All influent samples are taken from a six-inch gate valve located upstream of the CONTECH Stormwater Solutions system. A collection bin housing a 500 mL sample container is positioned beneath the valve. Five seconds before each sample is taken, the valve is quickly opened and closed to eliminate any interference from particles that have settled in the low velocity region of the gate. This eliminates artificially high influent readings. The time that the influent sample was taken is recorded and the corresponding effluent sample is collected after a period of time equal to the detention time. Effluent grab samples are collected at the discharge pipe, by sweeping the mouth of a 500 mL bottle through the exiting flow stream. Samples are annotated and refrigerated until they can be analyzed.

Sample Analysis

TSS samples are analyzed in the CONTECH Stormwater Solutions laboratory, following EPA method 160.2, a method for the measurement of total non-filterable solids. Volume measurements are accurate to 0.6 mL using a 500 mL graduated cylinder. An Acculab V-1 analytical balance with a readability of 0.001 g is used to measure mass.

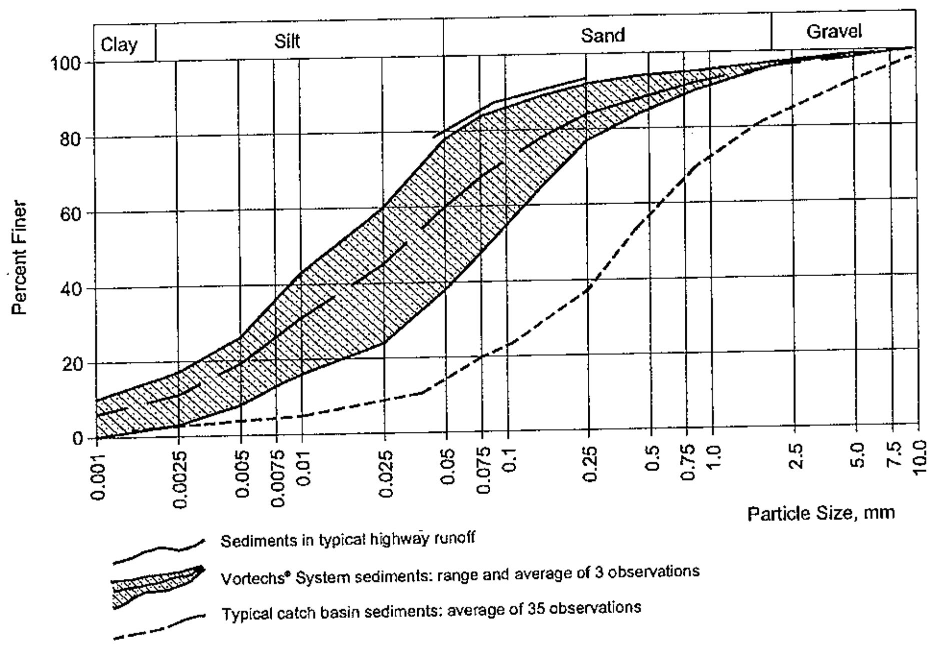
Vortechs®

Technical Bulletin 2

Particle Distribution of Sediments and the Effect on Heavy Metal Removal

Sediments removed from Vortechs® stormwater treatment system installations in Portland and South Portland, Maine were analyzed by a soil testing laboratory to determine size and distribution. These results were compared to similar tests done on sediments carried in highway runoff[1] and on material removed from catch basins by a Vactor truck[2]. The highway runoff sediment data is useful in characterizing typical total stormwater sediment loading. The catch basin data is indicative of sediment removed by typical plug-flow tanks. The data is plotted below for graphical comparison:

Sediment Size and Distribution Comparison



The curves describing sediments extracted from CONTECH Stormwater Solutions systems show enhanced effectiveness across the entire range of particle sizes. In the "mid-range" for example, over 80 percent of the sediment retained by a CONTECH Stormwater Solutions system is approximately 250 microns ("medium sand") and finer particles, compared with less than 40 percent of the sediment in catch basin sumps. The difference between the curves may be interpreted as sediment loss from the catch basins due to turbulence and the resuspension of previously deposited grit. These problems are widely recognized to occur in catch basins and, for that matter, conventional oil/grit separators during brief periods of high flow.

[1]Yousef, Y. A. et.al., 1991, Maintenance Guidelines in Accumulated Sediments in Retention/Detention Ponds Receiving Highway Runoff, Florida Department of Transportation, Tallahassee, FL, p. 17. The study included samples from Highway 50, (Sacremanto), I-81, (Harrisburg), I-94, (Milwaukee) and I-85, (Effland). The curve shown is the average of the four samples.

[2]Analysis of sediments from 35 catch basins performed under the direction of Steven Lazoff, Laboratory Director, Aquatic Research, Inc., Seattle, WA and reported to Bob Storer, King County Surface Water Management Division, Seattle, WA, June 21, 1993.

Vortechs®
Technical Bulletin 2

The curve describing the particle size distribution of sediments found in highway runoff from the study by Dr. Yousef is the result of averaged samples taken from highway sites across the U.S. and is therefore representative of sediment loading. The curve describing sediments in highway runoff and the curves describing sediments in the Vortechs Systems are very similar. This shows that the Vortechs System is highly effective in capturing sediment particles found in highway runoff. The fact that the curves are of such similar shape suggests further that Vortechs System removal efficiency applies equally to the full spectrum of particle sizes and that the Vortechs System never washes out.

A catch basin or virtually any tank with a sump where particles can be stored can effectively settle particles out of stormwater runoff if the flow rate is low enough. In most wet weather the flow rate is low enough to achieve high efficiency. But the converse is also widely recognized to be true; that is, when the flow rate is high, the efficiency is low, often dropping to negative efficiency with the result that the overall efficiency over time approaches zero, especially for fine-grained particles.

Fine-grained sediments pose the greatest environmental threat. Heavy metals, nutrients, and hydrocarbons adhere to the surface of suspended particles and are transported by stormwater runoff. A large number of small particles will provide a larger total surface area for substances to adhere to than a smaller number of larger particles of the same total volume. Trapping this material will significantly reduce the presence of these harmful contaminants in surface waters.

For example, a 1.0 mm cube has a surface area of 6 square millimeters. Dividing that one cube into a thousand 0.1 mm cubes increases the total surface area tenfold to 60 square millimeters. Seventy percent of sediments found in catch basins are 1 mm or smaller, and seventy percent of the sediments removed by Vortechs Systems are 0.1 mm or smaller, so the potential for pollutant capture is much greater.

Relative to more traditional Best Management Practices (BMP's) for stormwater quality improvement, the Vortechs System compares very favorably with respect to dry weight concentrations (mg/kg) of metals found in captured sediments.[3]

	Detention Basin	Sand Filter	Sand Filter w/ Sediment Chamber	Wet Pond	Grassed Swale	BMP Average	Vortechs Average	Variation
Cadmium	4	1.3	4.6	6.4	1.9	3.6	2.8	-22%
Chromium	30	30	52	36	30	36	55	53%
Copper	59	43	71	24.5	27	45	85	89%
Lead	161	81	171	160	420	199	417	110%
Nickel	n/a	30	49	38	13	33	37	12%
Zinc	448	182	418	299	202	310	470	52%
# of observations	11	1	1	38	8	n/a	3	n/a

Research now indicates that the greatest environmental risk appears to occur when metal and hydrocarbon-laden sediments are deposited in downstream lakes and estuaries. This material has a long-term negative impact on the health of surface waters. The data presented in this report shows the Vortechs System is approximately 50% more effective in capturing these sediments than conventional BMP's.

[3]Schueler, Thomas R. and Yousef, Y. A. 1994. Pollutant Dynamics of Pond Muck. Watershed Protection Techniques. Vol. 1, No. 2, p. 44.

Sizing for Net Annual Sediment Removal

One of the greatest threats to aquatic ecosystems is chronic pollution caused by stormwater runoff. Sediments and other associated pollutants accumulate over time seriously degrading surface water quality. For this reason, CONTECH Stormwater Solutions Inc. recommends sizing stormwater best management practices (BMPs) to provide a specific net reduction of pollutants on an annual basis. A typical net annual removal efficiency target is 80%, but depending on sensitivity of the receiving water body or the presence of other best management practices (BMPs), greater or lesser load reduction may be required.

This Technical Bulletin provides a simple two-step sizing methodology that will produce the most appropriate, and most cost effective CONTECH Stormwater Solutions system for your site.

Step #1 – Sizing for a Specific Net Annual Load Reduction

CONTECH Stormwater Solutions system performance is dependent on the local rainfall intensity distribution and other site-specific factors. In order to account for regional rainfall differences, CONTECH Stormwater Solutions developed the Rational Rainfall Method™ of sizing. Central to the method is the design ratio, which changes according to regional differences in precipitation patterns, as well as site and model characteristics. Maximum design ratios for different geographic regions across North America have been determined through analysis of historical precipitation records archived by the National Climatic Data Center.

To determine the minimum CONTECH Stormwater Solutions system model that will meet your treatment objective, perform the following steps:

A. Determine the net annual removal efficiency target and time of concentration that best match your site.

B. Determine the design ratio for your site location that corresponds to your treatment goal and time of concentration. The design ratio for the chosen model should not exceed the target design ratio (see below equation). Please contact your local CONTECH Stormwater Solutions representative for the appropriate design ratio number.

Imperial:

$$\text{Target Design Ratio} \geq \frac{\text{CdA *448.83 gpm/cfs}}{\text{Grit Chamber Area}}$$

Metric:

$$\text{Target Design Ratio} \geq \frac{\text{CdA * 2.78}}{\text{Grit Chamber Area}}$$

Where:

A = Drainage Area (acres/hectares)
C_d = Runoff Coefficient

C. Calculate the necessary swirl chamber area and corresponding CONTECH Stormwater Solutions system model using the following equation:

Imperial:

$$\text{Minimum Swirl Chamber Area} \geq \frac{C_dA \text{ *448.83 gpm/cfs}}{\text{Design Ratio}}$$

Metric:

$$\text{Minimum Swirl Chamber Area} \geq \frac{C_dA \text{ * 2.77}}{\text{Design Ratio}}$$

D. Based on the required swirl chamber area calculated in Step C, choose the appropriate Vortechs® model number from Table 3.1.

This is the smallest model that can be expected to achieve your treatment goal. To decide if this CONTECH Stormwater Solutions system will be "on-line", without a bypass, or "off-line", with a bypass, proceed to Step #2.

Vortechs® Model	Grit Chamber Area	
	ft²	m²
1000	0 - 7	0 - 0.66
2000	7 - 13	0.66 - 1.7
3000	13 - 20	1.7 - 1.8
4000	20 - 28	1.8 - 2.6
5000	28 - 38	2.6 - 3.6
7000	38 - 50	3.6 - 4.7
9000	50 - 64	4.7 - 5.9
11000	64 - 79	5.9 - 7.3
16000	79 - 113	7.3 - 10.5

Table 3.1

Step #2 – On-Line vs. Off-Line Configuration

The CONTECH Stormwater Solutions system has been tested at operating rates up to 100 gpm/ft² (70 L/m²) of swirl chamber surface area, which corresponds to the peak treatment capacity for each model, and has been found to provide positive removal efficiencies of suspended solids throughout this range. Flow rates exceeding the treatment capacity of the system may cause resuspension of previously captured materials, therefore, it is recommended that flows in excess of the peak treatment capacity for each respective model be bypassed.

The appropriate configuration of the model selected in Step #1 is determined as follows:

A. Calculate the flow rate resulting from an infrequent (10 to 25-year recurrence interval) storm on your site.
B. Compare this flow rate to the peak treatment capacity (Table 3.2) of the model selected in Step #1.
   1. If it is less, the model selected in Step #1 is appropriate on-line.
   2. If it is more, either:
      a. The model selected in Step #1 should be configured with a bypass (provided by CONTECH Stormwater Solutions) in an off-line orientation, or
      b. A system should be selected from Table 3.2 with a treatment capacity equal to or greater than the flow from above. This system should be configured on-line without a bypass.

Vortechs® Model	Peak Treatment Flow	
	cfs	L/s
1000	1.6	45
2000	2.8	80
3000	4.5	130
4000	6.0	170
5000	8.5	240
7000	11	310
9000	14	400
11000	17.5	500
16000	25	710

Table 3.2

The choice between an off-line model and an on-line model is usually determined by economics. For example the cost savings gained by using the smaller off-line unit must be weighed against the cost of additional manholes typically required to split and rejoin bypassed flows. For pricing information please contact your CONTECH Stormwater Solutions representative.

Vortechs®

Technical Bulletin 3a

Determining Bypass Weir Elevation for Off-Line Vortechs® Systems

Proper bypass configuration maximizes the amount of flow treated by a CONTECH Stormwater Solutions system while ensuring that the system's treatment capacity is not exceeded. Since the crest elevation of the bypass weir is dependant on the design of the CONTECH Stormwater Solutions system, CONTECH Stormwater Solutions Inc. prefers to recommend the bypass design. To optimize the bypass function, the following design methodology is typically followed.

Calculating the Bypass Weir Crest Elevation

1. Determine peak conveyance capacity of the stormwater collection system (minimum 10-year event).
2. Subtract the treatment capacity of the CONTECH Stormwater Solutions system from the peak flow rate determined in Step 1. The result (Q_{bypass}) is the flow rate that must be bypassed to avoid surcharging the CONTECH Stormwater Solutions system.
3. Use the bypass weir length, as dictated by the diversion structure, to calculate the depth required to pass the flow calculated in Step 2 with the following arrangement of the Francis formula (which assumes a rectangular broad crested weir).

$$H=\left(\frac{Q_{bypass}}{C_d L}\right)^{2/3}$$

Where:
C_d = 3.3 = Discharge Coefficient for Broad Crested Weir
L = Length of Bypass Weir Crest

4. Subtract the depth calculated in Step 3 from the elevation at the top of the weir opening in the Vortechs® system flow control wall (supplied by CONTECH Stormwater Solutions). The result is the crest elevation of the bypass weir.

In cases where tailwater elevations exceed the crown of the outlet pipe, or where other site conditions require special consideration, some variation of this method may be used. If a specific water quality flow must be treated before bypass, the length of the bypass weir and the flow controls within the CONTECH Stormwater Solutions system can be modified accordingly. For all designs, CONTECH Stormwater Solutions engineers complete a stage discharge worksheet, which is available on request.

Bypass Weir Calculations

Q_{bypass}	=	Flow over bypass weir (cfs)
Q_{design}	=	CONTECH Stormwater Solutions system treatment capacity (cfs)
Q_{convey}	=	Estimated peak conveyance capacity of collection system (cfs)
L	=	Length of bypass weir crest (ft)
C_d	=	Discharge Coefficient = 3.3 for rectangular weir
E_{bypass}	=	Elevation of bypass weir crest (ft)
WSE_{peak}	=	Water surface elevation for Q_{convey} (generally equal to the elevation at the top of the Cippoletti weir, ft)
H	=	Depth of flow over bypass weir crest (ft)
Q_{bypass}	=	$Q_{convey} - Q_{design}$ (Calculate the flow over the bypass weir during peak conveyance event)
Q_{bypass}	=	$C_d L H^{3/2}$ (Francis formula for rectangular weir)
H	=	$(Q_{bypass}/3.3L)^{2/3}$ (Use this arrangement of the Francis formula to solve for H)
E_{bypass}	=	WSE_{peak} - H (Solve for bypass weir crest levation – E_{bypass})

Vortechs®

Technical Bulletin 4

Modeling Long Term Load Reduction: The Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydrologically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. To estimate efficiencies as accurately as possible, CONTECH Stormwater Solutions Inc. has developed the Rational Rainfall Method™ which combines site-specific information with laboratory generated performance data (see Technical Bulletin 1 for more information), and local historical precipitation records.

Short duration rain gauge records from across the United States and Canada were analyzed by CONTECH Stormwater Solutions to determine the percent of the total annual rainfall that fell at a range of intensities. At U.S. stations, depths were totaled every 15 minutes or hourly and recorded in 0.01-inch increments. Depths were recorded hourly with 1 mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and intense storms contributed relatively little to the total depth.

These intensities along with the total drainage area and runoff coefficient for each specific site are translated into flow rates using the Rational Method. The flow rates are then used to calculate operating rates for a proposed CONTECH Stormwater Solutions system. Finally, operating rates are paired with their corresponding removal efficiencies. See figure 4 for a graphic illustration this relationship between operating rate, removal efficiency and intensity distribution.

The net annual TSS removal efficiency is then calculated by summing the relative efficiencies at each intensity (see Table 4.1 and 4.2).

How the Vortechs® System Removal Efficiencies and Operating Rates Relate to Rainfall Intensity Distribution

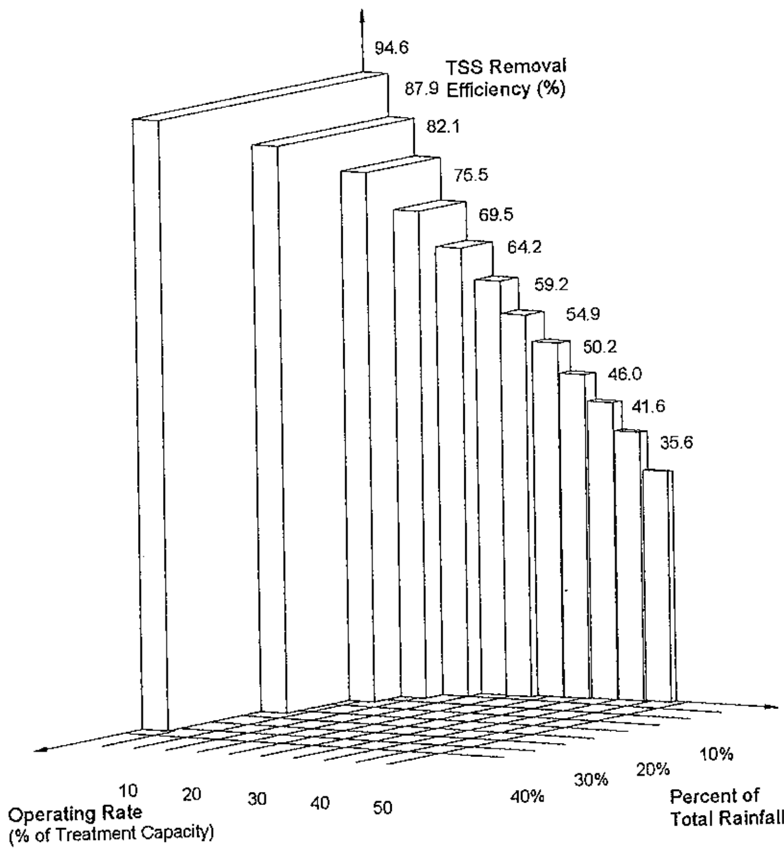


Figure 4

The same process was used to develop the CONTECH Stormwater Solutions sizing methodology described in Technical Bulletin 3. The design ratio was created as a tool to help calculate an operating rate from an intensity. Maximum design ratios for different geographic regions across North America have been determined through analysis of historical precipitation records archived by the National Climatic Data Center. Depending on climatic regime, design ratio thresholds vary, with higher design ratio thresholds in areas like the Gulf Coast where high intensity precipitation is common and lower thresholds in areas like the Pacific Northwest where the vast majority of rain falls at very low

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Technical Bulletin 4

Table 4.1: Vortechs® Model 5000 Net Annual TSS Removal Efficiency in Portland, ME

$$\text{Design Ratio}^1 = \frac{(4.5 \text{ acres}) * (0.95) * 449 \text{ gpm/ft}^2)}{38.5 \text{ ft}^2} = 50$$

Rainfall Intensity		Operating Rate[2]	% Total Rainfall Volume[3]	Removal Efficiency[4]	Relative Efficiency
in/0.25 hr	in/hr	gpm/ft²			
0.02	0.08	4	36.9%	94%	34.7%
0.04	0.16	8	21.9%	88%	19.3%
0.06	0.24	12	11.9%	82%	9.8%
0.08	0.32	16	7.6%	76%	5.8%
0.10	0.40	20	5.0%	70%	3.5%
0.12	0.48	24	2.9%	64%	1.9%
0.14	0.56	28	3.0%	60%	1.8%
0.16	0.64	32	2.0%	55%	1.1%
0.18	0.72	36	1.8%	51%	0.9%
0.20	0.80	40	1.4%	46%	0.7%
0.22	0.88	44	1.2%	41%	0.5%
0.24	0.96	48	0.8%	36%	0.3%
				subtotal:	**80.2%**
				% rain falling at 0.96 in/hr:	**3.5%**
				assumed removal efficiency of remaining %:	**0.0%**
				net annual TSS removal efficiency:	**80%**

1 - Design Ratio = (Total Drainage Area) * (Runoff Coefficient) * (cfs to gpm conversion) / Grit Chamber Area
- Total Drainage Area and Runoff Coefficient are specified by the site engineer.
- The conversion factor from cfs to gpm is 449.

2 - Operating Rate (gpm/ft²) = Intensity (in/hr) * Design Ratio
3 - Based on 5 years of rainfall data recorded at 15 minute intervals in Portland, ME.
4 - Based on CONTECH Stormwater Solutions laboratory verified removal of 50 micron particles.

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Table 4.2: Vortechs® Model 5000 Net Annual TSS Removal Efficiency in Toronto, ON, Canada

$$\text{Design Ratio}^1 = \frac{(2.3\ \text{hectare}) * (100\%) * (2.78)}{3.58\ m^2} = 1.79$$

Rainfall Intensity mm/hr	Operating Rate[2] (L/s)	% Total Rainfall Volume[3]	Removal Efficiency[4]	Relative Efficiency
1	1.8	19.7%	97%	19%
2	3.6	18.4%	93%	17%
3	5.4	10.8%	90%	9.7%
4	7.2	9.3%	86%	8.0%
5	8.9	7.3%	80%	5.9%
6	11	6.0%	77%	4.7%
7	13	5.8%	72%	4.2%
8	14	3.2%	68%	2.2%
9	16	1.9%	65%	1.3%
10	18	4.2%	62%	2.6%
11	20	2.5%	60%	1.5%
12	21	1.9%	56%	1.0%
15	27	3.5%	47%	1.6%
20	36	2.1%	31%	0.7%
25	45	2.4%	16%	1.4%
			subtotal:	**81%**
			% rain falling at > 25 mm/hr:	**1.0%**
			assumed removal efficiency of remaining %:	**0.0%**
			net annual TSS removal efficiency:	**81%**

1 - Design Ratio = (Total Drainage Area) * (Runoff Coefficient) * (2.77) / Grit Chamber Area
- Total Drainage Area and Runoff Coefficient are specified by the site engineer.

2 - Operating Rate (L/s) = Intensity (mm/hr) * Design Ratio

3 - Based on 10 years of rainfall data from Canadian Station 6158350, Toronto, Ontario, Canada.

4 - Based on CONTECH Stormwater Solutions laboratory verified removal of 50 micron particles.

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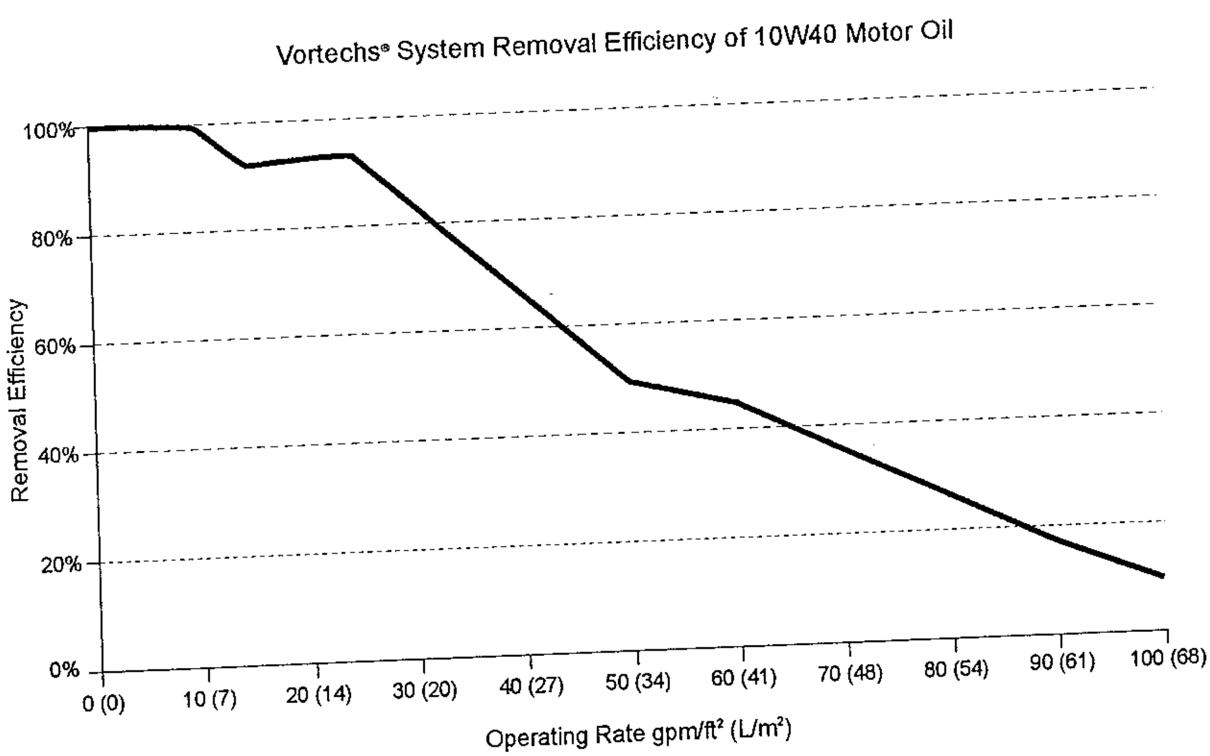
Technical Bulletin 5

Vortechs® System Performance: Oil Removal Efficiency

Petroleum based hydrocarbons are transported in stormwater at event mean concentrations typically ranging from two to five mg/L in residential areas to greater than 40 mg/L in concentrated traffic areas. Primary sources include leakage from improperly maintained vehicles; direct dumping of used oil and accidental spillage during maintenance and refueling of vehicles. The following CONTECH Stormwater Solutions system performance curve was generated from tests performed in the CONTECH Stormwater Solutions Inc. laboratory, with a full scale Vortechs® model 2000, using 10w40 motor oil. Oil was metered into the system using a variable speed peristaltic pump, producing influent concentrations between 15 mg/L and 90 mg/L. Influent concentrations decreased with operating rates, to simulate field conditions where the majority of oil is transported in the first flush and diluted at high flow rates. All samples were taken in one liter tinted glass bottles, fixed with H_2SO_4, and analyzed according to EPA Method 1664 by an independent laboratory.

Many localities recognize the potentially lethal effects of oil and grease in aquatic systems and require treatment of stormwater from high-risk areas. The CONTECH Stormwater Solutions system can help protect sensitive watersheds by removing very high percentages of incoming free oil. All Models provide emergency spill containment and can be designed to detain specific volumes. The graph below shows the removal efficiencies of the System over the range of operating rates. Routine storm events (about 80 to 90 percent of annual runoff volume) typically produce operating rates of less than 25 gpm/ft². At these lower operating rates, removal efficiencies are very high. Peak design storm flow rates (e.g., 10-year storms) may cause CONTECH Stormwater Solutions systems to operate at up to 100 gpm/ft².



CONTECH®
STORMWATER SOLUTIONS INC.

Vortechs® System

Technical Design Manual

Vortechs System Contents

Design and Operation

Basic Operation

The Vortechs® System is a hydrodynamic separator designed to enhance gravitational separation of floating and settling materials from stormwater flows. Stormwater flows enter the unit tangentially to the grit chamber, which promotes a gentle swirling motion. As polluted water circles within the grit chamber, pollutants migrate toward the center of the unit where velocities are the lowest. The majority of settleable solids are left behind as stormwater exits the grit chamber through two apertures on the perimeter of the chamber. Next, buoyant debris and oil and grease are separated from water flowing under the baffle wall due to their relatively low specific gravity. As stormwater exits the System through the flow control wall and ultimately through the outlet pipe, it is relatively free of floating and settling pollutants.

Over time a conical pile tends to accumulate in the center of the unit containing sediment and associated metals, nutrients, hydrocarbons and other pollutants. Floating debris and oil and grease form a floating layer trapped in front of the baffle wall. Accumulation of these pollutants can easily be accessed through manholes over each chamber. Maintenance is typically performed through the manhole over the grit chamber.

Design Process

Each Vortechs System is custom designed based on:

- Site size
- Site runoff coefficient
- Regional precipitation intensity distribution
- Anticipated pollutant characteristics

These factors are incorporated into the Rational Rainfall Method™ to estimate net annual pollutant removal efficiency.

The Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydraulically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. The Rational Rainfall Method™ combines site-specific information with laboratory generated performance data, and local historical precipitation records to estimate efficiencies as accurately as possible.

Short duration rain gauge records from across the United States and Canada were analyzed to determine the percent of the total annual rainfall that fell at a range of intensities. US stations' depths were totaled every 15 minutes or hourly and recorded in 0.01-inch increments. Depths were recorded hourly with 1 mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Rainfall Method. Since most sites are relatively small and highly impervious, the Rational Rainfall Method is appropriate. Based on the flow rates calculated for each intensity, an operating rate within a proposed Vortechs System is determined. Finally, a removal efficiency is selected for each operating rate based on anticipated pollutant characteristics and on full scale laboratory tests. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

CONTECH Stormwater Solutions typically selects the system that will provide an 80% annual TSS load reduction based on laboratory generated performance curves for 50-micron sediment particles, however the Rational Rainfall Method can accommodate other removal efficiency or particle size targets. It can also be used to estimate annual hydrocarbon load reductions.

Once a System size is established, the internal elements of the System will be designed based on information provided by the site engineer. Flow control sizes and shapes, sump depth, spill storage capacity, sediment storage volume and inlet and outlet orientation are determined for each System. In addition, bypass weir calculations are made for off-line Systems.

Flow Control Calculations

The Orifice

The lower flow control or "orifice" is typically sized to submerge the inlet pipe when the Vortechs System is operating at 20% of its' treatment capacity. The orifice is typically a Cippoletti shaped aperture defined by its flat crest and sides which incline outwardly at a slope of 1 horizontal to 4 vertical.

➡ Flow through orifice = $Q_{orf} = C_d \bullet A \bullet (2gh)^{0.5}$

Where C_d = Orifice contraction coefficient = 0.56 (based on CONTECH Stormwater Solutions laboratory testing)
A = Orifice flow area, ft^2 (calculated by CONTECH Stormwater Solutions technical staff)
h = Design head, ft (equal to the inlet pipe diameter)

The minimum orifice crest length is 3-inches and the minimum orifice height is 4-inches. If flow must be restricted beyond what can be provided by this size aperture, a Fluidic-Amp™ hydro-brake flow control will be used. The hydro-brake allows the minimum flow constriction to remain at 3-inches or greater while further reducing flow due to its unique throttling action.

The Weir

The high flow control or "weir" is sized to pass the peak System capacity minus the peak orifice flow when the water surface elevation is at the top of the weir. This flow control is also a Cippoletti type weir.

The weir flow control is sized by solving for the crest length and head in the following equation:

➡ Flow through weir = $Q_{weir} = C_d \bullet L \bullet (h)^{1.5}$

Where C_d = Cippoletti Weir coefficient = 3.37 (based on CONTECH Stormwater Solutions laboratory testing)
h = Available head, ft (height of weir)
L = Design weir crest length, ft (calculated by CONTECH Stormwater Solutions technical staff)

Bypass Calculations

In some cases, pollutant removal goals can be met without treating peak flow rates and it is most feasible to use a smaller Vortechs System configured with an external bypass. In such cases, a bypass design is recommended by CONTECH Stormwater Solutions for each off-line System. To calculate the bypass capacity, first subtract the System's treatment capacity from the peak conveyance capacity of the collection system (minimum of 10 year recurrence interval). The result is the flow rate that must be bypassed to avoid surcharging the Vortechs System. Then use the following arrangement of the Francis formula to calculate the depth of flow over the bypass weir.

➡ Flow over bypass weir = $H = (Q_{bypass}/(C_d \bullet L))^{2/3}$

Where
C_d = Discharge Coefficient = 3.3 for rectangular weir
H = Depth of flow over bypass weir crest, ft
L = Length of bypass weir crest, ft

The bypass weir crest elevation is then calculated to be the elevation at the top of the Cippoletti weir minus the depth of flow.

Hydraulic Capacity

In the event that the peak design flow from the site is exceeded, it is important that the Vortechs System is not a constriction to runoff leaving the site. Therefore, each System is designed with enough hydraulic capacity to pass the 100-year flow rate. It is important to note that at operating rates above 100 gpm/ft^2 of the grit chamber area (peak *treatment* capacity), captured pollutants may be lost.

When the System is operating at peak *hydraulic* capacity, water will be flowing through the gap over the top of the flow control wall as well as the orifice and the weir.

Maintenance

The Vortechs System should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit, e.g., unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. CONTECH Stormwater Solutions recommends ongoing quarterly inspections of the accumulated sediment. Pollutant deposition and transport may vary from year to year and quarterly inspections will help insure that systems are cleaned out at the appropriate time. Inspections should be performed more often in the winter months in climates where sanding operations may lead to rapid accumulations, or in equipment washdown areas. It is very useful to keep a record of each inspection. A simple form for doing so is provided.

The Vortechs System should be cleaned when inspection reveals that the sediment depth has accumulated to within six inches of the dry-weather water surface elevation. This determination can be made by taking 2 measurements with a stadia rod or similar measuring device; one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. The System should be cleaned out if the difference between the two measurements is six inches or less. Note: to avoid underestimating the volume of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.

Cleaning

Maintaining the Vortechs system is easiest when there is no flow entering the system. For this reason, it is a good idea to schedule the cleanout during dry weather. Cleanout of the Vortechs system with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. If such a truck is not available, a "clamshell" grab may be used, but it is difficult to remove all accumulated pollutants with such devices.

In installations where the risk of large petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually cheaper to dispose of than the oil water emulsion that may be created by vacuuming the oily layer. Trash can be netted out if you wish to separate it from the other pollutants.

Accumulated sediment is typically evacuated through the manhole over the grit chamber. Simply remove the cover and insert the vacuum hose into the grit chamber. As water is evacuated, the water level outside of the grit chamber will drop to the same level as the crest of the lower aperture of the grit chamber. It will not drop below this level due to the fact that the bottom and sides of the grit chamber are sealed to the tank floor and walls. This "Water Lock" feature prevents water from migrating into the grit chamber, exposing the bottom of the baffle wall. Floating pollutants will decant into the grit chamber as the water level there is drawn down. This allows most floating material to be withdrawn from the same access point above the grit chamber.

If maintenance is not performed as recommended, sediment may accumulate outside the grit chamber. If this is the case, it may be necessary to pump out all chambers. It is a good idea to check for accumulation in all chambers during each maintenance event to prevent sediment build up there.

Manhole covers should be securely seated following cleaning activities, to ensure that surface runoff does not leak into the unit from above.

Vortechs System Inspection & Maintenance Log – Sample

Model: 5000			Location: Smith Superstores, Detroit, MI		
Date	Water Depth to Sediment[1]	Floatable Layer Thickness[2]	Maintenance Performed	Maintenance Personnel	Comments
12/1/01	36"	0"	N/A	B. Johnson	Installed
3/1/02	28"	Sheen	None	B. Johnson	Swept parking lot
6/1/02	24"	Heavy Sheen	None		
9/1/02	20"	1"	Sorbent pads deployed to remove captured oil	S. Riley	Oil spill
12/1/02	12"	Sheen	None	S. Riley	
4/1/03	6"	0.5"	Clean-out scheduled	S. Riley	Heavy floating debris
4/15/03	36"	0"	Grit Chamber evacuated	ACE Environmental Services	Cleanout completed

SAMPLE SHEET

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. When the difference between the two measurements is six inches or less, the system should be cleaned out.
2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of a spill, the system should be cleaned immediately.

Vortechs System Inspection & Maintenance Log

Model:			Location:		
Date	Water Depth to Sediment[1]	Floatable Layer Thickness[2]	Maintenance Performed	Maintenance Personnel	Comments

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. When the difference between the two measurements is six inches or less, the system should be cleaned out.
2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of a spill, the system should be cleaned immediately.

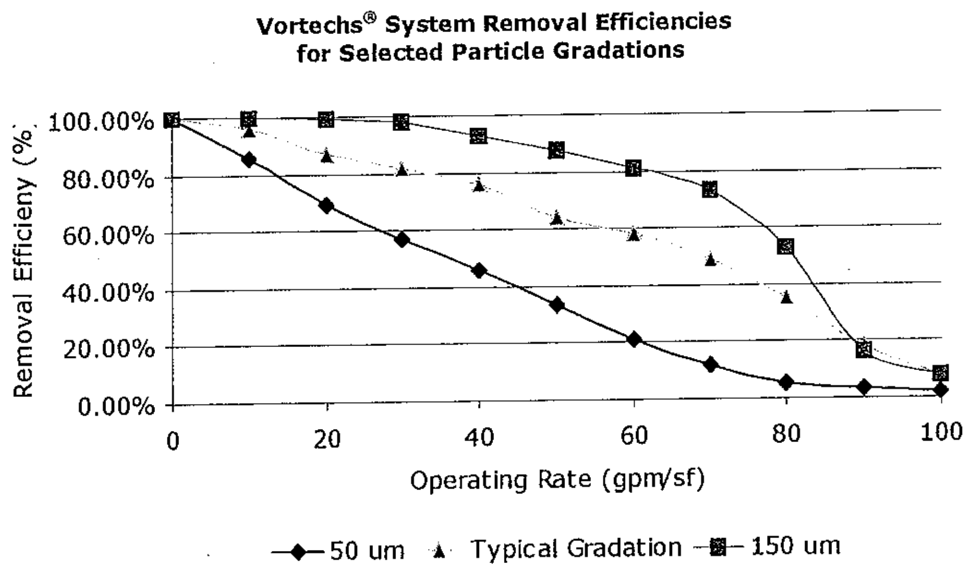
Laboratory and Field Testing

Introduction

CONTECH Stormwater Solutions is an established leader in the stormwater treatment industry, marketing the Vortechs Stormwater Treatment System as a technology capable of removing a high percentage of floating and settling pollutants from stormwater flows. Extensive testing in both the laboratory and in the field has produced a comprehensive set of data describing the relationship between flow rate, particle size, and removal efficiency.

Sections 1 and 2 contain the results of laboratory and field-testing. Section 1 shows the results of full-scale testing with a Vortechs Model 2000 at a CONTECH Stormwater Solutions laboratory in Portland, Maine. Section 2 includes long term monitoring results from several Vortechs Systems installed on typical projects.

Figure 1. Laboratory Testing - Vortechs Stormwater Treatment System Performance



These performance curves are based on laboratory tests using a full scale Vortechs Model 2000. The testing protocol used is described on the following pages. The 150-micron curve demonstrates the results of tests using particles that passed through a 100-mesh sieve and were retained on a 150-mesh sieve. The 50-micron curve is based on tests of particles passing through a 200-mesh sieve and retained on a 400-mesh sieve. A slurry representing an average stormwater sediment gradation, with the particle size gradation shown in Table 1 on page 121, was also tested in our laboratory.

As the graph clearly shows, Vortechs Systems maintain positive total suspended solids (TSS) removal efficiencies over the full range of operating rates, allowing the system to effectively treat all runoff from large infrequent design storms as well as runoff from the more frequent low intensity storms. Precast Vortechs Systems are designed to treat peak flows from 1.6 cfs up to 25 cfs without bypassing. Peak flows that exceed rated treatment capacities can be conveyed around the system with an external bypass. Internal bypasses can be configured to direct low flows from the last chamber of the Vortechs system to polishing treatment when more stringent water quality standards are imposed. In all configurations, high removal efficiencies are achieved during the lower intensity storms, which constitute the majority of annual rainfall volume.

Laboratory Quality Control Brief

The following protocol summarizes standard operating procedures for Total Suspended Solids (TSS) testing in the CONTECH Stormwater Solutions Laboratory. These guidelines were followed in the creation of the preceding performance curves.

Sediment Source

Sediment samples are sorted according to ASTM Special Technical Publication 477 B, which establishes sieve analysis procedures. U.S. Standard Sieves in a Gilson SS-15 sieve shaker are used to separate particles to the various fractions required for our tests. To ensure uniformity of those fractions, an unsorted sample is sieved until less than 1% of that sample passes through the sieve in one minute. All sediment recovered after a test is dried and sent back through a sieve before reuse. Unless otherwise specified, mineral sediments with a density of 2.65 g/cm^3 are used.

The following table describes the particle size distribution of samples tested by CONTECH Stormwater Solutions to represent TSS Loading in typical urban runoff.

Table 1.

Particle Size Distribution	**Percentage of Sample Make-up**
< 63 mm	42%
63 – 75 mm	4%
75 – 100 mm	9%
100 – 150 mm	7%
150 – 250 mm	11%
> 250 mm	27%

Flow Calibration and Regulation

Flow calibration is accomplished by calculating the head at the baffle wall required to produce a given flow rate through the orifice and the weir in the flow control wall. Flow is regulated by a 12-inch butterfly valve located upstream of the Vortechs system. In order to simulate field conditions, flow rates are changed gradually to avoid flow surges through the system. The test flow rate is set by observing the head in the Vortechs system and adjusting the regulating valve accordingly. Before any samples are collected, the valve must remain fixed for a period equal to half of the detention time so that flow equalizes throughout the system. Each test group is planned so that flow rates increase incrementally in consecutive tests.

Sediment Metering

All sediment is injected into the inlet pipe via a ¼-inch flexible hose using a Watson Marlow 5058 peristaltic metering pump. For TSS tests, a known gradation of sediment and water are combined in approximately a 1/2 pound/gallon ratio in a holding tank and homogenized by a mixing propeller powered by a 1/3 horsepower motor. The mixer is activated at least 5 minutes before testing commences and runs continuously throughout the test. The metering pump is activated for a period of time equal to at least half of the detention time of the Vortechs system at the test flow rate, before the first influent sample is taken. The pump must run continuously until the last effluent sample is taken.

Sample Collection

All influent samples are taken from a 6-inch gate valve located upstream of the Vortechs system. A collection bin housing a 500 mL sample container is positioned beneath the valve. Five seconds before each sample is taken the valve is quickly opened and closed to eliminate any interference from particles that have settled in the low velocity region of the gate. This eliminates artificially high influent readings. The time that the influent sample was taken is recorded and the corresponding effluent sample is collected after a period of time equal to the detention time. Effluent grab samples are collected at the discharge pipe, by sweeping the mouth of a 500 mL bottle through the exiting flow stream. Samples are annotated and refrigerated until they can be analyzed.

Sample Analysis

TSS samples are analyzed in the CONTECH Stormwater Solutions laboratory, following EPA method 160.2, a method for the measurement of total non-filterable solids. Volume measurements are accurate to 0.6 mL using a 500 mL graduated cylinder and an Acculab V-1 analytical balance with a readability of 0.001 g is used to measure mass.

Field Testing - Vortechs System Field Monitoring Summary

CONTECH Stormwater Solutions has become a leader in the stormwater industry in large part because of the company's unwavering long-term commitment to research and development. In addition to performing their own field tests, CONTECH Stormwater Solutions has diligently pursued opportunities to work with third party organizations to test their products. In fact, the Vortechs system has been subjected to the most comprehensive third party testing in the industry. These independent studies have allowed CONTECH Stormwater Solutions to corroborate their lab and field data to ensure that actual performance of the Vortechs system matches their claims.

Following are brief summaries of the field tests completed to date. Please contact CONTECH Stormwater Solutions for the full reports. In addition, all reports are available for download on CONTECH Stormwater Solutions web site at www.contechstormwater.com.

DeLorme Mapping Company - Yarmouth, ME
CONTECH Stormwater Solutions

Prior to this premier field test of the Vortechs system, CONTECH Stormwater Solutions developed an extensive body of laboratory data to document total suspended solids (TSS) removal efficiency. CONTECH Stormwater Solutions performed this field study in order to compare the performance predicted using laboratory data to the performance of a correctly sized system in the field.

The study site was the headquarters of DeLorme Mapping in Yarmouth, Maine. The building, driveway, parking lot and ancillary facilities were constructed in 1996. A Vortechs Model 11000 was installed to treat runoff from the 300-space, 4-acre parking lot.

Testing Period	May 1999 to Dec. 1999
# of Storms Sampled	20
Mean Influent Concentration	328 mg/L
Mean Effluent Concentration	60 mg/L
Removal Efficiency	82%

The main purpose of the DeLorme study was to verify that the sizing methodology developed from our full-scale laboratory testing was valid and an accurate means of predicting field performance. The results of the study confirmed our sizing methodology.

Village Marine Drainage - Lake George, NY
New York State Department of Environmental Conservation, Division of Water

The New York State DEC used funds obtained in a Section 319 grant to initiate a study of the effectiveness of the Vortechs system to remove sediment and other pollutants transported by stormwater to Lake George, Lake George Village, New York. "Since the 1970s, when there was a rapid increase in the rate and concentration of development along the southwestern shores of Lake George, we have been concerned about the impact of stormwater discharges into the lake," said Tracy West, co-author of the study.

Testing Period	Feb. 2000 to Dec. 2000

# of Storms Sampled	13
Mean Influent Concentration	801 mg/L
Mean Effluent Concentration	105 mg/L
Removal Efficiency	88%

The study concluded that the Village and Town of Lake George should consider installing additional Vortechs Systems in areas where sedimentation and erosion have been identified as non-point source pollution problems.

Harding Township Rest Area - Harding Township, NJ
RTP Environmental Associates

This third party evaluation was performed under a U.S. Environmental Protection Agency grant, administered by the New Jersey Department of Environmental Protection. A. Roger Greenway, principal of RTP Environmental Associates, Inc., conducted the study in conjunction with Thonet Associates, which assisted with data analysis and helped develop best management practices (BMP) recommendations.

The Vortechs Model 4000 was sized to handle a 100-year storm from the three-acre paved parking area at the Harding Rest Stop, located off the northbound lane of I-287 in Harding Township, New Jersey.

Testing Period	May 1999 to Nov. 2000
# of Storms Sampled	5
Mean Influent Concentration (TSS)	493 mg/L
Mean Effluent Concentration (TSS)	35 mg/L
Removal Efficiency (TSS)	93%
Mean Influent Concentration (TPH)	16 mg/L
Mean Effluent Concentration (TPH)	5 mg/L
Removal Efficiency (TPH)	67%

The study concluded that truck rest stops and similar parking areas would benefit from installing stormwater treatment systems to mitigate the water quality impacts associated with stormwater runoff from these sites.

Timothy Edwards Middle School - South Windsor, CT
UCONN Department of Civil & Environmental Engineering

Susan Mary Board published this study of the Vortechs system as a thesis as part of the requirements for a Master of Science degree from the University of Connecticut. Her objective was to determine how well the Vortechs system retained pollutants from parking lot runoff, including total suspended solids (TSS), nutrients, metals, and petroleum hydrocarbons.

A Vortechs Model 5000 was installed in 1998 to treat runoff from the 82-space parking lot of Timothy Edwards Middle School. The entire watershed was approximately 2 acres, and was 80% impervious.

Testing Period	July 2000 to April 2001
# of Storms Sampled	Weekly composite samples taken
Mean Influent Concentration	324 mg/L
Mean Effluent Concentration	73 mg/L
Removal Efficiency	77%

Additionally, the Vortechs system was particularly effective in removing zinc (85%), lead (46%), copper (56%), phosphorus (67%) and nitrate (54%).

The study concluded that the Vortechs Stormwater Treatment system significantly reduced effluent concentrations of many pollutants in stormwater runoff.

SECTION 02721

STORMWATER TREATMENT SYSTEM

PART 1.00 GENERAL

1.1 DESCRIPTION

A. Work included:
The Contractor, and/or a manufacturer selected by the Contractor and approved by the Engineer, shall furnish all labor, materials, equipment and incidentals required and install all precast concrete stormwater treatment systems and appurtenances in accordance with the Drawings and these specifications.

1.2 QUALITY CONTROL INSPECTION

A. The quality of materials, the process of manufacture, and the finished sections shall be subject to inspection by the Engineer. Such inspection may be made at the place of manufacture, or on the work site after delivery, or at both places, and the sections shall be subject to rejection at any time if material conditions fail to meet any of the specification requirements, even though sample sections may have been accepted as satisfactory at the place of manufacture. Sections rejected after delivery to the site shall be marked for identification and shall be removed from the site at once. All sections which have been damaged beyond repair during delivery will be rejected and, if already installed, shall be repaired to the Engineer's acceptance level, if permitted, or removed and replaced, entirely at the Contractor's expense.

B. All sections shall be inspected for general appearance, dimensions, soundness, etc. The surface shall be dense, close textured and free of blisters, cracks, roughness and exposure of reinforcement.

C. Imperfections may be repaired, subject to the acceptance of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final acceptance. Cement mortar used for repairs shall have a minimum compressive strength of 4,000 psi (28 MPa) at the end of 7 days and 5,000 psi (34 MPa) at the end of 28 days when tested in 3 inch (76 mm) diameter by 6 inch (152 mm) long cylinders stored in the standard manner. Epoxy mortar may be utilized for repairs.

1.3 SUBMITTALS

Shop Drawings

The Contractor shall be provided with dimensional drawings and, when specified, utilize these drawings as the basis for preparation of shop drawings showing details for construction, reinforcing, joints and any cast-in-place appurtenances. Shop drawings shall be annotated to indicate all materials to be used and all applicable standards for materials, required tests of materials and design assumptions for structural analysis. Shop drawings shall be prepared at a scale of not less than 3/16-inches per foot (1:75). Six (6) hard copies of said shop drawings shall be submitted to the Engineer for review and approval.

PART 2.00 PRODUCTS

2.1 MATERIALS AND DESIGN

A. Concrete for precast stormwater treatment systems shall conform to ASTM C 857 and C 858 and meet the following additional requirements:

1. The wall thickness shall not be less than 6 inches (152 mm) or as shown on the dimensional drawings. In all cases the wall thickness shall be no less than the minimum thickness necessary to sustain HS20-44 (MS18) loading requirements as determined by a Licensed Professional Engineer.
2. Sections shall have tongue and groove or ship-lap joints with a butyl mastic sealant conforming to ASTM C 990.
3. Cement shall be Type II Portland cement conforming to ASTM C 150.
4. All sections shall be cured by an approved method. Sections shall not be shipped until the concrete has attained a compressive strength of 4,000 psi (28 MPa) or until 5 days after fabrication and/or repair, whichever is the longer.
5. Pipe openings shall be sized to accept pipes of the specified size(s) and material(s), and shall be sealed by the Contractor with a hydraulic cement conforming to ASTM C 595M

B. Internal aluminum plate components shall be aluminum alloy 5052-H32 in accordance with ASTM B 209.

C. Sealant to be utilized at the base of the swirl chamber shall be 60 durometer extruded nitrile butadiene rubber (Buna N) and shall be provided to the concrete precaster for installation.

D. Brick or masonry used to build the manhole frame to grade shall conform to ASTM C 32 or ASTM C 139 and shall be installed in conformance with all local requirements.

E. Casting for manhole frames and covers shall be in accordance with ASTM A48, CL.30B and AASHTO M105. The manhole frame and cover shall be equivalent to Campbell Foundry Pattern #1009A or #1012D custom cast with the CONTECH Stormwater Solutions logo and (optionally) tagline.

F. A bitumen sealant in conformance with ASTM C 990 shall be utilized in the sealing of the joint between the swirl chamber and the vault at the long wall tangent points. The butyl material shall be 3/4-inch thick by 3/4-inch wide.

2.2 PERFORMANCE

Each stormwater treatment system shall adhere to the following performance specifications at the design treatment capacities, as listed below:

Table 2.

Vortechs Model	Design Treatment Capacity cfs (l/s)	Sediment Storage yd^3 (m^3)
1000	0 - 1.6 (0 - 45)	0.7 (0.54)
2000	1.6 - 2.8 (45-80)	1.2 (0.91)
3000	2.8 - 4.5 (80-125)	1.8 (1.38)
4000	4.5 - 6.0 (125-175)	2.4 (1.84)
5000	6.0 - 8.5 (175-240)	3.2 (2.45)
7000	8.5 - 11.0 (240-315)	4.0 (3.06)
9000	11.0 - 14.0 (315-400)	4.8 (3.67)
11000	14.0 - 17.5 (400-495)	5.6 (4.28)
16000	17.5 - 25.0 (495-710)	7.1 (5.43)

Each stormwater treatment system shall include a circular aluminum "swirl chamber" (or "grit chamber") with a tangential inlet to induce a swirling flow pattern that will accumulate and store settleable solids in a manner and a location that will prevent re-suspension of previously captured particulates.

Each stormwater treatment system shall be of a hydraulic design that includes flow controls designed and certified by a professional engineer using accepted principles of fluid mechanics that raise the water surface inside the tank to a pre-determined level in order to prevent the re-entrainment of trapped floating contaminants.

Each stormwater treatment system shall be capable of removing **80% of the net annual Total Suspended Solids (TSS)** load based on a 50-micron particle size. Annual TSS removal efficiency models shall be based on documented removal efficiency performance from full scale laboratory tests. Annual TSS removal efficiency models shall only be considered valid if they are corroborated by independent third party field testing. Said field testing shall include influent and effluent composite samples from a minimum of ten storms at one location. Individual stormwater treatment systems shall have the Design Treatment Capacity listed in Table 2 on page 125, and shall not re-suspend trapped sediments or re-entrain floating contaminants at flow rates up to and including the specified Design Treatment Capacity.

Individual stormwater treatment systems shall have usable sediment storage capacity of not less than the corresponding volume listed in Table 2. The systems shall be designed such that the pump-out volume is less than ½ of the total system volume. The systems shall be designed to not allow surcharge of the upstream piping network during dry weather conditions.

A water-lock feature shall be incorporated into the design of the stormwater treatment system to prevent the introduction of trapped oil and floatable contaminants to the downstream piping during routine maintenance and to ensure that no oil escapes the system during the ensuing rain event. Direct access shall be provided to the sediment and floatable contaminant storage chambers to facilitate maintenance. There shall be no appurtenances or restrictions within these chambers.

Stormwater treatment systems shall be completely housed within one rectangular structure.

2.3 MANUFACTURER

Each stormwater treatment system shall be of a type that has been installed and used successfully for a minimum of 5 years. The manufacturer of said system shall have been regularly engaged in the engineering design and production of systems for the physical treatment of stormwater runoff during the aforementioned period.

Each stormwater treatment system shall be a Vortechs system as manufactured by CONTECH Stormwater Solutions, a division of CONTECH Construction Products, Inc. and as protected under U.S. Patent #5,759,415.

PART 3.00 EXECUTION

3.1 INSTALLATION

A. Each Stormwater Treatment system shall be constructed according to the sizes shown on the Drawings and as specified herein. Install at elevations and locations shown on the Drawings or as otherwise directed by the Engineer.

B. Place the precast base unit on a granular subbase of minimum thickness of six inches (152 mm) after compaction or of greater thickness and compaction if specified elsewhere. The granular subbase shall be checked for level prior to setting and the precast base section of the trap shall be checked for level at all four corners after it is set. If the slope from any corner to any other corner exceeds 0.5% the base section shall be removed and the granular subbase material re-leveled.

C. Prior to setting subsequent sections place bitumen sealant in conformance with ASTM C 990 along the construction joint in the section that is already in place.

D. After setting the base and wall or riser sections, prepare to install the swirl chamber. Place the 3/4-inch (19 mm) thick by 3/4-inch (19 mm) wide butyl mastic seal vertically on the outside of the swirl chamber starting one inch above the bottom of the swirl chamber and continuing to a height equal to the elevation of the bottom of the upper aperture of the swirl chamber. The butyl mastic seal should abut the downstream side of the pre-drilled mounting holes that attach the swirl chamber to the long walls of the concrete vault. Next, install the extruded Buna N seal on the bottom edge of the 180 degree downstream section of the swirl chamber by first applying a bead of Sikaflex-1a polyurethane elastomeric sealant into the extruded slot then slide the seal onto the swirl chamber. The extruded seal should extend 3-inches (76 mm) upstream of the mounting holes, toward the inlet end of the vault. Set the swirl chamber into position and keep the seal approximately ½-inch (13 mm) above the floor of the concrete vault. Apply a continuous bead of Sikaflex-1a sealant under the cupped bottom of the seal. Set the circular swirl chamber on the floor of the vault and anchor it by bolting the swirl chamber to the side walls of the concrete vault at the three (3) tangent points and at the inlet tab using HILTI brand stainless steel drop-in wedge anchors or equivalent 3/8-inch (10 mm) diameter by 2-3/4 inch (70 mm) minimum length at heights of approximately three inches (3") (76 mm) off the floor and at fifteen inch (15") (381 mm) intervals to approximately the same height of the butyl mastic sealant (at locations of pre-drilled holes in aluminum components). Apply a continuous bead of Sikaflex-1a sealant to the intersection of the inside bottom edge of the extruded seal and the vault floor.

E. If the oil baffle wall (Baffle A) and flow control wall (Baffle B) are not integrally cast-in to riser/wall sections then the Baffle wall panels shall be placed in the formed keyways or between bolted-in-place angle flanges as provided by the manufacturer. Apply non-shrink grout or Sikaflex-1a sealant to each end of Baffle A and Baffle B at the upstream intersection with the side walls of the concrete vault.

F. Prior to setting the precast roof section, bitumen sealant equal to ASTM C 990 shall be placed along the top of the oil baffle wall (Baffle A), using more than one layer of mastic if necessary, to a thickness at least 1-inch (25 mm) greater than the nominal gap between the top of the baffle and the roof section. The nominal gap shall be determined either by field measurement or the shop drawings. Do not seal the top of Baffle B unless specified on the shop drawings to do so. After placement of the roof section has compressed the butyl mastic sealant in the gap over Baffle A, finish sealing the gap with an approved non-shrink grout on both sides of the gap using the butyl mastic as a backing material to which to apply the grout. If roof section is "clamshell" or "bathtub" halves, then finish sealing the ends of the Baffle walls by applying non-shrink grout or Sikaflex-1a sealant to each end of Baffle A at the upstream intersection with the side walls of the concrete vault and to each end of Baffle B at the downstream intersection with the side walls of the concrete vault.

G. After setting the precast roof section of the stormwater treatment system, set precast concrete manhole riser sections, to the height required to bring the cast iron manhole covers to grade, so that the sections are vertical and in true alignment with a ¼-inch (6 mm) maximum tolerance allowed. Backfill in a careful manner, bringing the fill up in 6-inch (152 mm) lifts on all sides. If leaks appear, clean the inside joints and caulk with lead wool to the satisfaction of the Engineer. Precast sections shall be set in a manner that will result in a watertight joint. In all instances, installation of Stormwater Treatment Systems shall conform to ASTM specification C 891 "Standard Practice for Installation of Underground Precast Utility Structures".

H. Holes made in the concrete sections for handling or other purposes shall be plugged with a non-shrink grout or by using grout in combination with concrete plugs.

I. Where holes must be cut in the precast sections to accommodate pipes, do all cutting before setting the sections in place to prevent any subsequent jarring which may loosen the mortar joints. The Contractor shall make all pipe connections.

SECTION 02721

STORMWATER TREATMENT SYSTEM

PART 1.00 GENERAL

1.1 DESCRIPTION

A. Work included:

The Contractor, and/or a manufacturer selected by the Contractor and approved by the Engineer, shall furnish all labor, materials, equipment and incidentals required and install all precast concrete stormwater treatment systems and appurtenances in accordance with the Drawings and these specifications.

1.2 QUALITY CONTROL INSPECTION

A. The quality of materials, the process of manufacture, and the finished sections shall be subject to inspection by the Engineer. Such inspection may be made at the place of manufacture, or on the work site after delivery, or at both places, and the sections shall be subject to rejection at any time if material conditions fail to meet any of the specification requirements, even though sample sections may have been accepted as satisfactory at the place of manufacture. Sections rejected after delivery to the site shall be marked for identification and shall be removed from the site at once. All sections which have been damaged beyond repair during delivery will be rejected and, if already installed, shall be repaired to the Engineer's acceptance level, if permitted, or removed and replaced, entirely at the Contractor's expense.

B. All sections shall be inspected for general appearance, dimensions, soundness, etc. The surface shall be dense, close textured and free of blisters, cracks, roughness and exposure of reinforcement.

C. Imperfections may be repaired, subject to the acceptance of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final acceptance. Cement mortar used for repairs shall have a minimum compressive strength of 4,000 psi (28 MPa) at the end of 7 days and 5,000 psi (34 MPa) at the end of 28 days when tested in 3 inch (76 mm) diameter by 6 inch (152 mm) long cylinders stored in the standard manner. Epoxy mortar may be utilized for repairs.

1.3 SUBMITTALS

A. Shop Drawings

The Contractor shall be provided with dimensional drawings and, when specified, utilize these drawings as the basis for preparation of shop drawings showing details for construction, reinforcing, joints and any cast-in-place appurtenances. Shop drawings shall be annotated to indicate all materials to be used and all applicable standards for materials, required tests of materials and design assumptions for structural analysis. Shop drawings shall be prepared at a scale of not less than 3/16-inches per foot (1:75). Six (6) hard copies of said shop drawings shall be submitted to the Engineer for review and approval.

PART 2.00 PRODUCTS

2.1 MATERIALS AND DESIGN

A. Concrete for precast stormwater treatment systems shall conform to ASTM C 857 and C 858 and meet the following additional requirements:

1. The wall thickness shall not be less than 6 inches (152 mm) or as shown on the dimensional drawings. In all cases the wall thickness shall be no less than the minimum thickness necessary to sustain HS20-44 (MS18) loading requirements as determined by a Licensed Professional Engineer.

2. Sections shall have tongue and groove or ship-lap joints with a butyl mastic sealant conforming to ASTM C 990.

3. Cement shall be Type II Portland cement conforming to ASTM C 150.

4. All sections shall be cured by an approved method. Sections shall not be shipped until the concrete has attained a compressive strength of 4,000 psi (28 MPa) or until 5 days after fabrication and/or repair, whichever is the longer.

5. Pipe openings shall be sized to accept pipes of the specified size(s) and material(s), and shall be sealed by the Contractor with a hydraulic cement conforming to ASTM C 595M

B. Internal aluminum plate components shall be aluminum alloy 5052-H32 in accordance with ASTM B 209.

C. Sealant to be utilized at the base of the swirl chamber shall be 60 durometer extruded nitrile butadiene rubber (Buna N) and shall be provided to the concrete precaster for installation.

D. Brick or masonry used to build the manhole frame to grade shall conform to ASTM C 32 or ASTM C 139 and shall be installed in conformance with all local requirements.

E. Casting for manhole frames and covers shall be in accordance with ASTM A48, CL.30B and AASHTO M105. The manhole frame and cover shall be equivalent to Campbell Foundry Pattern #1009A or #1012D custom cast with the CONTECH Stormwater Solutions logo and the words "Vortechs® Stormwater Treatment System".

F. A bitumen sealant in conformance with ASTM C 990 shall be utilized in the sealing of the joint between the swirl chamber and the vault at the long wall tangent points. The butyl material shall be 3/4-inch thick by 3/4-inch wide.

2.2 PERFORMANCE

Each stormwater treatment system shall adhere to the following performance specifications at the design treatment capacities, as listed below:

Table 2.2

Vortechs® Model	Design Treatment Capacity (cfs)/(l/s)	Sediment Storage (yd^3)/(m^3)
1000	0 - 1.6 (0 - 45)	0.7 (0.54)
2000	1.6 - 2.8 (45-80)	1.2 (0.91)
3000	2.8 - 4.5 (80-125)	1.8 (1.38)
4000	4.5 - 6.0 (125-175)	2.4 (1.84)
5000	6.0 - 8.5 (175-240)	3.2 (2.45)
7000	8.5 - 11.0 (240-315)	4.0 (3.06)
9000	11.0 - 14.0 (315-400)	4.8 (3.67)
11000	14.0 - 17.5 (400-495)	5.6 (4.28)
16000	17.5 - 25.0 (495-710)	7.1 (5.43)

Each stormwater treatment system shall include a circular aluminum "swirl chamber" (or "grit chamber") with a tangential inlet to induce a swirling flow pattern that will accumulate and store settleable solids in a manner and a location that will prevent re-suspension of previously captured particulates.

Each stormwater treatment system shall be of a hydraulic design that includes flow controls designed and certified by a professional engineer using accepted principles of fluid mechanics that raise the water surface inside the tank to a pre-determined level in order to prevent the re-entrainment of trapped floating contaminants.

Each stormwater treatment system shall be capable of removing **80% of the net annual Total Suspended Solids (TSS)** load based on a 50-micron particle size. Annual TSS removal efficiency models shall be based on documented removal efficiency performance from full scale laboratory tests. Annual TSS removal efficiency models shall only be considered valid if they are corroborated by independent third party field testing. Said field testing shall include influent and effluent composite samples from a minimum of ten storms at one location. Individual stormwater treatment systems shall have the Design Treatment Capacity listed in Table 2.2, and shall not re-suspend trapped sediments or re-entrain floating contaminants at flow rates up to and including the specified Design Treatment Capacity.

Individual stormwater treatment systems shall have usable sediment storage capacity of not less than the corresponding volume listed in Table 2.2. The systems shall be designed such that the pump-out volume is less than ½ of the total system volume. The systems shall be designed to not allow surcharge of the upstream piping network during dry weather conditions.

A water-lock feature shall be incorporated into the design of the stormwater treatment system to prevent the introduction of trapped oil and floatable contaminants to the downstream piping during routine maintenance and to ensure that no oil escapes the system during the ensuing rain event. Direct access shall be provided to the sediment and floatable contaminant storage chambers to facilitate maintenance. There shall be no appurtenances or restrictions within these chambers.

Stormwater treatment systems shall be completely housed within one rectangular structure.

2.3 MANUFACTURER

Each stormwater treatment system shall be of a type that has been installed and used successfully for a minimum of 5 years. The manufacturer of said system shall have been regularly engaged in the engineering design and production of systems for the physical treatment of stormwater runoff during the aforementioned period.

Each stormwater treatment system shall be a Vortechs® System as manufactured by CONTECH Stormwater Solutions Inc., 200 Enterprise Drive, Scarborough, Maine 04074, phone: 207-885-9830, fax: 207-885-9825; and as protected under U.S. Patent #5,759,415.

PART 3.00 EXECUTION

3.1 INSTALLATION

A. Each Stormwater Treatment System shall be constructed according to the sizes shown on the Drawings and as specified herein. Install at elevations and locations shown on the Drawings or as otherwise directed by the Engineer.

B. Place the precast base unit on a granular subbase of minimum thickness of six inches (152 mm) after compaction or of greater thickness and compaction if specified elsewhere. The granular subbase shall be checked for level prior to setting and the precast base section of the trap shall be checked for level at all four corners after it is set. If the slope from any corner to any other corner exceeds 0.5% the base section shall be removed and the granular subbase material re-leveled.

C. Prior to setting subsequent sections place bitumen sealant in conformance with ASTM C 990 along the construction joint in the section that is already in place.

D. After setting the base and wall or riser sections, prepare to install the swirl chamber. Place the 3/4-inch (19 mm) thick by 3/4-inch (19 mm) wide butyl mastic seal vertically on the outside of the swirl chamber starting one inch above the bottom of the swirl chamber and continuing to a height equal to the elevation of the bottom of the upper aperture of the swirl chamber. The butyl mastic seal should abut the downstream side of the pre-drilled mounting holes that attach the swirl chamber to the long walls of the concrete vault. Next, install the extruded Buna N seal on the bottom edge of the 180 degree downstream section of the swirl chamber by first applying a bead of Sikaflex-1a polyurethane elastomeric sealant into the extruded slot then slide the seal onto the swirl chamber. The extruded seal should extend 3-inches (76 mm) upstream of the mounting holes, toward the inlet end of the vault. Set the swirl chamber into position and keep the seal approximately ½-inch (13 mm) above the floor of the concrete vault. Apply a continuous bead of Sikaflex-1a sealant under the cupped bottom of the seal. Set the circular swirl chamber on the floor of the vault and anchor it by bolting the swirl chamber to the side walls of the concrete vault at the three (3) tangent points and at the inlet tab using HILTI brand stainless steel drop-in wedge anchors or equivalent 3/8-inch (10 mm) diameter by 2-3/4 inch (70 mm) minimum length at heights of approximately three inches (3") (76 mm) off the floor and at fifteen inch (15") (381 mm) intervals to approximately the same height of the butyl mastic sealant (at locations of pre-drilled holes in aluminum components). Apply a continuous bead of Sikaflex-1a sealant to the intersection of the inside bottom edge of the extruded seal and the vault floor.

E. If the oil baffle wall (Baffle A) and flow control wall (Baffle B) are not integrally cast-in to riser/wall sections then the Baffle wall panels shall be placed in the formed keyways or between bolted-in-place angle flanges as provided by the manufacturer. Apply non-shrink grout or Sikaflex-1a sealant to each end of Baffle A and Baffle B at the upstream intersection with the side walls of the concrete vault.

F. Prior to setting the precast roof section, bitumen sealant equal to ASTM C 990 shall be placed along the top of the oil baffle wall (Baffle A), using more than one layer of mastic if necessary, to a thickness at least 1-inch (25 mm) greater than the nominal gap between the top of the baffle and the roof section. The nominal gap shall be determined either by field measurement or the shop drawings. Do not seal the top of Baffle B unless specified on the shop drawings to do so. After placement of the roof section has compressed the butyl mastic sealant in the gap over Baffle A, finish sealing the gap with an approved non-shrink grout on both sides of the gap using the butyl mastic as a backing material to which to apply the grout. If roof section is "clamshell" or "bathtub" halves, then finish sealing the ends of the Baffle walls by applying non-shrink grout or Sikaflex-1a sealant to each end of Baffle A at the upstream intersection with the side walls of the concrete vault and to each end of Baffle B at the downstream intersection with the side walls of the concrete vault.

G. After setting the precast roof section of the stormwater treatment system, set precast concrete manhole riser sections, to the height required to bring the cast iron manhole covers to grade, so that the sections are vertical and in true alignment with a ¼-inch (6 mm) maximum tolerance allowed. Backfill in a careful manner, bringing the fill up in 6-inch (152 mm) lifts on all sides. If leaks appear, clean the inside joints and caulk with lead wool to the satisfaction of the Engineer. Precast sections shall be set in a manner that will result in a watertight joint. In all instances, installation of Stormwater Treatment Systems shall conform to ASTM specification C 891 "Standard Practice for Installation of Underground Precast Utility Structures".

H. Holes made in the concrete sections for handling or other purposes shall be plugged with a nonshrink grout or by using grout in combination with concrete plugs.

I. Where holes must be cut in the precast sections to accommodate pipes, do all cutting before setting the sections in place to prevent any subsequent jarring which may loosen the mortar joints. The Contractor shall make all pipe connections.

H.2 - Hydrology and Hydraulic Calculations Prepared by Huitt-Zollars, Inc. - Revised January 2008

PRELIMINARY
HYDROLOGY AND HYDRAULIC CALCULATIONS

FOR

CITY OF CHINO
EDGEWATER PROJECT

2, 5, 10 AND 100 YEAR HYDROLOGIC ANALYSIS
AND 100 YEAR HYDRAULIC ANALYSIS

PREPARED FOR:

CITY OF CHINO

PREPARED BY:

HUITT-ZOLLARS, INC
1101 SOUTH MILLIKEN AVENUE, SUITE #G
ONTARIO, CALIFORNIA 91761

REVISED – JANUARY, 2008

PROJECT NO. 10-1073-01

Prepared under the Direction Of: ______________________ __________

Maurice H. Murad, RCE — Date

Senior Vice President

C33366 Exp. 6/30/2008

Table of Contents

List of Technical Appendices

Introduction

A preliminary hydrologic and hydraulic analysis has been prepared for the Edgewater Project in the City of Chino, California. The project site is bounded by Cucamonga Avenue to the west, Corona Road to the north, Hellman Avenue to the East and McCarty Road to the south. The site encompasses approximately 270 acres, of which approximately 210 acres drain through the site or directly to one of the four proposed lakes. The remaining 60 acres are below the inundated water surface elevation of 566 behind Prado Dam and do not require drainage improvements. An additional approximate 40 acres near the intersection of Cucamonga Avenue and Corona Road is County property that has been studied and summarized separately in this report.

Purpose

The purpose of this report is to estimate the preliminary storm drain improvements and sizes required for the development of this project. This study has been prepared in accordance with the City of Chino design criteria. The hydrologic and hydraulic analyses contained in this report are preliminary, based on various assumptions that are subject to change.

Discussion

The project will include the construction of on-site lakes that will help mitigate the runoff generated by the developed site to levels acceptable by the City and State agencies. The site will include 5 storm drain systems that will intercept the generated runoff and ultimately outlet the runoff onto the proposed recreational open space areas surrounding the site.

The post developed condition ultimately will not increase the runoff generated by the site due to the construction of lakes and detention basins throughout the site. Each line (Lines A, B, C, and D) will drain to a detention basin located within the recreational open space areas and then outlet onto the proposed recreational open space before it sheet flows into the Mill Creek.

The property to the north will be required to mitigate flows such that the post-developed runoff from that site will be reduced prior to release to the 144" storm drain through the Edgewater Project. The Edgewater project will not be required to mitigate the runoff generated by the property to the north. The mitigated runoff from the properties to the north will not adversely affect the proposed development. The mitigated runoff generated by the property to the north will be picked up by a 144" storm drain and routed through the proposed development and ultimately outlet into the Mill Creek. The 144" size is required to insure that there will not be any hydraulic back up into the northerly development.

The County property to the northwest has an existing detention basin / retention basin and will be required to utilize a post development detention basin / retention basin which will be collected by Line E. The northwest property will require a detention basin to mitigate the runoff volume to levels comparable to the pre-developed condition. This runoff will be routed westerly into Cucamonga Avenue and then southerly and ultimately outlet into the Prado Southerly Regional Park.

Hydrologic Analysis

The preliminary hydrologic analyses were completed using the methodology outlined in the San Bernardino County Flood Control District (SBCFCD) Hydrology Manual. Both rational method and flood hydrograph analyses were completed for the 100-, 10-, 5-, and 2-year return events for both the existing and proposed site conditions.

The rainfall depths were either taken directly from the isohyetal maps, or developed through the procedures, in the Hydrology Manual. The slope of intensity duration is 0.60. The hydrologic soil type for the site is "B" and was taken from the soil map in the Hydrology Manual. A natural average cover "Grass" land use was assumed for the existing site conditions. The proposed land use plan includes "Commercial", "Condominium", "Low Density Residential", and "Medium Density Residential" land uses.

Due to software limitations, hydrographs cannot be developed for areas less than 10 acres. Therefore, subareas with less than 10 acres were modeled with 10 times the area and the results were then divided by 10.

The hydrologic analyses are contained in Technical Appendices A through H.

Hydraulic Analysis

A preliminary hydraulic analysis was completed for the mainline storm drain facilities. The hydraulic analyses were completed using the 100-year rational method peak flow rates developed in the hydrologic analysis. The controlling water surface elevations for the hydraulic analyses were assumed 566, which is the maximum design water surface behind Prado Dam. Preliminary mainline storm drain sizes are shown on the Hydrology Map for the proposed condition.

The hydraulic analyses are contained in Technical Appendix I.

Preliminary Results

Conditions on the project require that the development mitigate the increased runoff created due to the developed project. The following table summarizes the full conveyance hydrologic results of the existing versus the proposed condition. Note that since the proposed lakes are self-contained and will not contribute to flows leaving the site, the runoff for the lakes has not been included in the listed totals.

Edgewater - Chino Hills
Hydrologic Summary

Project Area

Existing Condition														
			100-Year			10-Year			5-Year			2-Year		
			Rational	Hydrograph		Rational	Hydrograph		Rational	Hydrograph		Rational	Hydrograph	
Location	Node	Area (ac)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)
Northeast Low Spot	103	52.70	61.1	71.0	19.9	30.8	32.2	5.4	22.2	18.0	1.2	8.6	9.7	0.6
East Low Spot	202	44.70	56.7	65.1	16.8	29.9	29.8	4.6	22.3	16.5	1.0	10.3	9.4	0.5
Southeast Low Spot	302	16.20	20.1	23.1	6.1	10.7	10.8	1.7	8.1	6.0	0.4	3.8	3.5	0.2
Southeast Pond	401	19.80	28.3	31.4	7.5	15.8	15.2	2.0	12.3	9.1	0.5	6.6	5.3	0.2
Southwest Pond	502	44.20	56.4	64.3	16.7	29.9	29.5	4.5	22.4	16.9	1.0	10.5	9.4	0.5
West Low Spot	602	35.30	40.1	47.2	13.3	20.4	21.6	3.6	14.8	12.1	0.8	6.0	6.5	0.4
Total *		212.90	262.7	302.1	80.3	137.5	139.1	21.8	102.1	78.6	4.9	45.8	43.8	2.4

Proposed Condition														
			100-Year			10-Year			5-Year			2-Year		
			Rational	Hydrograph		Rational	Hydrograph		Rational	Hydrograph		Rational	Hydrograph	
Location	Node	Area (ac)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)
Line A	40	27.64	56.3	56.3	11.5	35.4	32.6	5.7	29.5	26.0	4.3	20.2	17.2	2.8
Line B	18	69.33	111.2	110.6	23.0	65.7	50.7	6.8	53.4	33.6	3.8	34.8	21.0	2.4
Line C	61	25.30	49.1	53.6	9.9	29.8	30.5	4.3	24.4	23.1	3.1	15.9	15.1	2.0
Line D	87	20.00	39.4	42.5	7.8	23.6	24.4	3.4	19.1	18.6	2.5	12.2	12.3	1.6
Lake 1 (Self-Contained)	111	32.13	35.4	48.8	12.1	18.6	23.1	3.3	13.8	13.5	0.7	6.2	7.7	0.3
Lake 2 (Self-Contained)	113	26.11	31.5	42.7	9.8	16.9	20.4	2.7	12.8	11.9	0.6	6.2	6.8	0.3
Lake 3 (Self-Contained)	115	2.87	5.5	6.4	1.1	3.2	3.3	0.3	2.6	2.0	0.1	1.6	1.2	0.0
Lake 4 (Self-Contained)	117	5.99	10.8	12.4	2.3	6.3	6.3	0.6	5.0	4.0	0.1	3.0	2.3	0.1
Total *		209.37	256.0	263.0	52.2	154.5	138.2	20.2	126.4	101.3	13.7	83.1	65.6	8.8

* - Totals are Summed: Area includes all Locations, Runoff does not include Self-Contained Lakes

Edgewater - Chino Hills
Hydrologic Summary

County Area

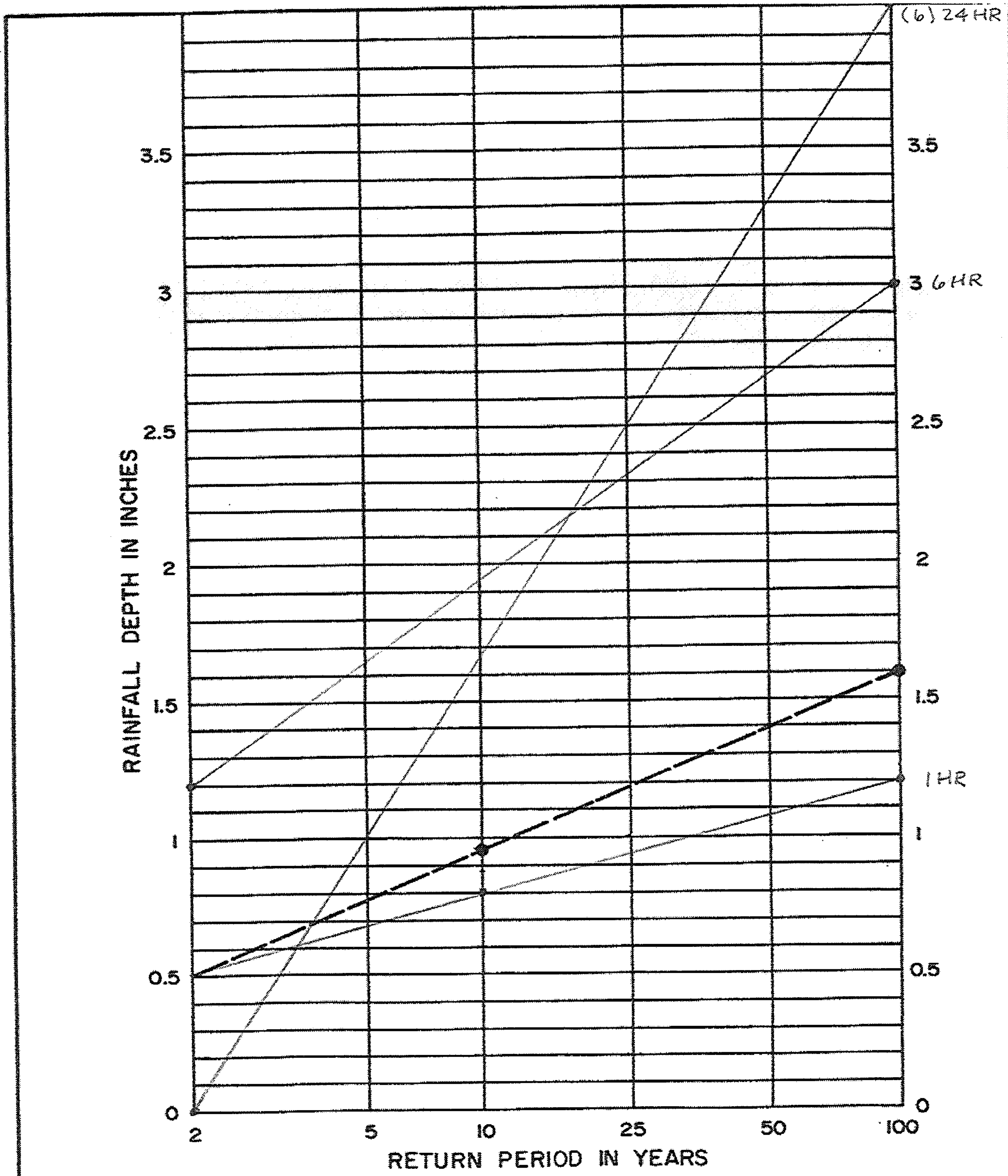
Existing Condition														
			100-Year			10-Year			5-Year			2-Year		
			Rational	Hydrograph		Rational	Hydrograph		Rational	Hydrograph		Rational	Hydrograph	
Location	Node	Area (ac)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)
Southwest Corner	703	4.30	3.1	4.4	1.6	1.3	1.8	0.4	0.7	0.9	0.1	0.3	0.5	0.0
Southwest Pond	801	4.50	7.6	7.9	1.7	4.4	3.9	0.5	3.5	2.3	0.1	2.0	1.3	0.0
Southeast Pond	902	31.70	27.2	35.6	11.9	12.5	15.3	3.3	8.3	8.1	0.7	1.6	4.4	0.3
Total *		40.50	37.9	47.9	15.2	18.2	21.0	4.2	12.5	11.3	0.9	3.9	6.2	0.3

Proposed Condition														
			100-Year			10-Year			5-Year			2-Year		
			Rational	Hydrograph		Rational	Hydrograph		Rational	Hydrograph		Rational	Hydrograph	
Location	Node	Area (ac)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)	Flow (cfs)	Flow (cfs)	Volume (ac-ft)
Line E	105	42.60	55.4	66.7	16.8	32.5	37.4	7.5	25.9	28.8	5.4	15.6	19.1	3.5
Total *		42.60	55.4	66.7	16.8	32.5	37.4	7.5	25.9	28.8	5.4	15.6	19.1	3.5

* - Totals are Summed

Edgewater - Chino Hills
Rainfall Summary

	Depth			
Duration	100-Year (in)	10-Year (in)	5-Year (in)	2-Year (in)
5-Minute	0.45	0.30	0.25	0.18
30-Minute	0.90	0.60	0.52	0.38
1-Hour	1.20	0.80	0.68	0.50
3-Hour	2.10	1.36	1.16	0.85
6-Hour	3.00	1.94	1.64	1.20
24-Hour	6.00	3.66	3.00	2.00



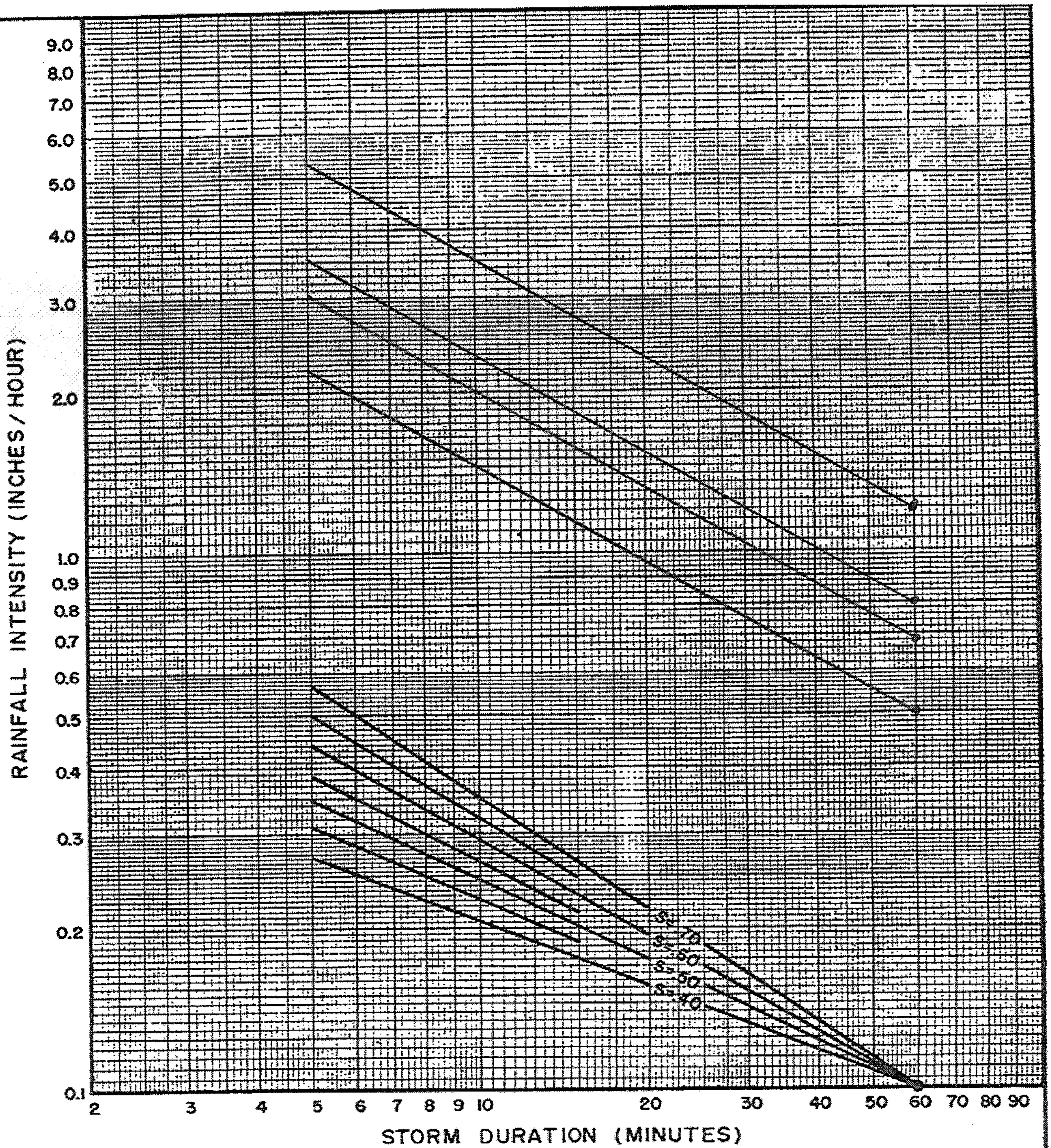
NOTE:
1. FOR INTERMEDIATE RETURN PERIODS PLOT 10-YEAR AND 100-YEAR ONE HOUR VALUES FROM MAPS, THEN CONNECT POINTS AND READ VALUE FOR DESIRED RETURN PERIOD. FOR EXAMPLE GIVEN 10-YEAR ONE HOUR = 0.95" AND 100-YEAR ONE HOUR = 1.60", 25-YEAR ONE HOUR = 1.18".

REFERENCE: NOAA ATLAS 2, VOLUME XI-CAL., 1973

SAN BERNARDINO COUNTY
HYDROLOGY MANUAL

RAINFALL DEPTH VERSUS RETURN PERIOD FOR PARTIAL DURATION SERIES

FIGURE D-2
0730



DESIGN STORM FREQUENCY = ______ YEARS

ONE HOUR POINT RAINFALL = ______ INCHES

LOG-LOG SLOPE = 0.60

PROJECT LOCATION = EDGEWATER - CHINO HILLS

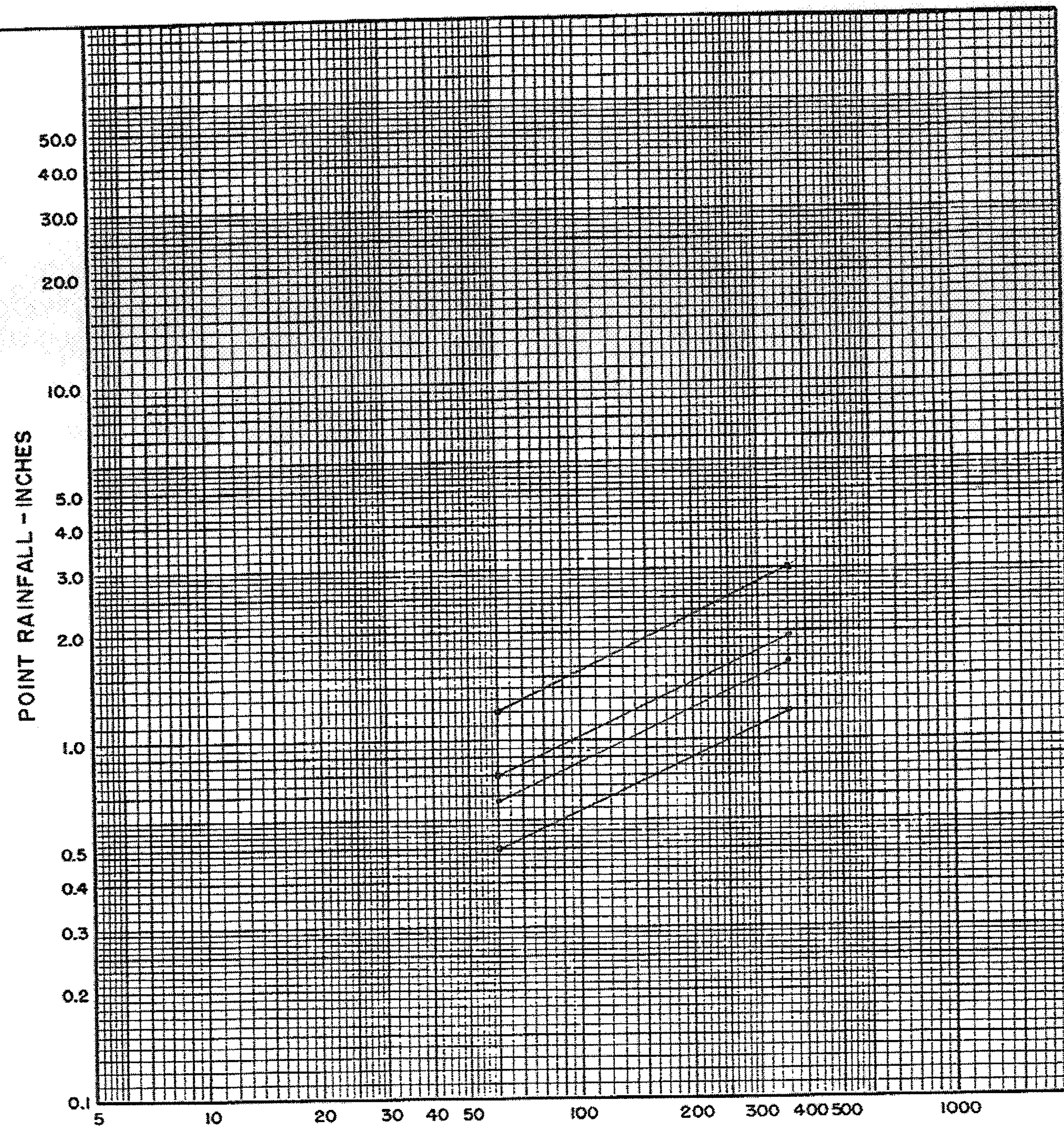
SAN BERNARDINO COUNTY

HYDROLOGY MANUAL

INTENSITY - DURATION CURVES CALCULATION SHEET

FIGURE D-3

0730



PROJECT LOCATION EDGEWATER-CHINO HILLS

NOTES

SAN BERNARDINO COUNTY

HYDROLOGY MANUAL

AREA - AVERAGED MASS RAINFALL PLOTTING SHEET

E-29

FIGURE E-8

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