While other impervious surfaces can be replaced, for example using green roofs to decrease the amount of impervious roof surface, for the most part, impervious roads will, for some time to come, constitute a significant percentage of urban imperviousness because of their current widespread existence. Reducing road widths and other strategies to limit the amount of impervious surface are critical, but truly addressing road runoff requires mitigating its effects.

> **Green Streets** achieve multiple benefits, such as improved water quality and more livable communities, through the integration of stormwater treatment techniques which use natural processes and landscaping.

Roads present many opportunities for green infrastructure application. One principle of green infrastructure involves reducing and treating stormwater close to its source. Urban transportation right-of-ways integrated with green techniques are often called "green streets". Green streets provide a source control for a main contributor of stormwater runoff and pollutant load. In addition, green infrastructure approaches complement street facility upgrades, street aesthetic improvements, and urban tree canopy efforts that also make use of the right-of-way and allow it to achieve multiple goals and benefits. Using the right-of-way for treatment also links green with gray infrastructure by making use of the engineered conveyance of roads and providing connections to conveyance systems when needed.

Green streets are beneficial for new road construction and retrofits. They can provide substantial economic benefits when used in transportation applications. Billions of dollars are spent annually on road construction and rehabilitation, with a large percentage focused on rehabilitation especially in urban areas. Coordinating green infrastructure installation with broader transportation improvements can significantly reduce the marginal cost of stormwater management by including it within larger infrastructure improvements. Also, and not unimportantly, right-of-way installations allow for easy public maintenance. A large municipal concern regarding green infrastructure use is maintenance; using roads and right-of-ways as locations for green infrastructure not only addresses a significant pollutant source, but also alleviates access and maintenance concerns by using public space.

In urban areas, roads present many opportunities for coordinated green infrastructure use. Some municipalities are capitalizing on the benefits gained by introducing green infrastructure in transportation applications. This paper will evaluate programs and policies that have been used to successfully integrate green infrastructure into roads and right-of-ways.

Green Street Designs

Green streets can incorporate a wide variety of design elements including street trees, permeable pavements, bioretention, and swales. Although the design and appearance of green streets will vary, the functional goals are the same: provide source control of stormwater, limit its transport and pollutant conveyance to the collection system, restore predevelopment hydrology to the extent possible, and provide environmentally enhanced roads. Successful application of green techniques will encourage soil and vegetation contact and infiltration and retention of stormwater.

Alternative Street Designs (Street Widths)

A green street design begins before any BMPs are considered. When building a new street or streets, the layout and street network must be planned to respect the existing hydrologic functions of the land (preserve wetlands, buffers, high-permeability soils, etc.) and to minimize the impervious area. If retrofitting or redeveloping a street, opportunities to eliminate unnecessary impervious area should be explored.

Implementation Hurdles

Many urban and suburban streets, sized to meet code requirements for emergency service vehicles and provide a free flow of traffic, are oversized for their typical everyday functions. The Uniform Fire Code requires that streets have a *minimum 20 feet of unobstructed width;* a street with parking on both sides would require a width of at least 34 feet. In addition to stormwater concerns, wide streets have many detrimental implications on neighborhood livability, traffic conditions, and pedestrian safety.[5]

Oregon State Code Granting Authority for Street Standards to Local Government

ORS 92.044 - Local governments shall *supersede and prevail over any specifications and standards for roads and streets set forth in a uniform fire code adopted by the State Fire Marshal, a municipal fire department or a county firefighting agency....* Local governments shall consider the needs of the fire department or fire-fighting agency when adopting the final specifications and standards.

The Transportation Growth and Management Program of Oregon, through a Stakeholder Design Team, developed a guide for reducing street widths titled the *Neighborhood Street Design Guidelines.*[6] The document provides a helpful framework for cities to conduct an inclusive review of street design profiles with the goal of reducing widths. Solutions for accommodating emergency vehicles while minimizing street widths are described in the document. They include alternative street parking configurations, vehicle pullout space, connected street networks, prohibiting parking near intersections, and smaller block lengths.

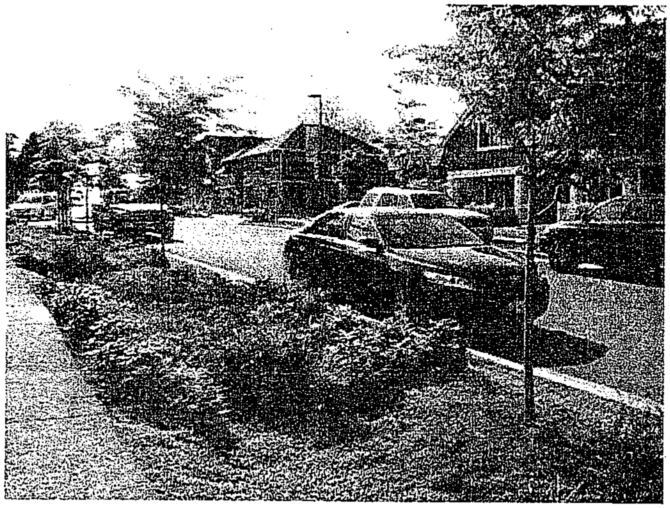

Figure 1. The street-side swale and adjacent porous concrete sidewalk are located in the High Point neighborhood of Seattle, WA
(Source: Abby Hall, US EPA).

In 1997, Oregon, which has adopted the *Uniform Fire Code,* specifically granted local government the authority to establish alternative street design standards but requires them to consult with fire departments before standards are adopted. Table 2 provides examples of alternative street widths allowed in U.S. jurisdictions.[7]

Swales

Swales are vegetated open channels designed to accept sheet flow runoff and convey it in broad shallow flow. The intent of swales is to reduce stormwater volume through infiltration, improve water quality through vegetative and soil filtration, and reduce flow velocity by increasing channel roughness. In the simple roadside grassed form, they have been a common historical component of road design. Additional benefit can be attained through more complex forms of swales, such as those with amended soils, bioretention soils, gravel storage areas, underdrains, weirs, and thick diverse vegetation.

Implementation Hurdles

There is a common misconception of open channel drainage being at the bottom of a street development hierarchy in which curb and gutter are at the top. Seattle's Street Edge Alternative Project and other natural drainage swale pilot projects have demonstrated that urban swales not only mitigate stormwater impacts, but they can also enhance the urban environment.[8]

Table 2. Examples of Alternative Street Widths

Jurisdiction	Street Width	Parking Condition
Phoenix, AZ	28'	parking both sides
Santa Rosa, CA	30' 26'-28' 20' 20'	parking both sides, <1000ADT parking one side no parking neck downs @ intersection
Orlando, FL	28' 22'	parking both sides, res. Lots<55' wide parking both sides, res. Lots>55' wide
Birmingham, MI	26' 20'	parking both sides parking one side
Howard County, MD	24'	parking unregulated
Kirkland, WA	12' 20' 24' 28'	alley parking one side parking both sides – low density only parking both sides
Madison, WI	27' 28'	parking both sides, <3DU/AC parking both sides, 3-10 DU/AC

ADT: Average Daily Traffic DU/AC: dwelling units per acre

Bioretention Curb Extensions and Sidewalk Planters

Bioretention is a versatile green street strategy. Bioretention features can be tree boxes taking runoff from the street, indistinguishable from conventional tree boxes. Bioretention features can also be attractive attention grabbing planter boxes or curb extensions. Many natural processes occur within bioretention cells: infiltration and storage reduces runoff volumes and attenuates peak flows; biological and chemical reactions occur in the mulch, soil matrix, and root zone; and stormwater is filtered through vegetation and soil.

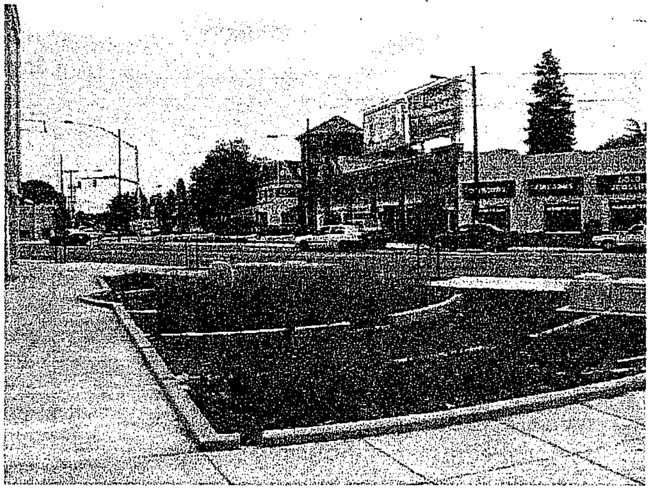

Figure 2. This bioretention area takes runoff from the street through a trench drain in the sidewalk as well as runoff from the sidewalk through curb cuts *(Source: Abby Hall, US EPA).*

Implementation Hurdles

A few municipal DOT programs have instituted green street requirements in roadway projects, but as of yet, specifications for street bioretention have not yet been incorporated into municipal DOT specifications. Many cities do have street bioretention pilot projects; two of the well documented programs are noted in the table. Several concerns and considerations have prevented standard implementation of bioretention by DOTs.

Table 3. Municipalities with Swale Specifications and Standard Details

Municipality	Document	Section Title	Section #
City of Austin[9]	Standard Specifications and Standard Details	Grass-Lined Swale and Grass-Lined Swale with Stone Center	627S
City of Seattle[10]	2008 Standard Specifications for Municipal Construction	Natural Drainage Systems	7-21

Table 4. Municipalities with Bioretention Pilot Projects in the Right-of-Way

Municipality	Bioretention Type	Document
Maplewood, MN	Rain gardens	*Implementing Rainwater in Urban Stormwater Management* [11]
Portland, OR	• Curb extensions • Planters • Rain gardens	*2006 Stormwater Management Facility Monitoring Report* [12]

The diversity of shapes, sizes, and layouts bioretention can take is a significant obstacle to their incorporation with DOT specifications and standards. Street configurations, topography, soil conditions, and space availability are some of the factors that will influence the design of the bioretention facility. These variables make documentation of each new bioretention project all the more important. By building a menu of templates from local bioretention projects, future projects with similar conditions will be easier to implement and cost less to design. The documentation should include copies of the details and specifications for the materials used. A section on construction and operation issues, costs, lessons learned, and recommendations for similar designs should also be included in project documentation. Portland's Bureau of Environmental Services has proven adept at documenting each of its Green Streets projects and making them accessible online.[13]

Utilities are a chief constraint to implementing bioretention as a retrofit in urban areas. The Prince George's County, MD Bioretention Design Specifications and Criteria manual recommends applying the same clearance criteria recommended for storm drainage pipes.[14] Municipal design standards should specify the appropriate clearance from bioretention or allowable traversing.

Prince George's County, MD - 2.12.1.16 Utility Clearance

Utility clearances that apply to storm drainage pipe and structure placement also apply to bioretention. Standard utility clearances for storm drainage pipes have been established at 1' vertical and 5' horizontal. However, bioretention systems are shallow, non-structural IMP's consisting of mostly plant and soil components, (often) with a flexible underdrain discharge pipe. For this reason, other utilities may traverse a bioretention facility without adverse impact. Conduits and other utility lines may cross through the facility but construction and maintenance operations must include safeguard provisions. In some instances, bioretention could be utilized where utility conflicts would make structural BMP applications impractical.

Plants are another common concern of municipal staff, whether it is maintenance, salt tolerance, or plant height with regard to safety and security. Cities actively implementing LID practices in public spaces maintain lists of plants which fit the vegetated stormwater management practice niche. These are plants that flourish in the regional climate conditions, are adapted to periodic flooding, are low maintenance, and, if in cold climates, salt tolerant. Most often these plants are natives, but sometimes an approved non-native will best fit necessary criteria. A municipal plant list should be periodically updated based on maintenance experience, and vegetation health surveys.

Permeable Pavement

Permeable pavement comes in four forms: permeable concrete, permeable asphalt, permeable interlocking concrete pavers, and grid pavers. Permeable concrete and asphalt are similar to their impervious counterparts but are open graded or have reduced fines and typically have a special binder added. Methods for pouring, setting, and curing these permeable pavements also differ from the impervious versions. The concrete and grid pavers are modular systems. Concrete pavers are installed with gaps between them that allow water to pass through to the base. Grid pavers are typically a durable plastic matrix that can be filled with gravel or vegetation. All of the permeable pavement systems have an aggregate base in common which provides structural support, runoff storage, and pollutant removal through filtering and adsorption. Aside from a rougher unfinished surface, permeable concrete and asphalt look very similar to their impervious versions. Permeable concrete and asphalt and certain permeable concrete pavers are ADA compliant.

Implementation Hurdles

Of all the green streets practices, municipal DOTs have been arguably most cautious about implementing permeable pavements, though it should be noted that some DOTs have, for decades, specified open-graded asphalt for low use roadways because of lower cost; to minimize vehicle hydroplaning; and to reduce road noise. The reticence to implement on a large-scale, however, is understandable given the lack of predictability and experience behind impervious pavements. However, improved technology, new and ongoing research, and a growing number of pilot projects are dispelling common myths about permeable pavements.

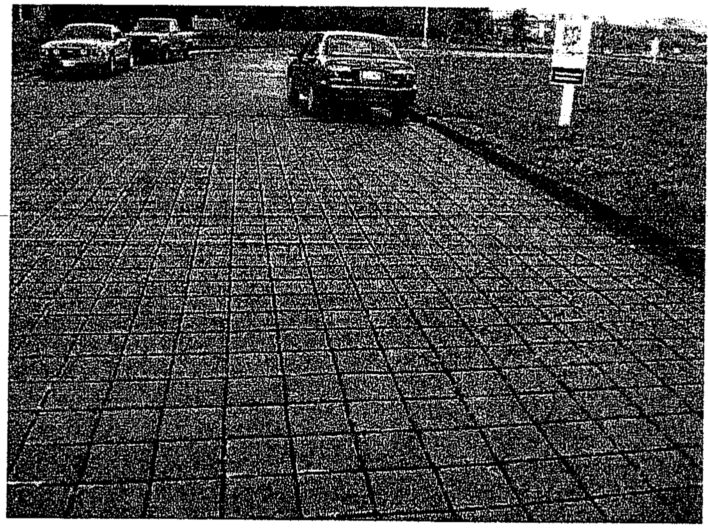

Figure 3. Pervious pavers used in the roadway of a neighborhood development in Wilsonville, OR *(Source: Abby Hall, US EPA).*

The greatest concern among DOT staff seems to be a perceived lack of long-term performance and maintenance data. Universities and DOTs began experimenting with permeable pavements in parking lots, maintenance yards, and pedestrian areas as early as twenty years ago in the U.S., even earlier in Europe. There is now a wealth of data on permeable pavements successfully used for these purposes in nearly every climate region of the country. In recent years, the cities of Portland, OR, Seattle, WA, and Waterford, CT and several private developments have constructed permeable pavement pilots within the roadway with positive results.

> Permeable pavement concerns in the roadway often raise concerns of safety, maintenance, and durability. Municipalities can replace impervious surfaces in other non-critical areas such as sidewalks, alleys, and municipal parking lots. These types of applications help municipalities build experience and a market for the technology.

The two typical maintenance activities are periodic sweeping and vacuuming. The City of Olympia, WA has experimented with several methods of clearing debris from permeable concrete sidewalks. Each of the methods was evaluated on the ease of use, debris removal, and the performance pace. The cost analysis by Olympia, WA found that the maintenance cost for pervious pavement was still lower than the traditional pavement when the cost of stormwater management was considered.

Table 5. Municipalities with Permeable Pavement Specifications and Standard Details

Municipality	Document	Section Title	Section #
Portland	2007 Standard Construction Specifications	Unit Pavers (includes permeable pavers)	00760
Olympia	WSDOT Specification	Pervious Concrete Sidewalks	8-30

Freeze/thaw and snow plows are the major concerns for permeable pavements in cold climate communities. However, these concerns have proven to be generally unwarranted when appropriate design and maintenance practices are employed. A well designed permeable pavement structure will always drain and never freeze solid. The air voids in the pavement allow plenty of space for moisture to freeze and ice crystals to expand. Also, rapid drainage through the pavement eliminates the occurrence of freezing puddles and black ice. Cold climate municipalities will need to make adjustments to snow plowing and deicing programs for permeable pavement areas. Snow plow blades must be raised enough to prevent scraping the surface of permeable pavements, particularly paver systems. Also, sand should not be applied.

Table 6. A Study in Olympia, WA Comparison of the cost of permeable concrete sidewalks to the cost of traditional impervious sidewalks[15]

Traditional Concrete Sidewalk		Permeable Concrete Sidewalk	
Construction Cost	Maintenance Cost	Construction Cost	Maintenance Cost
$5,003,000*	$156,000	$2,615,000*	$147,000
Total = $5,159,000 $101.16 per square yard		Total = $2,762,000 $54.16 per square yard	

*The cost of stormwater management (stormwater pond) for the added impervious surface is factored into the significantly higher cost of constructing the traditional concrete sidewalk. Maintenance of the stormwater pond is also factored into the traditional concrete sidewalk maintenance cost.

Sidewalk trees and tree boxes

From reducing the urban heat island effect and reducing stormwater runoff to improving the urban aesthetic and improving air quality, much is expected of street trees. Street trees are even good for the economy. Customers spend 12% more in shops on streets lined with trees than on those without trees.[16] However, most often street trees are given very little space to grow in often inhospitable environments. The soil around street trees often becomes compacted during the construction of paved surfaces and minimized as underground utilities encroach on root space. If tree roots are surrounded by compacted soils or are deprived of air and water by impervious streets and sidewalks, their growth will be stunted, their health will decline, and their expected life span will be cut short. By providing adequate soil volume and a good soil mixture, the benefits obtained from a street tree multiply. To obtain a healthy soil volume, trees can simply be provided larger tree boxes, or structural soils, root paths, or "silva cells" can be used under sidewalks or other paved areas to expand root zones. These allow tree roots the space they need to grow to full size. This increases the health of the tree and provides the benefits of a mature sized tree, such as shade and air quality benefits, sooner than a tree with confined root space.

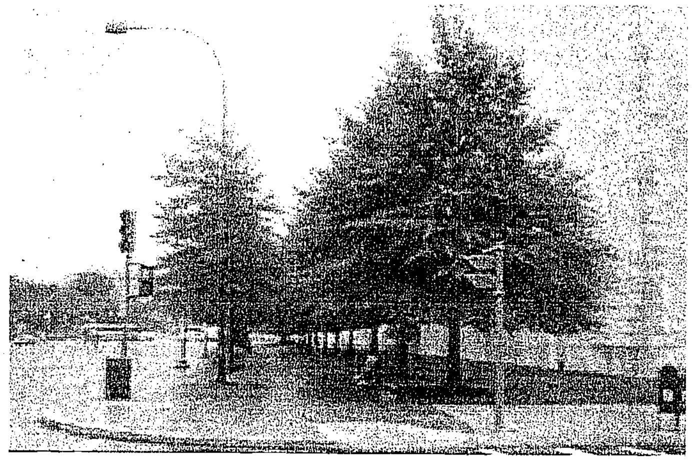

Figure 4. Trees planted at the same time but with different soil volumes, Washington DC
(Source: Casey Trees)

Table 7. Healthy Tree Volume and Permeable Pavement Specifications and Standard Details

Jurisdictions	Minimum Soil Volume	Section Title	Section #
Prince William County, VA	Large tree 970 cf Medium tree 750 cf Small tree 500 cf	Design Construction Manual (Sec 800)	Table 8-8
Alexandria, VA	300 cf	Landscape Guidelines	II.B. (2)

Implementation Hurdles

Providing an adequate root volume for trees comes down to a trade off between space in the right-of-way and added construction costs. The least expensive way to obtain the volume needed for roots to grow to full size is providing adequate space unhindered by utilities or other encroachments. However, it is often hard to reserve space dedicated just to street trees in an urban right-of-way with so many other uses competing for the room they need. As a result, some creative solutions, though they cost more to install, have become useful alternatives in crowded subsurface space. Structural soils, root paths, and "silva cells" leave void space for roots and still allow sidewalks to be constructed near trees.

Root Paths can be used to increase tree root volume by connecting a small tree root volume with a larger subsurface volume nearby. A tunnel-like system extends from the tree underneath a sidewalk and connects to an open space on the other side.

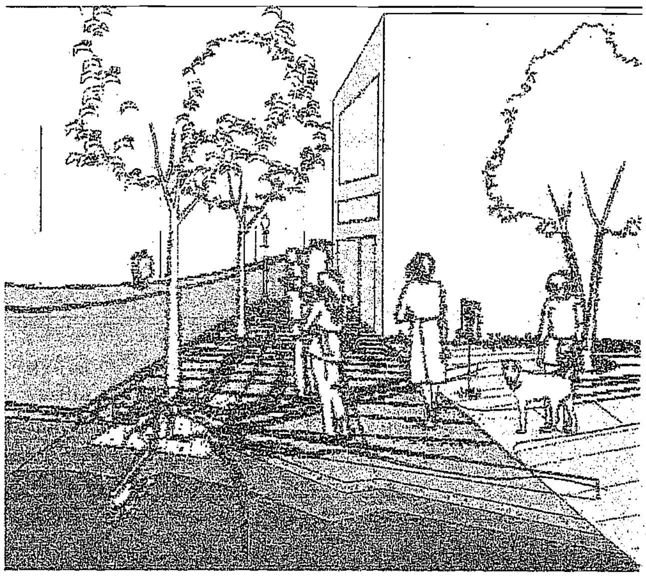

Figure 5. Root Paths direct tree roots under paving and into better soil areas for tree root growth
(Source: Arlington County, VA).

Silva Cells[17] are another option for supporting sidewalks near trees while still providing enough space for roots to grow. These plastic milk crate-like frames fit together and act as a supporting structure for a sidewalk while leaving room for uncompacted soil and roots inside the frame.

Permeable pavement sidewalks are another enhancement to the root space. They provide moisture and air to roots under sidewalks. Soils under permeable pavements can still become compacted. Structural soils[18] are a good companion tree planting practice to permeable pavement. When planting a tree in structural soils an adequate tree root volume is excavated and filled with a mix of stone and soil that still provides void space for healthy roots and allows for sidewalks, plazas or other paved surfaces to be constructed over them.

Case Studies

Portland, OR: Green Street Pilot Projects

Portland, Oregon is a national leader in developing green infrastructure. Portland's innovation in stormwater management was necessitated by the need to satisfy a Combined Sewer Overflow consent decree, Safe Drinking Water Act requirements, impending Total Maximum Daily Load limitations, Superfund cleanup measures and basement flooding. Through the 1990s, over 3 billion gallons of combined sewer overflow discharged to the Willamette River every year.[19] All of these factors plus leadership and local desires to create green solutions and industries compelled the city to implement green infrastructure as a complement to adding capacity to the sewer system with large pipe overflow interceptors. Despite gaps in long-term performance data, Portland took a proactive approach in implementing green infrastructure pilot projects.

Portland's green infrastructure pilot projects have their roots in the city's 2001 Sustainable Infrastructure Committee. The committee, consisting of representatives from Portland's three infrastructure management Bureaus, documented the city's ongoing efforts toward sustainable infrastructure, gathered research on green infrastructure projects from around the country, and identified opportunities for local pilots.[20, 21, 22]

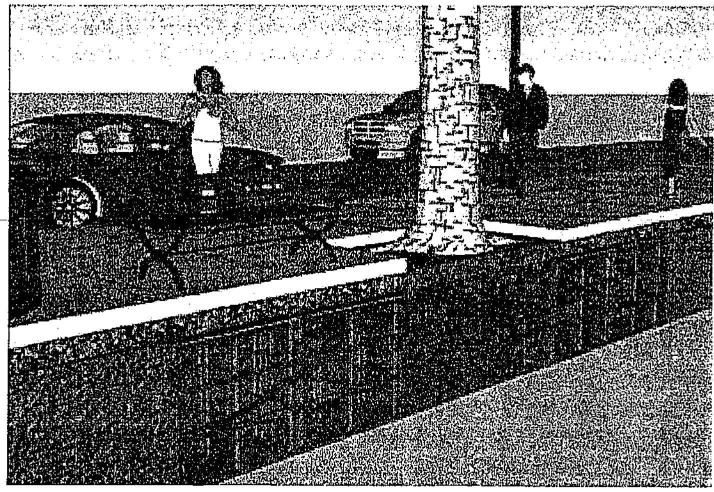

Figure 6. Silva cell structures support the sidewalk while providing root space for street trees
(Source: Deep Root Partners, LP).

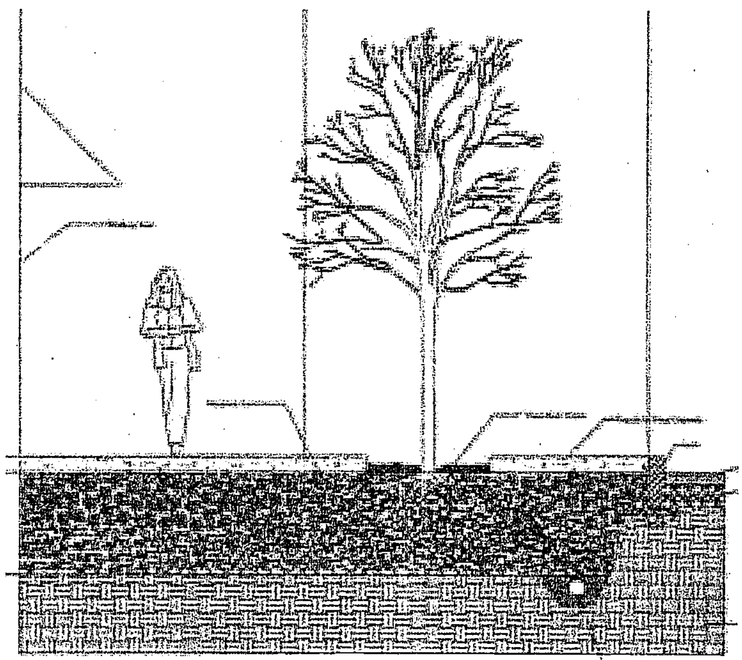

Figure 7. Structural soils provide void space for root growth and load-bearing for sidewalk
(Source: Urban Horticulture Institute, Cornell University).

One of the Bureau of Environmental Services' (BES) earliest green infrastructure retrofit projects within the right-of-way was a set of two stormwater curb extensions on NE Siskiyou Street. Portland had been retrofitting many streets with curb extensions for the purpose of pedestrian safety, but this was the first done for the purpose of treating street runoff. In a simulated 25-year storm event flow test, the curb extensions captured 85% of the runoff volume that would be discharged to the combined sewer system and reduced peak flow by 88%.[23]

Between 2003 and 2007, Portland designed and implemented a variety of Green Street pilots. Funding sources for these projects have come from BES, Portland Department of Transportation, U.S. EPA, and an Innovative Wet Weather Fund. BES combined funds with an EPA grant to create the Innovative Wet Weather Fund. In 2004, nearly $3 million from the Innovative Wet Weather Fund was budgeted for a long list of projects from city green roofs, public-private projects, and a number of pilot projects within the right-of-way.[24] Several pilots have been cost competitive with or less costly than conventional upgrades. The Bureau recognizes that costs will decrease once these projects become more routine. Many of the pilot project costs included one time costs such as the development of outreach materials and standard drawings.

Figure 8: NE Siskiyou Vegetated Curb Extensions
Source: City of Portland – Bureau of Environmental Services

Table 8. Portland, OR - Green Street Pilot Projects

Location	Design	Year Completed	Cost
NE Siskiyou b/w NE 35th Pl. and NE 36th Ave	Stormwater curb extension	2003	$20,000
3 blocks of the Westmoreland Neighborhood	Permeable Pavers in parking lanes and curb to curb	2004	$412,000
SE Ankeny b/w SE 56th and SE 57th Ave.	Stormwater curb extensions	2004	$11,946
NE Fremont b/w NE 131st and 132nd Av	Stormwater curb extension	2005	$20,400
SW 12th Ave b/w SW Montgomery and Mill	Stormwater planters	2005	$34,850
East Holladay Park	Pervious paver parking lot	2005	$165,000
4 blocks of North Gay Avenue b/w N Wygant and N Sumner	Porous concrete in curb lanes and curb to curb; porous asphalt in curb lanes and curb to curb	2005	--
SW Texas	Stormwater wetlands and swales	2007	$2.3 million
Division St. – New Seasons Market	Stormwater planters and swales	--	--
SE Tibbetts and SE 21st Ave.	Stormwater curb extension and planters	--	--

Source: Portland Bureau of Environmental Services, 2008
http://www.portlandonline.com/bes/index.cfm?c=44463&

Each of the pilot projects have been well documented by BES. A consistent format has been used to describe pilot background, features, engineering design, landscaping, project costs, maintenance, monitoring, and, most importantly, lessons learned. These case studies as well as other Green Street documentation can be found on BES's Sustainable Stormwater webpage, http://www.portlandonline.com/BES/index.cfm?c=34598. Due to physical factors (drainage, slope, soil, existing utilities, multiple uses) and development factors (retrofit, redevelopment, and new construction), there will be many variations on Green Streets. As part of the program, a continually updated Green Street Profile Notebook will catalog the successful green street projects. Users can use the Notebook for permitting guidance, to identify green streets facilities appropriate for various factors, but the document is not a technical document with standard details.

The Green Streets Team

The City of Portland, OR is widely acknowledged for long term, forward thinking, and comprehensive transportation and environmental planning. Portland recognized the fact that 66% of the City's total runoff is collected from streets and the right-of-way.[25] The city also saw the potential for transportation corridors to meet multiple objectives, including:

- Comprehensively address numerous City goals for neighborhood livability, sustainable development, increased green spaces, stormwater management, and groundwater protection;
- Integrate infrastructure functions by creating "linear parks" along streets that provide both pedestrian/bike areas and stormwater management;
- Avoid the key impacts of unmanaged stormwater whereby surface waterbodies are degraded, and water quality suffers;
- Manage stormwater with investments citizens can support, participate in, and see;
- Manage stormwater as a resource, rather than a waste;
- Protect pipe infrastructure investments (extend the life of pipe infrastructure, limit the additional demand on the combined sewer system as development occurs);
- Protect wellhead areas by managing stormwater on the surface; and
- Provide increased neighborhood amenities and value.

In a two phased process from 2005 to 2007, the Green Streets Team, a cross agency and interdisciplinary team, developed a comprehensive green streets policy and a way forward for the green streets agenda. Phase 1 identified challenges and issues and began a process for addressing them. Barriers to the public initiation of green street projects included a code and standards that would disallow or discourage green street strategies, long term performance unknowns, and maintenance responsibilities. To address these barriers, the Green Streets Team organized into subgroups focusing on outreach, technical guidance, infrastructure, maintenance, and resources.

Phase 2 of the Green Streets project synthesized the opportunities and solutions identified in Phase 1 into a citywide Green Streets Program. The first priority for this phase was the drafting of a binding citywide policy. The resolution was adopted by the Portland City Council in March 2007.

Prior to the start of the Portland effort, 90% of implemented green street projects were issued by private permits rather than city initiated projects.

Six Approaches to Implementing Green Streets

Pathway	Implementation
City-initiated street improvement projects	City designs, manages, maintains
City-initiated stormwater retrofits	City designs, manages, maintains
Neighborhood-initiated LIDs	
Developer-initiated subdivisions with public streets	Developer designs and builds via City permit and review process, then turns over new right of way to the City after warranty period
Developer-initiated subdivisions with private streets	Developer designs and builds via City permit and review process, and turns over to home-owner association
Developer-related initiated frontage improvements on existing public streets	Developer designs and builds new sidewalks and curbs via City permit and review process, usually because the City required it via a building permit or via a land division

Source: Portland Green Streets, Phase 1

Portland City Council Approved Green Streets Policy

Goal: City of Portland will promote and incorporate the use of green street facilities in public and private development.

City elected officials and staff will:

1. Infrastructure Projects in the Right of Way:
   a. Incorporate green street facilities into all City of Portland funded development, redevelopment or enhancement projects as required by the City's September 2004 (or updated) Stormwater Management Manual. Maintain these facilities according to the May 2006 (or updated) Green Streets Maintenance Policy.

      If a green street facility (infiltrating or flow through) is not incorporated into the Infrastructure Project, or only partial management is achieved, then an off site project or off site management fee will be required.

   b. Any City of Portland funded development, redevelopment or enhancement project, that does not trigger the Stormwater Manual but requires a street opening permit or occurs in the right of way, shall pay into a "% for Green" Street fund. The amount shall be 1% of the construction costs for the project.
      Exceptions: Emergency maintenance and repair projects, repair and replacement of sidewalks and driveways, pedestrian and trail replacement, tree planting, utility pole installation, street light poles, traffic, signal poles, traffic control signs, fire hydrants, where this use of funds would violate contracted or legal restrictions.
2. Project Planning and Design:
   a. Foster communication and coordination among City Bureaus to encourage consideration of watershed health and improved water quality through use of green street facilities as part of planning and design of Bureau projects.
   b. Coordinate Bureau work programs and projects to implement Green Streets as an integrated aspect of City infrastructure.
   c. Plan for large-scale use of Green Streets as a means of better connecting neighborhoods, better use of the right of way, and enhancing neighborhood livability.
   d. Strive to develop new and innovative means to cost-effectively construct new green street facilities.
   e. Develop standards and incentives (such as financial and technical resources, or facilitated permit review) for Green Streets projects that can be permitted and implemented by the private sector. These standards and incentives should be designed to encourage incorporation of green street facilities into private development, redevelopment and enhancement projects.
3. Project and Program Funding:
   a. Seek opportunities to leverage the work and associated funding of projects in the same geographic areas across Bureaus to create Green Street opportunities.
   b. Develop a predictable and sustainable means of funding implementation and maintenance of Green Street projects.
4. Outreach:
   a. Educate citizens, businesses, and the development community/industry about Green Streets and how they can serve as urban greenways to enhance, improve, and connect neighborhoods to encourage their support, demand and funding for these projects.
   b. Establish standard maintenance techniques and monitoring protocols for green street facilities across bureaus, and across groups within bureaus.
5. Project Evaluation:
   a. Conduct ongoing monitoring of green street facilities to evaluate facility effectiveness as well as performance in meeting multiple City objectives for:
      - Gallons managed;
      - Projects distributed geographically by watershed and by neighborhood; and

The second priority for Phase 2 was developing communication and planning procedures for incorporating multi-bureaus plans into the scheduled Portland DOT Capital Improvement Program (CIP). Three timeframes for green street project planning were recommended. In the short term, the CIP Planning Group, backed by the citywide policy directive, will shift to a focus on "identifying and evaluating opportunities to partner." For example, coordinating Water Bureau and BES pipe replacement projects with DOT maintenance, repair, and improvement projects. The mid-term approach is more proactive and involves forecasting potential green street projects using existing bureau data and GIS tools. As for the long term, green street objectives will be incorporated into the citywide systems plan which guides city bureaus for the next 20 years.

The Green Street Team methodology propelled Portland's early green street pilot projects into a comprehensive, citywide multi-bureau program. The program built on previous efforts by the Sustainable Infrastructure Committee as well as other efforts such as the 2005 Portland Watershed Management Plan, established a City Council mandated policy, and institutionalized green street development. The outcome of this approach is multi-agency buy-in and responsibility for the effort. For instance, because of their knowledge of plant maintenance, Portland Parks and Recreation is responsible for the maintenance of some DOT installations.

Chicago, IL: Green Alleys Program

The City of Chicago, Illinois has an alley system that is perhaps the largest in the world. These 13,000 publicly owned alleys result in 1,900 miles, or 3,500 acres, of impermeable surfaces in addition to the street network. Because the alley system was not originally paved, there are no sewer connections as part of the original design. Over time the alleys were paved and flooding in garages and basements began to occur as a result of unmanaged stormwater runoff. Since the city already spends $50 million each year to clean and upgrade 4,400 miles of sewer lines and 340,000 related structures, the preferred solution to the flooded alleys is one that doesn't put more stress on an already overburdened and expensive sewer system.[26]

In 2003, the Chicago Department of Transportation (CDOT) used permeable pavers and French drain pilot applications to remedy localized flooding problems in alleys in the 48th Ward.[27] These applications proved to be successful and by 2006, CDOT launched its Green Alley Program with the release of the Chicago Green Alley Handbook (Handbook).[28]

The Chicago Green Alley Program is unique because it marries green infrastructure practices in the public right-of-way with green infrastructure efforts on private property. The user-friendly Handbook, which describes both facets of the program including the design techniques and their benefits, is an award winning document. The American Society of Landscape Architects awarded the creators of the Handbook the 2007 Communications Honor Award for the clear graphics and simple, yet effective, message.[29] The Handbook explains to the residents why green infrastructure is important, how to be good stewards of the Green Alley in their neighborhood, and what sorts of "green" practices they can implement on their property to reduce waste, save water, and help manage stormwater wisely.

While the initial impetus behind the Green Alley Program was stormwater management, Chicago decided to use this opportunity to address other environmental concerns as well as reducing the urban heat island effect, recycling, energy conservation, and light pollution.

Green Infrastructure in the Right-of-Way

Chicago's Green Alley Program uses the following five techniques in the public right-of-way to "green" the alley:

1. Changing the grade of the alley to drain to the street rather than pond water in the alley or drain toward garages or private property.

2. Using permeable pavement that allows water to percolate into the ground rather than pond on the surface.

3. Using light colored paving material that reflects sunlight rather than adsorbing it, reducing urban heat island effect.

4. Incorporating recycled materials into the pavement mix to reduce the need for virgin materials and reduce the amount of waste going into the landfill.

5. Using energy efficient light fixtures that focus light downward, reducing light pollution.

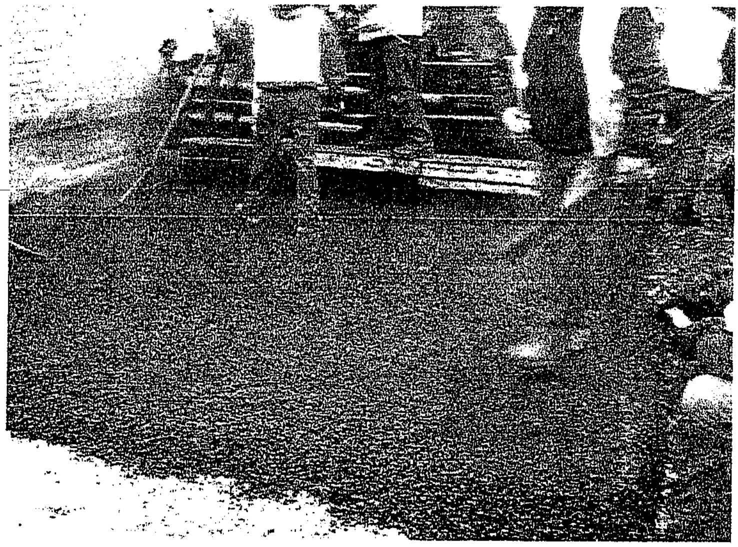

Figure 9: Permeable Asphalt Installation Using Ground Tire Rubber.
Source: Chicago Department of Transportation, Sustainable Development Initiatives; Streetscape and Urban Design Program, CDOT Division of Project Development.

Four design approaches were created using these techniques. Based on the local conditions, the most appropriate approach is selected. In areas where soils are well-draining, permeable pavement is used. In areas where buildings come right up to the edge of pavement and infiltrated water could threaten foundations, impermeable pavement strips are used on the outside with a permeable pavement strip down the middle. In areas where soils do not provide much infiltration capacity, the alley is regraded to drain properly and impermeable pavement made with recycled materials is used. Another approach utilizes an infiltration trench down the middle of the alley. Light colored (high albedo) pavement, recycled materials, and energy efficient, glare reducing lights are a part of each design approach.

Green Infrastructure on Private Property
The Handbook also describes actions that property owners can take to "green" their own piece of Chicago. The Handbook describes the costs, benefits, and utility of the following practices:

- Recycling;
- Composting;
- Planting a tree;
- Using native landscape vegetation;
- Constructing a rain garden;
- Installing a rain barrel;
- Using permeable pavement for patios;
- Installing energy efficient lighting; and
- Utilizing natural detention.

By bringing this wide range of "green" practices to the attention of homeowners, the positive impacts of the Green Alley Program spread beyond the boundaries of the right-of-way, increasing awareness and providing practical resources to help community members be a part of the solution.

Chicago Green Alley Cost Considerations
When the program began in 2006, repaving the alleys with impermeable pavement ranged in cost from $120,000 to $150,000, whereas a total Green Alley reconstruction was more along the lines of $200,000 to $250,000.[30] While less expensive conventional rehabilitation options may seem more attractive, they don't provide a solution to the localized flooding issues or the combined sewer system overflow problems. Sewer system connections could be established to solve the localized flooding problem, but it would add to the already overburdened sewer system and increase the cost of the reconstruction to that of the impermeable alley option. Consequently, the higher priced Green Alley option proved to be the best investment as it has multiple benefits in addition to solving localized flooding and reducing flow into the combined sewer system. The additional benefits of the Green Alley Program include not only urban heat

island effect reduction, material recycling, energy conservation, and light pollution reduction, but also the creation of a new market.

In 2006, when the Green Alley Program began, the city paid about $145 per cubic yard of permeable concrete. Just one year later, the cost of permeable concrete had dropped to only $45 per cubic yard. Compared with the cost of ordinary concrete, $50 per cubic yard, permeable concrete may have seemed like an infeasible option in the past to customers wanting to purchase concrete.[31] After the city's initial investment in the local permeable concrete market, the product cost has come down making permeable concrete a more affordable option for other consumers besides the city. This has resulted in an increased application of permeable concrete throughout the region.

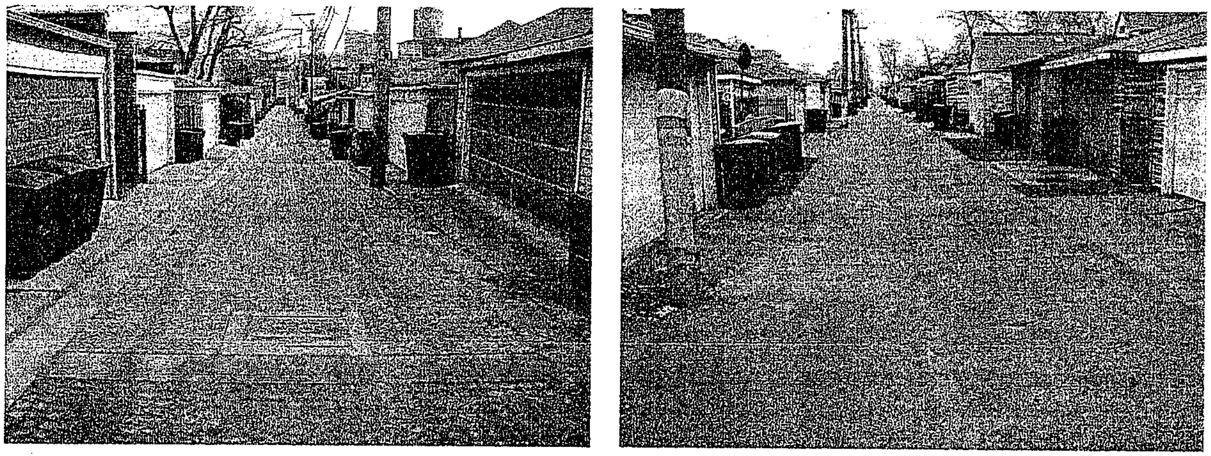

Figure 10: Permeable Pavers and Permeable Concrete Chicago Alleys
(Source: Abby Hall, US EPA)

The success of the Chicago Green Alley Program is evident. Not only are the alleys been "greened" as a result of the program, the surrounding properties and even the surrounding neighborhoods are experiencing the positive impacts of the program's implementation.

Conclusions and Recommendations

Incorporating green streets as a feature of urban stormwater management requires matching road function with environmental performance. Enhancing roads with green elements can improve their primary function as a transportation corridor while simultaneously mitigating their negative environmental impacts. In theory and practice many municipalities are not far removed from dedicated green streets programs. Street tree and other greenscaping programs are often identified and promoted along urban transportation corridors. Adapting them to become fully functional green streets requires minor design modifications and an evaluation of how to maximize the benefits of environmental systems.

Portland's green streets program demonstrates how common road and right-of-way elements (e.g., traffic calming curb extensions, tree boxes) can be modified and optimized to provide stormwater management in addition to other benefits. The curb cuts and design variations to allow runoff to enter the vegetated areas are subtle changes with a significant impact and demonstrate how stormwater can be managed successfully at the source. One of the biggest successes of the program was reassessing common design features and realizing that environmental performance can be improved by integrating stormwater management.

Where Portland used vegetation, Chicago's Green Alley Program similarly demonstrates that hardscape elements can be an integral part of a greening program. By incorporating permeable pavements that simulate natural infiltration, Chicago enhances the necessary transportation function of alleys while enhancing infrastructure and environmental management. Portland also contrasts the "soft" and "hard" elements of green streets by using both permeable pavements and vegetated elements. The green options available demonstrate the flexibility of green infrastructure to satisfy road function and environmental objectives and highlight why transportation corridors are well suited for green infrastructure.

Elements necessary for a successful green streets program:

- **Pilot projects are critical.** The most successful municipal green street programs to date all began with well documented and monitored pilot projects. These projects have often been at least partially grant funded and receive the participation of locally active watershed groups working with the city infrastructure programs. The pilot projects are necessary to demonstrate that green streets can work in the local environment, can be relied upon, and fit with existing infrastructure. Pilot projects will help to dispel myths and resolve concerns.
- **Leadership in sustainability from the top.** The cities with the strongest green streets programs are those with mayors and city councils that have fully bought into sustainable infrastructure. Council passed green policies and mayoral sustainability mandates or mission statements are needed to institutionalize green street approaches and bring it beyond the token green project.
- **Buy-in from all municipal infrastructure departments.** By their nature, green streets cross many municipal programs. Green street practices impact stormwater management, street design, underground utilities, public lighting, green space planning, public work maintenance, and budgeting. When developing green streets, all of the relevant agencies must be represented. Also, coordination between the agencies on project planning is important for keeping green infrastructure construction costs low. Superior green street design at less cost occurs when sewer and water line replacement projects can be done in tandem with street redevelopment. These types of coordination efforts must happen at the long-term planning stage.
- **Documentation.** Green street projects need to be documented on two levels, the design and construction level and on a citywide tracking level. Due to the different street types and siting conditions, green street designs will take on many variations. By documenting the costs, construction, and design, the costs of similar future projects can be minimized and construction or design problems can be avoided or addressed. Tracking green street practices across the city is crucial for managing maintenance and quantifying aggregate benefits.
- **Public outreach.** Traditional pollution prevention outreach goes hand in hand with green street programs. Properly disposing of litter, yard waste, and hazardous chemicals and appropriately applying yard chemicals will help prolong the life of green street practices. An information campaign should also give the public an understanding of how green infrastructure works and the benefits and trade offs. In many cases, remedial maintenance of green street practices will be performed by neighboring property owners; they need to know how to maintain the practices to keep them performing optimally.

As public spaces, roads are prime candidates for green infrastructure improvements. In addition to enabling legislation, and technical guidance, developing a green streets program requires an institutional re-evaluation of how right-of-ways are most effectively managed. This process typically includes:

- Assessing the necessary function of the road and selecting the minimum required street width to reduce impervious cover;
- Enhancing streetscaping elements to manage stormwater and exploring opportunities to integrate stormwater management into roadway design; and
- Integrating transportation and environmental planning to capitalize on economic benefits.

The use of green streets offers the capability of transforming a significant stormwater and pollutant source into an innovative treatment system. Green streets optimize the performance of public space easing maintenance concerns and allowing municipalities to coordinate the progression and implementation of stormwater control efforts. In addition, green streets optimize the performance of both the transportation and water infrastructure. Effectively incorporating green techniques into the transportation network provides significant opportunity to decrease infrastructure demands and pollutant transport.

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EXHIBIT D

EXHIBIT 7.III

TECHNICAL GUIDANCE DOCUMENT FOR THE PREPARATION OF CONCEPTUAL/PRELIMINARY AND/OR PROJECT WATER QUALITY MANAGEMENT PLANS (WQMPs)

For Santa Ana Regional Board Consideration

March 22, 2011

TABLE OF CONTENTS

Code to Highlighted Text in Review Document

Blue text = active hyperlinks

Green highlight = text that will be linked to the TGD Appendices when documents are merged

Blue highlight = text that will be linked to the WQMP Template or the Model WQMP, if logistically possible, following posting of documents online. .

APPENDICES

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TABLES

FIGURES

ACRONYMS

BMP – Best Management Practice
CEQA - California Environmental Quality Act
CMF – Cartridge Media Filtration
CWA – Federal Clean Water Act
DAMP – Drainage Area Management Plan
DCIA – Directly Connected Impervious Area
DEDB – Dry Extended Detention Basin
ESA – Environmentally Sensitive Area
ET – Evapotranspiration
HCOC – Hydrologic Condition Of Concern
HMP – Hydromodification Management Plan
HSC – Hydrologic Source Control
EIATA – Effective Irrigated Area to Tributary Area
IWRMP – Integrated Water Resources Management Plan
LID – Low Impact Development
LIP – Local Implementation Plan
MEP – Maximum Extent Practicable
MS4 – Municipal Separate Storm Sewer System
NOC – North Orange County (Region 8- SARWQCB Jurisdictional Area)
NPDES – National Pollutant Discharge Elimination System
NTS – Natural Treatment Systems
OCWD – Orange County Water District
POC – Pollutant Of Concern
RWQCB – Regional Water Quality Control Board
SARWQCB – Santa Ana Regional Water Quality Control Board
SDRWQCB – San Diego Regional Water Quality Control Board
SOC – South Orange County (Region 9 -SDRWQCB Jurisdictional Area)
SQDF - Stormwater Quality Design Flow
SQDV – Stormwater Quality Design Volume
SSMP – Standard Stormwater Mitigation Plan
TGD – Technical Guidance Document
TMDL – Total Maximum Daily Load
TUTIA – Toilet Users To Impervious Area
WIHMP – Watershed Infiltration and Hydromodification Master Plan
WMA – Watershed Management Area
WQ – Water Quality
WQDF – Water Quality Design Flow
WQDV – Water Quality Design Volume
WQMP – Water Quality Management Plan

GLOSSARY OF KEY TERMS

Agronomic demand – the amount of irrigation required to meet plant water needs, accounting for inefficiencies in irrigation.

Alternative compliance program – encompasses the elements used to satisfied remaining performance criteria after on-site LID BMPs have been implemented to the maximum feasible level (and in the North Orange County permit area, after both on-site and sub-regional/regional LID BMPs have been implemented to the maximum feasible level).

Assessment of Susceptibility (to **Hydrologic Conditions of Concern**) – an assessment of the receiving water(s) of a project to determine whether downstream water courses, water bodies, and/or stormwater conveyance infrastructure would potentially be impacted by changes in hydrologic regime.

Average annual capture efficiency (a.k.a. capture efficiency) – the estimated percent of long term average annual runoff volume that is managed/controlled by a BMP. Target capture efficiency serves as one element of the performance criteria for LID and treatment control BMPs.

Biotreatment BMP – a class of LID BMPs, biotreatment BMPs are vegetated treat-and-release BMPs that also promote infiltration and/or ET.

Biotreatment volume – the volume of storage in biotreatment BMPs, measured from the overflow elevation of the BMP outlet, which would be treated and discharged as the BMP drains; this volume includes surface storage and pore storage but does not include the volume that would be retained in the BMP and discharged to infiltration, ET, or uses.

Bypass – runoff that is routed around a BMP or passes through the BMP with minimal treatment. Bypass generally occurs when the inflow volume or flowrate has exceeded the BMP capacity.

Capture Efficiency (a.k.a. average annual capture efficiency) – the estimated percent of long term average annual runoff volume that is captured by a BMP (i.e., does not bypass). Target capture efficiency serves as one element of the performance criteria for LID and treatment control BMPs.

Capture Efficiency Method – a BMP sizing method based on capturing the average annual stormwater runoff volume from a project as determined with continuous flow modeling.

Conceptual Project WQMP - a Project WQMP prepared at the planning phase of projects subject to discretionary approval; intended to describe, at the earliest possibly phase in the development process, the BMPs that will be implemented and maintained throughout the project (functionally equivalent to a Preliminary Project WQMP; nomenclature varies by local jurisdiction).

Design capture storm depth – the 85th percentile, 24-hr storm depth.

Design Capture Volume (DCV)– the volume of storm water runoff resulting from the design capture storm depth.

Design criteria – requirements that serve as the basis for designing a BMP to meet performance criteria. Design criteria may encompass BMP sizing and other characteristics of BMP design.

Drainage Area Management Plan (DAMP) – The specific water pollutant control elements of the Orange County Stormwater Program are documented in the Drainage Area Management Plan (DAMP), which is the Permittees' primary policy, planning and implementation document for municipal NPDES Stormwater Permit compliance.

Drawdown – the act of discharging water from a BMP. Drawdown provides storage volume for subsequent storm events.

Drawdown rate – the rate at which water discharges from a BMP, making storage volume available for subsequent storm events.

Drawdown time – the time it takes to a BMP from brim full. Drawdown time may need to be calculated separately for the retention volume of the BMP and the biotreatment volume of the BMP in order to support design calculations if both types of volume exist. These separate measures are referred to as the "retention drawdown time" and "biotreatment drawdown time".

Environmentally Sensitive Area - areas such as those designated in the Ocean Plan as Areas of Special Biological Significance or waterbodies listed on the CWA Section 303(d) list of impaired waters (See full definition in **Section 2.3.3.4**).

Evapotranspiration (ET) - the loss of water to the atmosphere by the combined processes of evaporation (from water, soil and plant surfaces) and transpiration (from plant tissues). As used in this TGD, ET refers to one or both of these processes.

Evapotranspiration BMP (aka ET BMP) – a class of retention BMPs that discharges stored volume predominantly to ET; some infiltration may occur. ET includes both evaporation and transpiration, and ET BMPs may incorporate one or more of these processes.

Final Project WQMP – a Project WQMP submitted at the ministerial approval phase prior to final approval of a grading or building permit; expected to reflect the detail available at the time of project ministerial-level approval.

Harvest and Use – The process of capturing rainwater or stormwater runoff, storing it, and making it available for subsequent use. This process is performed by Harvest and Use BMPs.

Harvest and Use BMP (aka Rainwater Harvesting BMP) – a class of retention BMPs that captures rainwater or stormwater runoff and stores it for subsequent use.

Hydrocollapse - a sudden collapse of granular soils cause by a rise in groundwater dissolving or deteriorating the inter-granular contacts between the sand particles

Hydrologic condition of concern (HCOC) – a combination of upland hydrologic conditions and stream biological and physical conditions that presents a condition of concern for physical and/or biological degradation of a stream.

Hydrologic source control (HSC) - a class of LID BMPs integrated with site design that retain stormwater runoff and reduce the volume (and potentially rate) of stormwater discharge to the downstream system. HSCs are differentiated from retention and biotreatment classes of LID BMPs by their higher level of integration with a site. They are not sized according to engineering design criteria, and they do not typically result in a distinct facility. Consequently, they are usually regarded as site design practices, as opposed to structural treatment control BMPs. An example includes routing roof runoff into adjacent landscaped areas.

Hydromodification – Changes in runoff and sediment yield caused by land use modifications.

Hydromodification control – Management techniques which reduce the potential for hydromodification impact.

Hydromodification impact – The physical response of stream channels to changes in runoff and sediment yield caused by land use modifications

Infiltration BMP – a class of retention BMPs that discharges stored volume predominantly to deeper percolation/infiltration; some evapotranspiration may also occur.

In-stream control – Modification of a receiving channel as a technique for managing hydromodification impacts. The modifications are usually done for the purposes of allowing the channel to accept changes in hydrology while minimizing impacts to beneficial uses.

Irrigation Area Ratio – a ratio describing the agronomic irrigation demand for harvested stormwater as a fraction of the tributary area to the stormwater storage device.

Irrigation Efficiency – the ratio of plant irrigation needs met to the amount of irrigation water applied. A value of 0.75 implies that 1 inch of irrigation water must be applied to satisfy 0.75 inches of plant water needs.

LID BMP – a BMP that provides retention or biotreatment as part of an LID strategy – these may include HSCs, retention, and biotreatment BMPs.

LID site design – The component of LID that relates to the way in which a site is laid out to achieve strategic stormwater management and resource management objectives. Site design practices work synergistically with LID BMPs, treatment control, and hydromodification control strategies. Example practices include minimizing impervious areas and locating pervious areas such that impervious areas can drain to pervious areas.

Liquefaction - a seismically-induced geological hazard that can result in damage to structures as a result in reduction in bulk volume of saturated granular soils.

Local Implementation Plan (LIP) - The Local Implementation Plan (LIP) describes how the DAMP is being implemented by individual permittees under the MS4 Permit.. The DAMP provides a foundation for the description and detail of how the Orange County Stormwater Permittees commonly implement model programs designed to prevent pollutants from entering receiving waters to the maximum extent practicable (MEP). The LIP is designed to supplement the DAMP and each city and the County have developed a comprehensive LIP that is specific to their jurisdiction.

On-site LID practices – LID practices that are implemented within the project boundary.

Opportunity Criteria – characteristics of a drainage area that provide opportunity for a certain type of BMP. Opportunity criteria are tabulated for each BMP type and are intended to be used in the BMP Prioritization process.

Other Pollutants of Concern – A pollutant which is expected to be generated by the project's land uses for which there is no 303(d) listing or TMDL in place for any receiving water of the project.

Performance criteria – specific measurable or verifiable requirements against which the performance of a system is compared to assess compliance with a Project WQMP, the Model WQMP, and the Permit. There are three separate types of performance criteria: 1) LID, 2) treatment control, and 3) hydromodification control. These performance criteria are evaluated individually although they can be interrelated. It is possible to meet one and not meet the others. This is synonymous with "performance standard" as used by other guidance documents, but only "performance criteria" is used in this document.

Preliminary Project WQMP – a Project WQMP prepared at the planning phase of projects subject to discretionary approval; intended to describe, at the earliest possibly phase in the development process, the BMPs that will be implemented and maintained throughout the project (functionally equivalent to a Conceptual Project WQMP; nomenclature varies by local jurisdiction).

Primary Pollutant of Concern - A pollutant which is expected to be generated by the project's land uses for which there is a 303(d) listing or TMDL in place for any receiving water of the project.

Priority Project – a new development or redevelopment project meeting the thresholds described in Section 1.2 of the Model WQMP.

Project Water Quality Management Plan (Project WQMP) - a project submittal that describes the Best Management Practices (BMPs) that will be implemented and maintained throughout the life of a project. This term is used in this TGD to describe Conceptual/Preliminary and Final Project WQMPs.

Retention BMP – a class of LID BMPs including infiltration BMPs, evapotranspiration BMPs, and harvest and use BMPs whose design does not allow the discharge of stormwater runoff to the storm drainage system or surface water up to the DCV ; these BMPs either infiltration, evapotranspire, or allow for use of the retention volume.

Retention volume – the volume of storage in retention and biotreatment BMPs, measured from the overflow elevation of the BMP, which would be retained and discharged to infiltration, ET, or uses as the BMP drains. All storage volume is retention volume in retention BMPs.

Site design – a stormwater management strategy that emphasizes conservation and use of existing site features to reduce the amount of runoff and pollutant loading that is generated from a project site. Site design practices compliment LID BMPs, treatment control, and hydromodification control strategies. Example practices include clustering development, minimizing impervious areas, and locating pervious areas such that impervious areas can drain to pervious areas.

Sizing criteria – specific design criteria related to BMP size that serve as a basis for meeting performance criteria.

Source Control – a class of preventative measures intended to prevent the introduction of pollutants into stormwater.

Standard Stormwater Mitigation Plan (SSMP) – see Project WQMP

Susceptibility – a channel's lack of ability to resist physical response due to hydromodification

Treatment - the DCV is considered to have been subject to treatment or is considered treated when pollutant concentrations or loads have been reduced. Volume that is lost in a BMP via infiltration and ET is considered to meet treatment criteria, however the term "treated discharge" this is intended to refer to treated water discharged back to the storm drain system or surface waters.

Treatment control BMP – a structure designed to treat pollutants in stormwater runoff and release the treated runoff to surface waters or a storm drain system , but is not a biotreatment BMP. Examples include sand filters and cartridge media filters.

2-year, 24-hour event – a 24-hour storm event expected to be equaled or exceeded, on average, every 2 years. As defined for Orange County by the Orange County Hydrology Manual.

Water quality credit system – the system by which certain project types are granted reduction in the criteria for determining treatment control and/or offsite mitigation requirements for alternative program requirements.

Watershed-based plan – refers to a RWQCB Executive Officer-approved Watershed Master Plan (WMP), Hydromodification Management Plan (HMP), or other RWQCB Executive Officer-approved watershed-based plan developed with consideration for water quality, hydrologic, fluvial, water supply, and/or habitat, consistent with the LID and hydromodification principles and criteria described in the North County and/or South County permit. Watershed-based plans may include specific guidance and support for applying LID feasibility criteria, but may not substantively alter LID performance criteria. Approved WMPs and HMPs may substantively alter hydromodification performance criteria.

Watershed Management Area (WMA) - Watershed Management Areas (WMAs) are used in the countywide Water Quality Strategic Plan as the structure for water resource management. The eleven watersheds in Orange County are grouped by similar characteristics into three Watershed Management Areas: North, Central, and South County.

SECTION 1. INTRODUCTION

1.1. Role of Technical Guidance Document in Project Planning

This Technical Guidance Document (TGD) has been developed by the County of Orange in cooperation with the incorporated Cities of Orange County to aid agency staff and project proponents with addressing post-construction urban runoff and stormwater pollution from new development and significant redevelopment projects in the County of Orange.

Within the Santa Ana Regional Water Quality Control Board (Santa Ana Regional Board) jurisdiction, the Fourth Term MS4 Permit (Order R8-2009-0030) ("North County Permit") has been adopted with specific requirements for new development and significant redevelopment stormwater control. Within the San Diego Regional Water Quality Control Board (San Diego Regional Board) jurisdiction, the Fourth Term MS4 Permit Order (R9-2009-0002) ("South County Permit) has been adopted with similar but somewhat differing requirements for new development and significant redevelopment stormwater control.

A Model Water Quality Management Plan (WQMP) (DAMP Exhibit 7.II-2) has been prepared to explain the requirements and types of analyses that are required in preparing a Conceptual/ Preliminary or Project WQMP in compliance with the North County and South County Permits. A companion Project WQMP Template has also been prepared. The Model WQMP and the Project WQMP Template provide the framework for developing a Conceptual/Preliminary or Project WQMP in compliance with the MS4 Permits within Orange County. These documents describe the applicability of these requirements. The purpose of this TGD is to serve as a technical resource companion to the Model WQMP and the Project WQMP Template. Whereas the Model WQMP and Project WQMP Template are intended to answer "what, why, and when" for Project WQMP preparation, this TGD is intended to provide guidance on "how" to complete the Conceptual/ Preliminary or Project WQMP.

1.2. Stormwater Management Best Management Practices

Low impact development (LID) is a stormwater management strategy that emphasizes conservation and use of existing site features integrated with distributed stormwater controls that are designed to more closely mimic natural hydrologic patterns of undeveloped sites than traditional stormwater management controls. LID includes both site design and structural measures, as described below. Components of LID are considered to be "preventative" in that they prevent or reduce runoff from occurring by reducing the elements of development that produce runoff. These are referred to in this TGD as "LID Site Design Practices" or simply "Site Design Practices." Other elements of LID are considered to be "mitigative" in that they are used to manage runoff that is generated. These are referred to in this TGD as "LID best management practices (BMPs)." Hydrologic source controls (HSCs) are a group of LID practices, such as dispersing rooftop runoff through adjacent landscaping, for which this TGD provides a method of quantitatively estimating benefits. Therefore, these practices are considered separately from other site design practices described in this TGD.

Hydromodification control includes measures to minimize the potential for hydromodification impacts to streams as a result of land changes. Hydromodification is the physical response of stream channels to changes in catchment runoff and sediment yield caused by land use. Control methods include site design, hydrologic controls, and in-stream controls

In this TGD, treatment controls are structural BMPs, not including LID BMPs, which are used to remove pollutants from stormwater, such as sand filters and cartridge media filters. Treatment controls may be located on the project site or regionally. LID BMPs are considered to satisfy treatment control requirements as well as LID requirements.

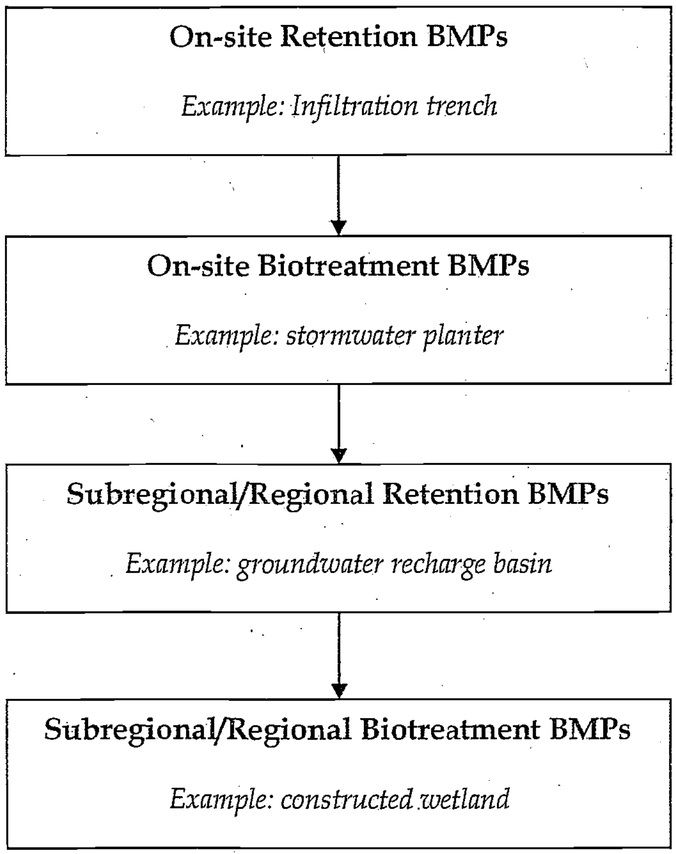
Depending upon the project size and characteristics, the Conceptual/Preliminary and/or Project WQMP may include combinations of the following types of BMPs:

- **LID Site Design Practices:** components of an overall LID strategy that relate to the way in which a site is laid out to achieve stormwater management and resource management objectives. Site design practices work synergistically with LID BMPs, treatment control, and hydromodification control strategies. Example practices include minimizing impervious areas and locating pervious areas such that impervious areas can drain to pervious areas.
- **Hydrologic source controls (HSCs):** can be considered to be a hybrid between site design practices and LID BMPs. HSCs are distinguished from site design BMPs in that they do not reduce the tributary area or reduce the imperviousness of a drainage area; rather they reduce the runoff volume that would result from a drainage area with a given imperviousness compared to what would result if HSCs were not used. HSCs are differentiated from LID BMPs in that they tend to be more highly integrated with site designs and tend to have less defined design and operation. For example, it may not be possible to precisely describe the storage volume and drawdown rate of a pervious area receiving drainage from downspout disconnects; however these systems can be very effective at reducing runoff.
- **On-site, Sub-regional, or Regional LID BMPs:** structural measures that provide retention or biotreatment of stormwater as part of an LID strategy – these may be located either on-site or off-site as dictated by LID performance criteria. Examples include infiltration BMPs, bioinfiltration systems (engineered landscaped areas that promote infiltration but include underdrains), harvest and use systems, green roofs, biofiltration systems (e.g., bioretention with underdrains, vegetated swales) and regional constructed wetland treatment systems.
- **Hydromodification Control BMPs:** on-site, regional, or in-stream measures used as part of an overall strategy to reduce the potential for hydromodification impact. Example hydromodification control BMPs include infiltration and detention basins, bioinfiltration facilities, underground detention vaults, and instream grade controls. HSCs and LID BMP provide volume reduction and/or peak flow benefits, therefore also serve or contribute to hydromodification control.

- **Treatment Control BMPs:** structural measures designed to remove pollutants of concern from stormwater, but which do not meet criteria to be categorized as LID BMPs, such as media filters.
- **Source Control BMPs:** non-structural and structural practices intended to prevent or reduce the introduction of pollutants into stormwater. This category include pollutant source controls for the purpose of the TGD and does not include HSCs, described above.

LID BMPs are required to be incorporated into a Project WQMPs according to the general hierarchy described in the MS4 Permits. This hierarchy is described in **Figure 1.1**.

Figure 1.1: General Hierarchy of LID BMPs



A principal role of the Model WQMP and this TGD is to describe the processes and criteria to ensure that this hierarchy is incorporated into project WQMPs to the maximum extent practicable (MEP)[1].

1.3. Organization of the Technical Guidance Document

The TGD is divided into seven sections and 16 appendices, as follows:

- Section 1 provides an introduction to the purpose of the document and its role in project planning.
- Section 2 contains guidance on how to prepare Conceptual/Preliminary and/or Project WQMPs as directed by the Model WQMP and in the same order as outlined in the Project WQMP Template.
- Section 3 provides guidance for site design principles and practices, including site planning and layout, vegetative protection, revegetation, slopes and channel buffers, techniques to minimize land disturbance, LID BMPs at scales from single parcels to watershed, and integrated water resource management practices. This section supports Project WQMP Template Section IV.2.
- Section 4 provides BMP design guidance for infiltration BMPs, harvest and use BMPs, evapotranspiration BMPs, biotreatment BMPs, treatment control BMPs, and pretreatment/gross solids removal BMPs. This section supports Project WQMP Template Section IV.3.
- Section 5 provides guidance for design approaches for hydromodification control BMPs, including, on-site / distributed controls, regional controls, and in-stream controls. This section also supports Project WQMP Template Section IV.3.
- Section 6 provides guidance for the type, functionality, and selection of Source Control Measures, both structural and non-structural. This section also supports Project WQMP Template Section IV.3.
- Section 7 provides general considerations and information on operation and maintenance planning, maintenance plans, and agreements. This section supports Project WQMP Template Section V.
- Appendix I summarizes the BMP sizing requirements for the North Orange County permit area.
- Appendix II summarizes the BMP sizing requirements for the South Orange County permit area.

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[1] *MEP is not defined in the Clean Water Act; it refers to management practices, control techniques, and system, design and engineering methods for the control of pollutants taking into account considerations of synergistic, additive, and competing factors, including, but not limited to, gravity of the problem, technical feasibility, fiscal feasibility, public health risks, societal concerns, and social benefits.* [North Orange County Permit]

- Appendix III provides hydrologic calculations and sizing methods for LID and treatment control BMPs.
- Appendix IV provides approved methods for quantifying hydrologic conditions of concern in the North Orange County permit area.
- Appendix V provides approved methods for meeting the Interim Hydromodification Control Standard in the South Orange County permit area.
- Appendix VI provides approved methods for calculating the alternative compliance volume.
- Appendix VII provides guidance for evaluating infiltration rates and determining safety factors for infiltration feasibility screening and design.
- Appendix VIII summarizes groundwater-related infiltration feasibility criteria.
- Appendix IX provides the technical basis for green roof design criteria.
- Appendix X summarizes harvest and use demand calculations and feasibility screening.
- Appendix XI provides criteria for designing LID BMPs to achieve maximum feasible retention and biotreatment.
- Appendix XII provides a discussion of biotreatment selection, design, and maintenance criteria.
- Appendix XIII describes and supports the incremental threshold benefit criterion.
- Appendix XIV provides concise fact sheets for 25 LID and treatment control BMPs with references to more extensive design guidance.
- Appendix XIV provides links to worksheets that are referenced throughout the TGD.
- Appendix XV contains watershed exhibits, including a rainfall zone map, infiltration feasibility constraint maps, and groundwater protection area maps.

SECTION 2. TECHNICAL GUIDANCE FOR PREPARING PROJECT WQMPS

TGD Section 2 provides guidance for how to fill in the Project WQMP Template and is organized to mirror the respective sections of the WQMP Template. The requirements for the Project WQMP preparation process are described in Section 2.0 of the Model WQMP.

2.1. Discretionary Permits and Water Quality Conditions

Section I of the Project WQMP should list the discretionary permit(s) applicable to the project and provide the site address or lot and tract/parcel map number describing the property.

List, verbatim, any Water Quality Conditions, including the condition requiring preparation of WQMP, if applicable. Water Quality Conditions may be included as mitigation measures in California Environmental Quality Act (CEQA) documents for the project. For example, a Mitigation Monitoring and Report Program (MMRP) adopted in a certified Environmental Impact Statement (EIR) may include Project Design Features (PDFs), Standard Conditions (SCs), and Mitigation Measures (MMs) related to water quality protection.

A Conceptual/Preliminary WQMP may have been prepared for the project in the preliminary planning stages, for example, as a technical appendix in an EIR. If so, the Conceptual/ Preliminary WQMP must be used as a source of information for the Project WQMP, if applicable. The Section I of the Project WQMP should discuss whether are any substantial differences compared to the Conceptual/Preliminary WQMP and the significance of these revisions.

Describe the Conceptual/Preliminary WQMP BMP plan in Section I of the Project WQMP, if applicable. If regional stormwater management facilities are identified in the Conceptual/Preliminary WQMP that will serve the project, but are located offsite, list and describe those regional facilities, including any sizing assumptions that may relate to the project. If the Conceptual/Preliminary WQMP included stormwater management site design, source control, low impact design, treatment control, or hydromodification control commitments or performance standards that are specific to the project, then list those in Section 1 of the Project WQMP.

Watershed-based plans may also contain special conditions that must be considered in Project WQMP development. The following watershed-based plans should be reviewed for requirements that may affect the selection of best management practices (BMPs) for the project:

Watershed Infiltration and Hydromodification Management Plans (WIHMP). WIHMPs will be prepared for the Coyote Creek-San Gabriel River by May 2011 and for the Anaheim Bay-Huntington Harbor, Santa Ana River, and Newport Bay-Newport Coast watersheds by May 2012. The WIHMPs will address the HCOCs on a watershed and sub-watershed basis; include maps to identify areas and structures that are susceptible to hydromodification impacts, including downstream erosion, impacts on physical structures, and impacts on riparian and aquatic habitats; include maps to identify areas where stormwater and urban runoff infiltration is possible and appropriate given sub-surface conditions and other factors such as downgradient habitats; and may specify hydromodification management standards for each sub-watershed.

Total Maximum Daily Load (TMDL) Implementation Plans. A TMDL sets a limit for the total amount of a particular pollutant that can be discharged to a waterbody, such that the pollutant loads from all sources will not impair the designated beneficial uses of the waterbody. A TMDL is developed when a waterbody has been identified as impaired. Section 303(d) of the federal Clean Water Act requires states to establish a listing of all impaired waterbodies and to rank those waterbodies according to priority for TMDL development. This list, called the 303(d) List, is updated every two years and is developed by the Regional and State Water Quality Control Boards and approved by EPA.

The following TMDLs have been established or are being developed for Orange County waterbodies. To find out more about each TMDL or to see the most recent list of TMDLs in Orange County, see the Orange County Watersheds Program webpage at www.ocwatershed.com/TMDL:

- Aliso Creek Indicator Bacteria
- Coyote Creek Metals (copper, lead, zinc)
- Dana Point Harbor - Baby Beach Indicator Bacteria
- San Diego Creek/Newport Bay (Sediment, Nutrient, Toxics, Fecal Coliform[2])
- San Juan Creek Indicator Bacteria
- South County Coastal Areas Indicator Bacteria

If a watershed-based plan contains specific stormwater management standards that are applicable to the project, list those specific standards in Section 1 of the Conceptual/Preliminary or Project WQMP. A watershed-based plan may contain standards more stringent than one or both permits.

2.2. Project Description

This section provides guidance for WQMP Template Section II. This section of the Conceptual/Preliminary or Project WQMP should provide the information listed below. The level of detail provided should be general in nature for Conceptual/ Preliminary WQMPs and more specific for Project WQMPs. The purpose of this information is to help determine the applicable Source Control BMPs, pollutants of concern, HCOCs, and long term maintenance responsibilities for the project. This information will be used in conjunction with the information in WQMP Template Section III, Site Description, to establish the performance

[2] The Fecal Coliform TMDL applies only to Newport Bay.

criteria and to select the BMP plan for the project, in accordance with WQMP Template Section IV.

2.2.1. Project Land Uses

Provide the following information:

- For the entire parcel, list and describe the proposed land uses, the area of each land use, and the estimated imperviousness for each land use.
- List and show on a figure where facilities will be located and what activities will be conducted:
    - List what kinds of materials and products will be used (if known), how and where materials will be received and stored (if applicable), and what kinds of wastes will be generated (if any).
    - Describe all paved areas, including the type of parking areas.
    - Describe all landscaped areas and open space areas (if any).
- For commercial and industrial projects:
    - Provide the Standard Industrial Classification (SIC) Code which best describes the facilities operations.
    - Describe the type of use (or uses) for each building or tenant space (if known).
    - If the project includes food preparation, cooking, and eating areas, specify the location and type of area.
    - Describe delivery areas and loading docks (specify location, design, if below grade, and types of materials expected to be transferred).
    - Describe outdoor materials storage areas (describe and depict location(s), specify type(s) of materials expected to be stored).
    - Describe activities that will be routinely conducted outdoors.
    - Describe any activities associated with equipment or vehicle maintenance and repair, including washing or cleaning.
    - Indicate the number of service bays or number of fueling islands/fuel pumps, if applicable.
- For residential projects:
    - For a single dwelling unit, describe the unit and project site.
    - For a tract, list the range of lot and home sizes.
    - Describe all community facilities such as laundry, car wash, swimming pools, jacuzzi, parks, open spaces, tot lots, etc.

2.2.2. Expected Stormwater Pollutants

Urban runoff from a developed site and stormwater pollution associated with the runoff has the potential to contribute pollutants to the municipal storm drain system and ultimately to the tributary receiving waters. Pollutants that are commonly associated with urban development include suspended solids/sediment, nutrients, metals, microbial pathogens, oil and grease, toxic organic compounds, and trash and debris. The pollutants of concern for a specific project are based upon the pollutants identified by regulatory agencies as impairing receiving waters (described below), and pollutants that are anticipated or potentially could be generated by the project based on the proposed land uses. Section 2.3.4 of the Model WQMP describes the regulatory criteria for determining the expected stormwater pollutants from a Priority Project.

2.2.2.1. Pollutant Categories

Pollutants of concern can be grouped into the following seven general categories:

- *Suspended Solids / Sediment*: consist of soils or other surficial materials that are eroded and then transported or deposited by wind, water, or gravity. Excessive sedimentation can increase turbidity, clog fish gills, reduce spawning habitat, lower young aquatic organisms survival rates, smother bottom dwelling organisms, and suppress aquatic vegetation growth. Sediments in runoff also transport other pollutants that adhere to them, including trace metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and phosphorus. The largest source of suspended solids / sediment is typically erosion from disturbed soils.
- *Nutrients:* includes the macro-nutrients nitrogen and phosphorus. They commonly exist in the form of mineral salts dissolved or suspended in water and as particulate organic matter transported by stormwater. Excessive discharge of nutrients to water bodies and streams can cause eutrophication, including excessive aquatic algae and plant growth, loss of dissolved oxygen, release of toxins in sediment, and significant swings in hydrogen ion concentration (pH). Primary sources of nutrients in urban runoff are fertilizers, trash and debris, and eroded soils. Urban areas with improperly managed landscapes can be substantial sources.
- *Metals:* includes certain metals that can be toxic to aquatic life if concentrations become high enough to stress natural processes. Metals of concern include cadmium, chromium, copper, lead, mercury, and zinc. Lead and chromium have been used as corrosion inhibitors in primer coatings and are also raw material components in non-metal products such as fuels, adhesives, paints, and other coatings. Copper and zinc are typically associated with building materials, including galvanized metal and ornamental copper, and automotive products, including tires and brake pads. 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, for

example lead additives in gasoline. The primary source of metals in urban stormwater is typically commercially available metal products and automobiles.

- *Microbial Pathogens (Bacteria and Viruses)*: include bacteria and viruses, which are ubiquitous microorganisms that thrive under a range of environmental conditions. Water containing excessive pathogenic bacteria and viruses can create a harmful environment for humans and aquatic life. The source of pathogenic bacteria and viruses is typically the transport of animal or human fecal wastes from the watershed, but pathogenic organisms do occur in the natural environment.
- *Oil and Grease* : are characterized as high-molecular weight organic compounds. Elevated oil and grease content can decrease the aesthetic value of the water body, as well as the water quality. Introduction of these pollutants to water bodies may occur due to the wide uses and applications of some of these products in municipal, residential, commercial, industrial, and construction areas. 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.
- *Toxic Organic Compounds*: include organic compounds (pesticides, solvents, hydrocarbons) which at toxic concentrations constitute a hazard to humans and aquatic organisms. Stormwater coming into contact with organic compounds can transport excessive levels organics to receiving waters. Dirt, grease, and grime retained in cleaning fluid or rinse water may also adsorb levels of organic compounds that are harmful or hazardous to aquatic life. Sources of organic compounds include landscape maintenance areas, vehicle maintenance areas, waste handling areas, and potentially most other urban areas.
- *Trash and Debris* – includes trash, such as paper, plastic, and various waste materials, that can typically be found throughout the urban landscape, and debris which includes waste products of natural origin which are not naturally discharged to water bodies such as landscaping waste, woody debris, etc. The presence of trash and debris may have a significant impact on the recreational value of a water body and upon the health of aquatic habitat.

2.2.2.2. Expected Pollutants Based on Project Land Use Activities

This section describes how to determine expected pollutants based on project land use activities and accompanies Section 2.3.4 of the Model WQMP. Pollutants in stormwater runoff are typically related to land use activities, which means that the project's site uses provide some indication of the pollutants that may be present in runoff from the project site. Pollutants that are expected to be generated or have a potential to be generated from a project based on the project's land use activities must be identified using **Table 2.1**, as applicable. The identification of expected pollutants must always be based on the land use activities proposed. In addition, site-specific conditions must also be considered for potential pollutant sources, such as legacy pesticides or nutrients in site soils as a result of past agricultural practices or hazardous materials in site soils from industrial uses. Hazardous materials that have been remediated and do not pose a current or future threat to stormwater quality are not considered a pollutant of concern.

Municipal projects should determine expected pollutants based on the pollutant generating activities associated with the project using Table 5.5 in Section 5 of the Orange County DAMP (**www.ocwatersheds.com/Documents/2003_DAMP_Section_5_Municipal_Activities.pdf**).

Table 2.1: Anticipated and Potential Pollutants Generated by Land Use Type

Priority Project Categories and/or Project Features	General Pollutant Categories							
	Suspended Solid/ Sediments	Nutrients	Heavy Metals	Pathogens (Bacteria/ Virus)	Pesticides	Oil & Grease	Toxic Organic Compounds	Trash & Debris
Detached Residential Development	E	E	N	E	E	E	N	E
Attached Residential Development	E	E	N	E	E	E(2)	N	E
Commercial/ Industrial Development	E(1)	E(1)	E(5)	E(3)	E(1)	E	E	E
Automotive Repair Shops	N	N	E	N	N	E	E	E
Restaurants	E(1)(2)	E(1)	E(2)	E	E(1)	E	N	E
Hillside Development >5,000 ft^2	E	E	N	E	E	E	N	E
Parking Lots	E	E(1)	E	E(4)	E(1)	E	E	E
Streets, Highways, & Freeways	E	E (1)	E	E(4)	E(1)	E	E	E
Retail Gasoline Outlets	N	N	E	N	N	E	E	E

E = expected to be of concern
N = not expected to be of concern

(1) *Expected pollutant if landscaping exists on-site, otherwise not expected.*
(2) *Expected pollutant if the project includes uncovered parking areas, otherwise not expected.*
(3) *Expected pollutant if land use involves food or animal waste products, otherwise not expected.*
(4) *Bacterial indicators are routinely detected in pavement runoff.*
(5) *Expected if outdoor storage or metal roofs, otherwise not expected.*

2.2.3. Hydrologic Conditions of Concern

As specified in Section 2.3.3 of the Model WQMP, projects must identify and mitigate any HCOCs. A HCOC is a combination of upland hydrologic conditions and stream biological and physical conditions that presents a condition of concern for physical and/or biological degradation of streams.

2.2.3.1. Determining HCOCs in North Orange County

In the North Orange County permit area, HCOCs are considered to exist if any streams located downstream from the project are determined to be potentially susceptible to hydromodification impacts and either of the following conditions exists:

- Post-development runoff volume for the 2-yr, 24-hr storm exceeds the pre-development[3] runoff volume for the 2-yr, 24-hr storm by more than 5 percent

  OR

- Time of concentration of post-development runoff for the 2-yr, 24-hr storm event exceeds the time of concentration of the pre-development condition for the 2-yr, 24-hr storm event by more than 5 percent[4].

Calculation methods for determination of HCOCs in the North Orange County permit area are provided in Appendix IV. If these conditions do not exist or streams are not potentially susceptible to hydromodification impacts, an HCOC does not exist and hydromodification does not need to be considered further.

Stream susceptibility must be determined using the regional stream susceptibility maps that are provided in Appendix XV, watershed-specific maps contained in a WIHMP, and/or site specific engineering analysis using the method described in Section 2.3.3 below.

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[3] In North Orange County (Order R8-2009-0030), predevelopment is defined as the existing conditions immediately prior to Project WQMP submittal.

[4] The North County Permit (Order R8-2009-0030), as adopted, provides the option of reducing Tc to less than the existing condition Tc (within 5 percent) as part of the primary and preferred option for mitigating HCOCs. However, a longer Tc is generally associated with natural conditions than urban conditions, and a longer Tc nearly universally results in lower concern for hydromodification impacts. In addition, it is not physically possible for a project to implement BMPs consistent with LID provisions of the permit without substantially increasing the Tc of the site. The use of retention BMPs results in water not discharged under design conditions, while the use of biotreatment BMPs general results in water not immediately discharged. Therefore, it would not generally be possible to mitigate HCOCs using the primary option for compliance described above while complying with LID requirements. This TGD therefore interprets this provision such that increases in Tc would be acceptable and reduction in Tc of more than 5 percent would not be acceptable. This interpretation is consistent with the overall goal of the permit to protect receiving waters from stormwater impacts to the maximum extent practicable.

2.2.3.2. Determining HCOCs in South Orange County

Interim Criteria

HCOCs are not considered to exist if the downstream conveyance network is not susceptible to hydromodification impacts. Streams susceptibility must be determined using the watershed-specific maps contained in the South Orange County HMP (to be developed by December 2011) and/or with site specific engineering analysis using the method described in Section **2.3.3** below.

If the project has a HCOC, the Project WQMP should describe the project's receiving waters and document the method used to determine whether the downstream receiving waters are susceptible to HCOCs.

- If regional susceptibility maps are used to establish susceptibility, the Project WQMP should include an exhibit showing the location of the project on the regional susceptibility maps.
- If determination of susceptibility is based on a site-specific investigation, the Project WQMP should summarize the findings of the site-specific investigation.

Appendix V describes the approved hydrologic methods for identifying and mitigating HCOCs in the South Orange County permit area

2.2.4. Post Development Drainage Characteristics

The Project WQMP should generally describe the proposed drainage for the site, including the following:

- Will the site connect to a storm drain system or discharge directly into a receiving water body?
- If the site will connect to a storm drain system, name the locations for the connection(s).
- Name the direct receiving water body for the project site and list each subsequent water body until reaching the ocean. If the project will connect to the storm drain, determine where the storm drain system discharges into a receiving water body. For assistance in mapping the receiving water bodies, see the maps provided in Appendix XV.
  The purpose of this section of the Project WQMP is to establish the immediate fate of water leaving the project site and to identify the site constraints relative to the general drainage patterns of the site and the off-site drainage connections. It is not the intent of this section to describe the drainage and BMP plan in detail. A more detailed description of the drainage and BMP plan should be provided in Section IV of the Project WQMP.

2.2.5. Property Ownership/Management

Describe the ownership of all portions of the project and site. State whether any infrastructure will transfer to public agencies (City, County, Caltrans, etc.). State if a homeowners or property owners association will be formed that will be responsible for the long term maintenance of the project's stormwater facilities.

2.2.6. Water Quality Credits

Water quality credits and their intended applicability and role in WQMP preparation are discussed in Model WQMP Section 3.1. Water quality credits are intended to reduce the remaining unmet obligations for LID and treatment control after the maximum feasible level of control has been provided. As such, a Project could qualify for water quality credits but not need to claim these credits if the required BMP sizing can be feasibly provided without these credits.

The applicability of water quality credits is generally based on Project characteristics, therefore the Project characteristics that qualify the Project for water quality credits should be described in this section of the WQMP Template, as applicable. If a Project qualifies for water quality credits, but does not claim these credits, it is optional for the WQMP to describe the qualifying project features. Calculation methods for applying water quality credits are described in Appendix VI.

2.3. Site Description

This section provides the guidance for WQMP Template Section III. The purpose of this section of the Conceptual/Preliminary or Project WQMP is to describe the project site conditions that will inform the selection and design of BMPs through an analysis of the physical conditions and limitations of the site and its receiving waters.

2.3.1. Physical Setting

If the project is not located on an already developed site, then identify the planned community and planning area for the project, if applicable. If the project is located on an already developed site, then identify the location using the site address.

2.3.2. Site Characteristics

Assessing a site's potential for implementation of LID, treatment control, and hydromodification control BMPs requires the review of existing information and may include the collection of site-specific measurements. Available information regarding site characteristics such as impervious cover, slope, soil type, geotechnical conditions, and local groundwater conditions should be discussed in this section of the WQMP Template. In addition, soil and infiltration testing may be necessary to determine if stormwater infiltration is feasible and to determine the appropriate design infiltration rates for infiltration-based BMPs. Impervious cover is the most important characteristic to determine the presence of HCOCs for the North Orange County permit area and is always required to be documented in this section of the Project WQMP. For redevelopment projects, the percentage of impervious cover added as a fraction of the existing impervious cover left in place is critical for determining the portions of the project that must comply with LID, hydromodification control, and treatment control requirements (See Section 1.2 of the Model WQMP for project applicability).

Model WQMP Section 2.3 describes mandatory site assessment requirements applicable to specific project types. The following subsections are intended to provide recommendations for meeting these requirements. The specific recommendations contained in this section are not intended to prevent the consideration of site-specific factors or substitute for the need to exercise sound engineering judgment. In addition, the recommendations made in this section are intended to be applied to the extent that they are necessary to meet minimum site-assessment requirements. These recommendations are not intended to imply that each of these analyses must be conducted for every Project. For example, if groundwater is known to be very deep, it is not necessary to conduct an evaluation of the exact water table or the potential for groundwater mounding.

2.3.2.1. Topography

The site's topography should be assessed to evaluate surface drainage, topographic high and low points, and to identify the presence of steep slopes that qualify as hillside locations, all of which have an impact on what type of LID and treatment control BMPs will be most beneficial for a given project site. Stormwater infiltration is more effective on level or gently sloping sites. Flows applied to slopes steeper than 15% may runoff as surface flows, rather than soak into the ground. On hillsides, infiltrated runoff may daylight a short distance down slope, which could cause slope instability depending on the soil or geologic conditions. See the Geotechnical Considerations section below.

Topographic assessment and mapping should also document existing condition impervious area, drainage patterns, the interface of site topography with adjacent parcels/right of ways (i.e., manufactured slopes), and any other topographic features of interest to site layout and/or stormwater management.

2.3.2.2. Soil Type and Geology

The site's soil types and geologic conditions should be determined to evaluate the site's ability to infiltrate stormwater and to identify suitable and unsuitable locations for siting infiltration-based BMPs. The Orange County Soil Survey (NRCS, CA678, 1978) identifies soils as Hydrologic Soil Groups (HSG) A, B, C and D [for further information, see http://soils.usda.gov/]. These soil groups are mapped in Appendix XVI.

- Group A soils are typically sands, loamy sands, or sandy loams. Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep and well to excessively drained sands or gravels and have a high rate of water transmission.
- Group B soils are typically silt loams or loams. They have a moderate infiltration rate when thoroughly wetted and consist chiefly of moderately deep to deep and moderately well to well drained soils with moderately fine to moderately coarse texture.
- Group C soils are typically sandy clay loams. They have low infiltration rates when thoroughly wetted, consist chiefly of soils with a layer that impedes downward movement of water, and/or have moderately fine to fine soil structure.
- Group D soils are typically clay loams, silty clay loams, sandy clays, silty clays, or clays. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with high swelling potential, permanent high water table, claypan or clay layer at or near the surface, and/or shallow soils over nearly impervious material.

Soils in Group A and B tend to have higher potential for infiltration based on likely infiltration rates and distance to a limiting horizon. Soils in Group C and D are less likely to have sufficient infiltration rate and distance to a limiting horizon to support stormwater infiltration.

Early identification of soil types throughout the project footprint can reduce the number of test pit investigations and infiltration tests by narrowing potential test sites to locations that are most amenable to infiltration. Guidance for conducting test pit investigations and infiltration tests is provided in Appendix VII.2

In addition, available geologic or geotechnical reports on local geology should be reviewed to identify relevant features such as depth to bedrock, rock type, lithology, faults, and hydrostratigraphic or confining units. These geologic investigations may also identify shallow water tables and past groundwater or soil contamination issues that are important for BMP design (see below). Geologic investigations may provide an assessment of whether soil infiltration properties are likely to be uniform or variable across the project site.

2.3.2.3. Groundwater Considerations

Site groundwater conditions should be considered prior to LID BMP and treatment control BMP siting, selection, sizing, and design.

Groundwater Levels

The depth to seasonal high groundwater table (normal high depth during the wet season) beneath the project may preclude infiltration. Depth to seasonal high groundwater level should be estimated as the average of the annual minima (i.e., the shallowest recorded measurements in each water year, defined as October 1 through September 30) for all years on record. If groundwater level data are not available or not considered to be representative, seasonal high groundwater depth can be determined by redoximorphic analytical methods combined with temporary groundwater monitoring for November 1 through April 1 at the proposed project site. Appendix VIII provides guidance for determining the depth to seasonally high groundwater table and the potential magnitude of groundwater mounding that could occur below infiltration BMPs.

Groundwater and Soil Contamination

In areas with known groundwater and soil pollution, infiltration may need to be avoided if it could contribute to the movement or dispersion of soil or groundwater contamination or adversely affect ongoing clean-up efforts. Mobilization of groundwater contaminants may also be of concern where contamination from natural sources is prevalent (e.g., marine sediments, selenium rich groundwater, to the extent that data is available). If infiltration is under consideration in areas where soil or groundwater pollutant mobilization is a concern, a site-specific analysis must be conducted where soil or groundwater pollutant mobilization is a concern to determine where infiltration-based BMPs can be used without adverse impacts.. It is possible that a certain amount of stormwater infiltration would not be detrimental, or could be beneficial. See Appendix VIII for specific guidance on assessing groundwater and soil contamination to ensure that project drainage plans are protective of groundwater quality.

Infiltration activities should be coordinated with the applicable groundwater management agency, such as the Orange County Water District, to ensure groundwater quality is protected. It is recommended that coordination be initiated as early as possible during the Preliminary/Conceptual WQMP development process. See Appendix VIII for specific guidance.

Protection of Groundwater Quality

Research conducted on the effects on groundwater from stormwater infiltration by Pitt et al. (1994) indicate that the potential for contamination due to infiltration is dependent on a number of factors including the local hydrogeology and the chemical characteristics of the pollutants of concern. Chemical characteristics that influence the potential for groundwater impacts include high mobility (low absorption potential), high solubility fractions, and abundance of pollutants in urban runoff. As a class of constituents, trace metals tend to adsorb onto soil particles and are filtered out by the soils. This has been confirmed by extensive data collected beneath stormwater detention/retention ponds in Fresno (conducted as part of the Nationwide Urban Runoff Program (Brown & Caldwell, 1984)) that showed that trace metals tended to be adsorbed in the upper few feet in the bottom sediments. Bacteria are also filtered out by soils. More mobile and soluble pollutants, such as chloride and nitrate, have a greater potential for impacting groundwater.

Appendix VIII provides criteria for infiltration related to protection of groundwater quality, including:

- Minimum separation groundwater, including guidance for calculating mounding potential,
- Categorization of infiltration BMPs by relative risk of groundwater contamination,
- Pollutant sources in the tributary watershed and pretreatment requirements,
- Setbacks from known plumes and contaminated sites,
- Guidelines for review by applicable groundwater management agencies.

Infiltration BMP Fact Sheets (Appendix XIV.2) identify BMPs that are potentially categorized as Class V Injection Wells, and may have additional permitting requirements.

Groundwater Recharge

Infiltration of stormwater can provide the benefit of recharging groundwater. As feasible, infiltration BMPs should be located in areas where infiltration would be most beneficial for groundwater recharge. The site characterization should attempt to identify areas where infiltration would have the greatest benefit for groundwater recharge. Generally a greater fraction of infiltrated water reaches groundwater in cases where there is a relatively direct hydrogeologic connection between the surface and an aquifer.

Groundwater/Surface Water Interactions

Groundwater discharge to surface water is generally a primary source of dry weather base flows in perennial stream systems. Intermittent and ephemeral systems are often characterized by groundwater discharge during portions of the year and streams losing flow to groundwater during other portions of the year. These systems may be sensitive to minor changes in groundwater levels which could result from increased infiltration compared to the existing condition. In such systems, increases in groundwater levels could potentially increase the duration of dry weather base flows in intermittent and ephemeral drainages. These changes may have significant impacts on riparian habitat and geomorphology. If intermittent or ephemeral drainages are located adjacent to and down-gradient of the project, the application of infiltration BMPs would could potentially impact these drainages, which would result in a finding of infeasibility for infiltration. The Conceptual/Preliminary or Project WQMP should provide analyses to support this finding.

2.3.2.4. Geotechnical Considerations

Infiltration of stormwater can cause geotechnical issues, including: (1) settlement through collapsible soil, (2) expansive soil movement, (3) slope instability, and (4) an increased liquefaction hazard. Stormwater infiltration temporarily raises the groundwater level near the infiltration facility, such that the potential geotechnical conditions are likely to be of greatest significance near the area of infiltration and diminish with distance. If infiltration BMPs are considered, a geotechnical investigation should be performed for the infiltration facility to identify potential geotechnical issues and geological hazards that may result from infiltration and identify potential mitigation measures.

Increased water pressure in soil pores reduces soil strength. Decreased soil strength can make foundations more susceptible to settlement and slopes more susceptible to failure. In general, infiltration-based BMPs must be set back from building foundations or steep slopes. Recommendations for each site should be determined by a licensed geotechnical engineer based on soils boring data, drainage patterns, and the current requirements for stormwater treatment.

Implementing the geotechnical engineer's requirements is essential to prevent damage from increased subsurface water pressure to surrounding properties, public infrastructure, sloped banks, and even mudslides.

Collapsible Soil

Typically, collapsible soil is observed in sediments that are loosely deposited, separated by coatings or particles of clay or carbonate, and subject to saturation. Infiltration of stormwater may result in a temporary rise in the groundwater elevation. This rise in groundwater could change the soil structure by dissolving or deteriorating the intergranular contacts between the sand particles, resulting in a sudden collapse, referred to as hydrocollapse. This collapse phenomenon generally occurs during the first saturation episode after deposition of the soil, and repeated cycles of saturation are not likely to result in additional collapse. If infiltration is considered, it is important to evaluate the potential for hydrocollapse during the geotechnical investigation. The magnitude of hydrocollapse is proportional to the thickness of the soil column where infiltration is occurring; in most instances, the magnitude of hydrocollapse will be small. Regardless, if infiltration BMPs are considered, the geotechnical engineer should evaluate the potential effects of hydrocollapse and, if necessary, specify mitigation and monitoring measures.

Expansive Soil

Expansive soil is generally defined as soil or rock material that has a potential for shrinking or swelling under changing moisture conditions. Expansive soils contain clay minerals that expand in volume when water is introduced and shrink when the water is removed or the material is dried. When expansive soil is present near the ground surface, a rise in groundwater from infiltration activities can introduce moisture and cause these soils to swell. Conversely, as the groundwater surface falls after infiltration, these soils will shrink in response to the loss of moisture in the soil structure. The effects of expansive soil movement (swelling and shrinking) will be greatest on near surface structures such as shallow foundations, roadways, and concrete walks. Basements or below-grade parking structures can also be affected as additional loads are applied to the basement walls from the large swelling pressures generated by soil expansion. If infiltration BMPs are considered, the geotechnical investigation should identify if expandable materials are present near the proposed infiltration facility, and if they are, evaluate if the infiltration will result in wetting of these materials and any potential mitigation measures.

Slopes

Slopes near infiltration facilities can be affected by the temporary rise in groundwater. The presence of a water surface near a slope can substantially reduce the stability of the slope from a dry condition. If infiltration BMPs are considered near a slope, groundwater mounding analysis should be performed to evaluate the rise in groundwater around the facility. If the computed rise in groundwater approaches nearby slopes, then a separate slope stability evaluation should be performed to evaluate the implications of the temporary groundwater surface. The geotechnical and groundwater mounding evaluations should identify the duration of the elevated groundwater and assign factors of safety consistent with the duration (e.g., temporary or long-term conditions).

Liquefaction

Soil liquefaction is a phenomenon in which saturated granular materials experience a reduction in bulk volume and a loss of bearing capacity induced by seismic motion. Soil liquefaction can also result in instabilities and lateral spreading in embankments and areas of sloping ground.

Saturation of the subsurface soils above the existing groundwater table may occur as a result of stormwater infiltration. If infiltration BMPs are considered, the potential for liquefaction should be assessed. If this assessment shows that potential for liquefaction exists, appropriate geotechnical analyses should be conducted to determine the level of stormwater infiltration that can be safely tolerated.

2.3.2.5. Off-Site Drainage

Locations and sources of off-site run-on onto the site should be identified in the Conceptual/ Preliminary or Project WQMP. Off-site drainage should be considered when determining appropriate BMPs for the site so that the drainage can be managed. Concentrated flows from offsite drainage may cause extensive erosion if not properly conveyed through or around the project site or otherwise managed. Vegetated swales or storm drains may be used to intercept, divert, and convey off-site drainage through or around a site, without treatment, to prevent comingling of drainage and flooding or erosion that might otherwise occur. Unless it is the goal of the project to provide treatment of off-site flows, these flows should be diverted around the project BMPs and should not be comingled with untreated water from the project site. Stormwater management requirements described in the Section 2.4 of the Model WQMP apply to off-site drainage if it is comingled with project runoff.

2.3.2.6. Existing Utilities

Existing subsurface utilities will limit the possible locations of certain BMPs and may constrain site design. If infiltration BMPs are considered, the potential impacts of stormwater infiltration on subsurface utilities should be evaluated to establish necessary setbacks from these utilities or if the utilities need to be relocated.

2.3.3. Watershed Description

2.3.3.1. Identifying Water Quality Impairments and TMDLs

The presence of impairments and TMDLs has an important role identification of pollutants of concern and therefore selection of BMPs for the project. Therefore, it is important to identify impairment and TMDLs as part of Section III of the Project WQMP.

When designated beneficial uses of a particular receiving water body are being compromised by water quality for a specific or multiple pollutants, Section 303(d) of the CWA requires identifying and listing that water body as "impaired". **Table 2.2** lists the impaired waterbodies within the North Orange County permit area that are included on the 2006 and tentative 2010 ~~303(d) lists and **Table 2.3** lists the impaired waterbodies within the South Orange County~~ permit area that are included on the 2006 and tentative 2010 303(d) list. Note, at the time of publishing, the 2010 303(d) lists had been approved by the State Water Resources Control Board, but had not been approved by USEPA Region 9. Edits may still occur before the 2010 303(d) list is finalized. Project proponents should consult the most recent 303(d) list to identify whether the project's proximate and downstream receiving water bodies are listed as impaired. The most recent 303(d) list is located on the State Water Resources Control Board website[5]

Table 2.4 lists TMDLs that have been adopted and are being implemented in the Orange County Watersheds as of May 2010.

[5] http://www.swrcb.ca.gov/water_issues/programs/#wqassessment

Table 2.2: Summary of the Approved 2006 and Tentative 2010 303(d) Listed Water Bodies and Associated Pollutants of Concern for North Orange County

Region	Water Body	Pollutant: Bacteria Indicators/ Pathogens		Metals		Nutrients		Pesticides		Toxicity		Trash		Salinity/ TDS/ Chlorides		Turbidity		Other Organics	
		2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List
Region 8 Santa Ana	Anaheim Bay			X	X			X	X	X	X							X	X
	Bolsa Chica Channel			X	X														
	Buck Gully Creek	X	X																
	Huntington Beach State Park	X																X	X
	Huntington Harbor	X	X	X	X			X	X	X	X							X	X
	Los Trancos Creek (Crystal Cove Creek)	X	X																
	Newport Bay, Lower			X		X		X		X	X							X	X
	Newport Bay, Upper (Ecological Reserve)			X		X		X		X	X					X		X	X
	San Diego Creek, Reach 1	X	X	X		X		X											
	San Diego Creek, Reach 2			X															
	Seal Beach	X	X															X	X
	Silverado Creek	X	X											X	X				

Note a the time of publication, the 2010 303(d) lists had been approved by the State Water Resources Control Board, but had not been approved by USEPA Region 9. Modifications may be made prior to approval by EPA. Project proponents should consult the most recent 303(d) list located on the State Water Resources Control Board website[6].

[6] http://www.swrcb.ca.gov/water_issues/programs/#wqassessment

Table 2.3: Summary of the Approved 2006 and Tentative 2010 303(d) Listed Water Bodies and Associated Pollutants of Concern for South Orange County

Region	Water Body	Pollutant																	
		Bacteria Indicators/ Pathogens		Metals		Nutrients		Pesticides		Toxicity		Trash		Salinity/ TDS/ Chlorides		Turbidity		Other Organics	
		2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List	2006 List	2010 List
Region 9 San Diego	Aliso Creek (Mouth)	X	X																
	Aliso Creek (20 Miles)	X				X	X			X	X								
	Dana Point Harbor	X	X		X						X								
	Pacific Ocean Shoreline, Aliso Beach HSA	X																	
	Pacific Ocean Shoreline, Dana Point HSA	X																	
	Pacific Ocean Shoreline, Laguna Beach HSAs	X																	
	Pacific Ocean Shoreline, Lower San Juan HSA	X	X																
	Pacific Ocean Shoreline, San Clemente HA at San Clemente City Beach, North Beach	X	X																
	Pacific Ocean Shoreline, Other San Clemente and San Joaquin Hills HAs	X																	
	Pacific Ocean Shoreline, San Mateo Canyon HAs		X																
	Prima Deshecha Creek				X	X	X									X	X		
	San Juan Creek	X			X		X	X			X								
	Segunda Deshecha Creek					X	X				X					X	X		

Note a the time of publication, the 2010 303(d) lists had been approved by the State Water Resources Control Board, but had not been approved by USEPA Region 9. Modifications may be made prior to approval by EPA. Project proponents should consult the most recent 303(d) list located on the State Water Resources Control Board website[7].

[7] http://www.swrcb.ca.gov/water_issues/programs/#wqassessment

Table 2.4: Summary of the Status of TMDLs for Waterbodies in Regions 8 and 9

Region	Water Body	Pollutant				
		Bacteria Indicators/ Pathogens	Metals	Nutrients	Pesticides	Turbidity/ Siltation
Region 8 Santa Ana	Newport Bay, Lower	Implementation Phase	Technical TMDLs	Implementation Phase	Technical TMDLs	Implementation Phase
	Newport Bay, Upper (Ecological Reserve)	Implementation Phase	Technical TMDLs	Implementation Phase	Technical TMDLs	Implementation Phase
	San Diego Creek, Reach 1		Technical TMDLs	Implementation Phase	Technical TMDLs and Implementation Phase	Implementation Phase
	San Diego Creek, Reach 2		Technical TMDLs	Implementation Phase		Implementation Phase
Region 9 San Diego	Aliso Creek (20 Miles) Pacific Ocean Shoreline, Laguna Beach HSAs	Implementation Phase				
	Dana Point Harbor Pacific Ocean Shoreline HSAs	Implementation Phase or In Progress				
	Pacific Ocean Shoreline, San Clemente HA	In Progress				
	San Juan Creek (mouth)	Implementation Phase				

2.3.3.2. Selecting the Pollutants of Concern for the Project

Compare the list of pollutants for which the receiving waters are impaired or for which TMDLs have been adopted with the pollutants anticipated to be generated by the land uses included in the project (as identified in **Table 2.1**)

Primary Pollutants of Concern are any pollutants anticipated to be generated by the project using **Table 2.1** that have also been identified as causing impairment of project receiving waters (**Table 2.2** or **Table 2.3**) or for which a TMDLs is in place (**Table 2.4**). Other pollutants of concern are those pollutants anticipated to be generated by the project using **Table 2.1** that have not been identified as causing impairment in the project's receiving waters.

Further information on pollutants of concern may also be available from the environmental impact assessment for the project (e.g., project-specific pollutant evaluations in CEQA EIRs). Watershed planning documents should also be reviewed for identification of specific implementation requirements that address pollutants of concern.

Guidance on selecting LID and treatment control BMPs to address pollutants of concern is provided in **Section 2.4.2.5**.

2.3.3.3. Method for Determining Stream Susceptibility

Definitions of susceptibility are similar in the North and South Orange County permit areas:

- In the North Orange County permit area, downstream channels are considered not susceptible to hydromodification, and therefore do not have the potential for a HCOC, if all downstream conveyance channels that will receive runoff from the project are engineered, hardened, and regularly maintained to ensure design flow capacity, and no sensitive habitat areas will be affected. The maps of such conveyance channels provided in Appendix XV may be used to determine susceptibility in the North Orange County permit area. These maps may be updated in the WIHMPs. The most current map should be used for this determination. The proponent should check for updates to these maps on the **www.ocwatersheds.com** website.
- In the South Orange County permit area, downstream channels are considered not susceptible to hydromodification, and therefore projects do not have a potential HCOC, if (1) the project discharges stormwater runoff into underground storm drains discharging directly to bays or the ocean, or (2) storm water runoff conveyance channels whose bed and bank are concrete lined all the way from the point of discharge to ocean waters, enclosed bays, estuaries, or water storage reservoirs and lakes. Hydromodification susceptibility maps will be prepared as part of the HMP development in the South Orange County permit area. In the interim until the HMP is developed, the guidance for assessing stream susceptibility provided in this section shall be followed to determine whether a channel is susceptible.

In the North Orange County permit area, determination of susceptibility is only required for projects which have a HCOC; projects which do not have a HCOC as a result of proposed development are not required to assess susceptibility.

~~Where regional maps are inconclusive, it must be assumed that the project's receiving waters~~ are susceptible to hydromodification impacts unless a downstream assessment is completed by a licensed geomorphic professional.

A downstream assessment of susceptibility may be conducted by a licensed geomorphic professional for any project. This assessment should consider:

- The inherent potential for a stream channel to undergo excessive downcutting or widening in response to hydromodification caused by land use changes is related to a number of factors, including the nature of the bed and bank materials, channel geometry and slope, sediment supply, and flow regime. Potential impacts on channel stability must include considerations of the following, as applicable:
    - **Bed and bank materials**. Sand bedded streams have lower critical shear stresses and are more readily transported by increased flows, whereas channel materials that are larger, such as gravels and cobbles, and more cohesive, such as clays, are more resistant.
    - **Channel geometry and slope**. The magnitude of applied shear stress on the channel boundary for a given flow is dependent on both cross section geometry and longitudinal slope. The width to depth ratio of the channel will influence how shear stresses increase with increasing flows (e.g. with other factors such as slope and bottom and side slope materials the same, deep, narrow channels will experience higher shear stresses for a given flow than a more shallow, wider channel of similar cross-sectional area). Incised channels may also have banks which are close to or above the critical height for stability (a function of bank angle and degree of cohesion, in addition to height).
    - **Sediment supply**. Sediment-starved or "hungry" water can lead to channel degradation and instability. Land development can cause a reduction in the amount of sediment delivered to a stream system by trapping sediment in detention facilities and/or removing sediment supply by mass grading, compaction, landscaping, and paving. In the tectonically active region of Southern California, many streams are naturally transport-limited, meaning the rate that sediment is supplied to the stream network is greater than the in-stream sediment transport capacity. If the sediment supply is reduced to a level less than the transport capacity, then the stream becomes supply-limited and susceptible to excess in-stream erosion due to sediment supply reductions.
    - **Flow regime.** Reduced infiltration and interception storage capacity associated with impervious surfaces and soil compaction result in increased magnitude and frequency of surface runoff. Furthermore, ephemeral/intermittent streams in

Southern California appear to be highly sensitive to changes in total basin impervious cover, more-so than perennial streams (SCCWRP, 2005[8]). Ephemeral/intermittent streams are also considered more susceptible to vegetation type changes (and resulting habitat impacts) due to dry weather flows even if these flows are not great enough to cause excess erosion.

- Physical structures may be severely impacted by channel morphological changes and instability, resulting in potential loss of infrastructure, property damage, creation of unsafe conditions for residents and motorists, and water quality impacts through leaks or spills of toxic or oxygen demanding materials. Infrastructure can in turn cause changes in sediment transport processes within stream channels, and therefore these data will also inform the assessment of susceptibility to excess erosion. Existing infrastructure may also provide some opportunities to control hydromodification impacts. For example, by retrofitting the existing outlet structure of a detention basin to mimic the pre-development flow regime or through routing runoff into a reclaimed water supply system (assuming water supply standards have been adequately addressed) such as Rattlesnake or Sand Canyon Reservoirs. Potential impacts to physical structures must consider the following, as applicable:

    - Utility networks (e.g., sewer lines, gas lines, etc.)
    - Road crossings (culverts and bridges)
    - Storm Drains
    - Constructed channel network
    - In-stream drop structures / grade control
    - Dams and other basins

- Currently, most quantitative design standards for hydromodification management focus primarily on controlling excess erosion. While prevention of excess erosion is considered a necessary prerequisite for a healthy stream ecosystem, it may not be a sufficient condition, as riparian habitats and aquatic biota can be impacted by other aspects of hydromodification including changes in flow regime and water quality. Therefore, a channel considered to be fairly resistant to excess erosion may still be highly susceptible to habitat and biota impacts. Potential impacts to riparian and aquatic habitat should consider:

    - Longitudinal connectivity of the stream system (i.e., to allow for migration of fauna)
    - Lateral connectivity of the stream channel to its floodplain
    - Existing riparian corridors

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[8] Southern California Coastal Water Research Project (SCCWRP). 2005. Effect of Increases in Peak Flows and Imperviousness on the Morphology of southern California Streams. Technical Report 450.

- Perennial and ephemeral channels
- Channels where groundwater discharges either seasonally or year-round
- Impaired waterbodies
- Existing and proposed treatment BMPs
- ~~Channel reaches planned for enhancement or restoration~~
- Water quality monitoring and bioassessment sampling locations and data
- Existing vegetation types, special habitat, locations of threatened or endangered species, and barriers restricting movement

2.3.3.4. Determining Environmentally Sensitive Areas and Areas of Special Biological Concern

To assist developers in determining the presence of ESAs such as areas designated in the Ocean Plan as Areas of Special Biological Significance (ASBS) or waterbodies listed on the CWA Section 303(d) list of impaired waters, The County of Orange has prepared watershed maps that identify each ESA within Orange County (see OC Watersheds website: **http://www.ocwatersheds.com/ESA.aspx**).

A Priority Project may potentially impact a water body considered to be an ESA if this project is:

- Within or adjacent to, or
- Discharge pollutants directly to an ESA

For the purposes of these procedures, the following terms are defined:

- *Adjacent* -located within 200 feet of the listed water body
- *Discharging directly to* -discharge from a drainage system that is composed entirely of flows from the subject facility or activity, i.e., discharge from an urban area that comingles with downstream flows prior to an ESA is not subject to this requirement.

An ESA exists if any of the following designations have been applied to the water body of concern:

- Clean Water Act 303(d) listed impaired water body based on **most recent approved 303(d) list.**
- Areas designated as Areas of Special Biological Significance by the SWRCB in the Water Quality Control Plan for Ocean Waters of California (California Ocean Plan)
- Water bodies designated with the RARE beneficial use by the SWRCB in the Water Quality Control Plans for the Santa Ana River and San Diego Basins (Region 8 and Region 9 Basin Plans)
- Water bodies located within areas designated under the California Department of Fish and Game's Natural Community Conservation Planning (NCCP) Program as preserves or equivalent in subregional plans (http://www.dfg.ca.gov/nccp/status.htm)
- Areas designated as Critical Aquatic Resources in the Orange County Drainage Area Management Plan (DAMP)

- Any other equivalent ESAs that contain water bodies that have been identified by the local jurisdiction to be of local concern.

The maps available at the OC Watersheds website (http://www.ocwatersheds.com/ESA.aspx) may be used to assist in the identification and classification Priority Projects in order to determine if they potentially impact an ESA.

2.4. Best Management Practices (BMPs)

This section provides the guidance for WQMP Template Section IV. The purpose of this section of the Conceptual/Preliminary or Project WQMP is to establish the project performance criteria, to describe the site design and drainage plan, to document the conformance of the project with the performance criteria, and to describe the alternative compliance plan (if applicable).

This section of this TGD describes how the regulatory requirements contained in Section 2.4 of the Model WQMP should be applied to develop a site design and drainage plan, and how to demonstrate that this plan conforms to project performance criteria. This section provides guidance for three general steps:

1. Identify and document performance criteria applicable to the project (**Section 2.4.1**),
2. Develop a site design and drainage plan that meets project performance criteria (**Section 2.4.2**)
3. Demonstrate that the site design and drainage plan meets performance criteria (**Section 2.4.3**)

Regulatory requirements are contained in Section 2.4 of the Model WQMP and are incorporated into this guidance by reference. Specific criteria and calculations supporting these steps are contained in Appendices to this TGD.

The scale at which analyses are conducted and calculations are performed is important to ensure that valid conclusions are reached. **Table 2.5** outlines the scale at which specific steps in the WQMP preparation process should be conducted.

Table 2.5: Recommended Scale of Analyses for Project WQMP Preparation

Step in Project WQMP Development	Scale of Analysis [1,2]
Determine applicable performance criteria (LID, treatment control, and hydromodification control)	Project/Regional
LID Infeasibility Screening	Group of similar, contiguous drainage areas *OR* individual drainage areas
LID BMP prioritization	Group of similar, contiguous drainage areas *OR* individual drainage areas
Calculate required BMP volumes or flowrates	Individual drainage areas
Evaluate maximum feasible LID BMP implementation	Individual drainage areas
Calculate remaining requirements not met by on-site LID BMPs	Individual drainage areas, combined to Project totals
Evaluate regional and subregional BMPs	Project
Identify acceptable treatment control BMPs to address POCs	Individual drainage areas
Alternative LID and/or WQ compliance	Project
Evaluate hydromodification performance criteria	Project, divided by receiving water

[1] Note that small projects may consist of one drainage area.

[2] Projects draining to multiple receiving waters shall conduct assessment for each distinct receiving water, as applicable.

2.4.1. Project Performance Criteria

This section describes how project performance criteria should be determined and summarized for inclusion in WQMP Template Section IV. Providing a summary of performance criteria in the Project WQMP provides context for the Site Design and Drainage Plan and the Project Conformance Analysis.

The checklist contained in Section IV of the WQMP template is the recommended means of summarizing performance criteria. Performance criteria for LID, treatment control, and hydromodification control BMPs and their applicability are contained in Section 2.4 of the Model WQMP.

2.4.2. Site Design and Drainage Plan

This section describes a process for developing a functional drainage plan that works with the site constraints and for selecting BMPs based on BMP priority, site conditions/constraints, and pollutants of concern.

2.4.2.1. Incorporating Site Design Practices

LID requires an integrated approach to site design and stormwater management. Traditional approaches to stormwater management planning are not likely to be effective. The use of site planning techniques presented in this section will help generate a more hydrologically functional site, help to maximize the effectiveness of LID BMPs, and integrate stormwater management throughout the site.

2.4.2.2. Conceptual Drainage Planning

Conceptual drainage plans are key tools in site planning. A conceptual drainage plan shows the rough delineations of the major drainage areas on the project, typically defined by the points of discharge from the site. Small projects may have only one drainage area.

The following concepts should be considered during the early site planning stages:

- LID BMPs should be considered as early as possible in the site planning process. Hydrology should be an organizing principle that is integrated into the initial site assessment planning phases. Where flexibility exists, conceptual drainage plans should attempt to route water to areas suitable for retention BMPs.
- A multidisciplinary approach is recommended that includes planners, engineers, landscape architects, and architects at the initial phases of the project.
- Individual LID BMPs may be distributed throughout the project site as feasible and may influence the configuration of roads, buildings and other infrastructure.
- Flood control should be considered early in the design stages. Even sites with LID BMPs will still have runoff that occurs during large storm events, but LID facilities can have flood control benefits. It may be possible to simultaneously address flood control requirements through an integrated water resources management approach (see **Section 3.7**)

Perhaps the most important aspect of site planning is allowing sufficient space for LID BMPs in areas that can physically accept runoff. Simple rules of thumb are presented in **Table 2.6** to help allow sufficient space in preliminary design.

Table 2.6: Approximate Space Requirements for Structural BMPsBMPs Selected	Percent of Tributary Impervious Area Required	
	Well Drained Soils	Moderately Drained Soils
LID Infiltration	2 to 5	5 to 10
LID Harvest and Reuse	1-2 percent of tributary area (cistern 8 feet tall, indoor or outdoor)	

Site design principles presented in **Section 3** should be employed at this phase in the Project WQMP preparation process.

Refer to the Bay Area Stormwater Management Agencies Association (BASMAA) **Start at the Source** manual for more guidance on LID site design practices.

Divide Site into Drainage Management Areas or Similar

Dividing the project site into DMAs is a common step in the preparation of stormwater management plans, and provides a framework for feasibility screening, BMP prioritization, and stormwater management system configuration. The use of DMAs is strongly encouraged, but is not mandatory. Similar strategies for laying out the conceptual drainage plan for the site may be used in the Project WQMP preparation process.

DMAs are defined based on the proposed drainage patterns of the site and the BMPs to which they drain. At this phase of the Project WQMP preparation process, BMPs may not have been selected. In this case, DMAs would be delineated based on site drainage patterns and possible BMP locations identified in the site planning process.

A DMA may drain to a single BMP or to a group of similar BMPs distributed throughout the DMA. For example, a drainage management area may be defined as 10 acres of mixed urban land uses draining to an infiltration basin near the lower end of the project site, or a DMA may be defined as a 2 acre parking lot with several bioretention areas distributed throughout with similar design standards. DMAs should not overlap and should be approximately homogenous with respect to BMP opportunities and feasibility constraints.

Calculate Design Capture Volume for Drainage Areas

The design capture volume (DCV) should be established for each drainage area and documented in the Project WQMP. Appendix III provide instructions for calculating DCV.

2.4.2.3. Evaluating and Selecting BMPs

This section describes a process for developing a comprehensive LID, treatment control, and hydromodification control plan for typical projects.

Select LID BMPs

Figure 2.1 outlines the LID BMP selection process. The first step in the process is to consider HSCs, such as downspout disconnects and other controls described in Section 4.2, based on opportunities in the project layout. HSCs can be a cost-effective part of a meeting LID requirements, but are not required to be used if LID requirements can be met in other ways. Some HSCs are also effective at removing pollutants. HSCs that effectively remove pollutants are allowed to have their captured storm water volume count towards the DCV, consequently reducing the size of downstream BMPs. Where claimed, the contribution of HSCs is quantified in terms of inches of the design capture storm depth and the percentage of average annual runoff volume that is reduced. This is deducted from sizing criteria for downstream BMPs as described in Appendix III.

If the volume of runoff retained by HSCs in a DMA is greater than or equal to the design capture storm depth for the DMA, the DMA is considered to be "self-retaining" and no additional BMPs are required to treat discharges from the drainage area to meet LID or treatment control requirements.

If the retained storm water volume of HSCs are accounted for in downstream BMP sizing, then supporting calculations shall be prepared as described in Appendix III. These calculations must be submitted using Worksheet A (see Appendix XV) or an equivalent format.

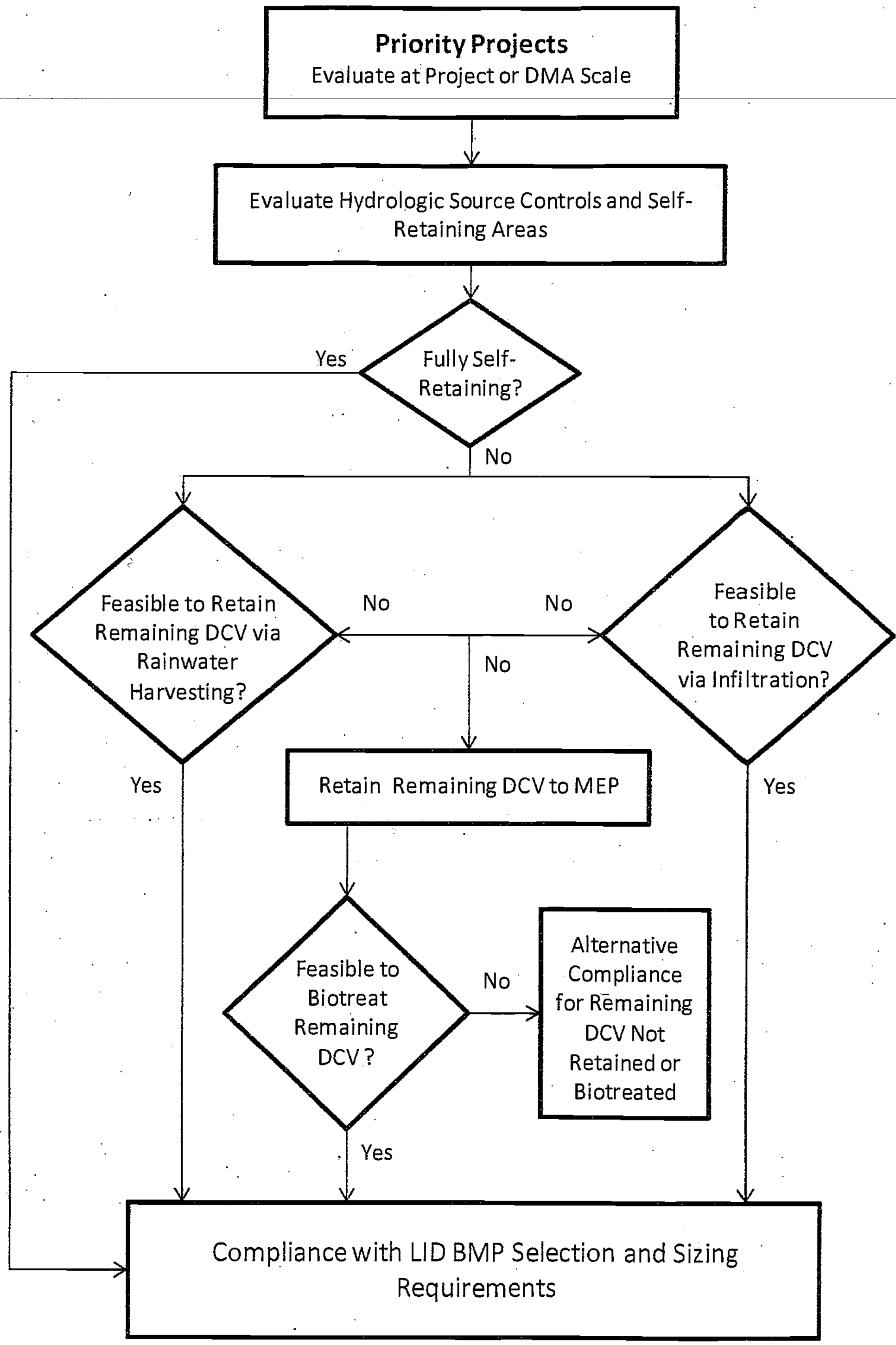
The next steps are to select and size either infiltration BMPs or harvest and use BMPs, if feasible, for the remaining runoff from DMAs that are not self-retaining. If it is feasible to use either of these types of LID BMPs to fully retain the DCV from the DMA, then no additional BMPs are required to treat discharges from the drainage area to meet LID requirements. Feasibility criteria are contained in **Section 2.4.2.4** and sizing approaches to manage the entire DCV are described in Appendix I, II, and III.

If it is not feasible to fully retain the runoff using either infiltration BMPs or rainwater harvesting, then LID BMPs must be selected to retain the remaining DCV to the maximum extent feasible. Feasibility criteria are contained in **Section 2.4.2.4**. For guidance on designing LID BMPs to retain the maximum feasible portion of the DCV, see Appendix XI.

If it is infeasible to fully retain the DCV on the project site, then biotreatment BMPs must be selected and sized for the remaining DCV, if feasible. Biotreatment BMPs must be selected to address the pollutants of concern and must be designed to achieve the maximum feasible infiltration and ET. **<u>Guidance on selecting biotreatment BMPs to address the pollutants of concern</u>** is provided in **Section 2.4.2**. For guidance on designing Biotreatment BMPs to achieve the maximum feasible infiltration and ET, see Appendix XI.

If it is infeasible to fully retain or biotreat the DCV on the project site, then see **Section 2.4.4** below for guidance on Alternative Compliance.

Figure 2.1: LID BMP Selection Flow Chart



2.4.2.4. LID Feasibility Criteria

Narrative feasibility criteria are described in Section 2.4.2 of the Model WQMP.

Conceptually, the feasibility criteria contained in this TGD are intended to:

- Prevent significant risks to human health and environmental degradation as a result of compliance activities; and
- Describe circumstances under which regional and watershed-based strategies may be selected when they are consistent with the MEP standard considering such factors as technical feasibility, fiscal feasibility, societal concerns, and social benefits; and
- Define performance criteria to ensure that compliance does not result in undue fiscal or societal burdens, including such considerations as:
    - Cost-effectiveness of on-site stormwater management versus off-site stormwater management, including capital costs and maintenance cost and considerations, and
    - Incremental cost-benefit of additional BMPs in stormwater management systems, including capital costs and maintenance costs and considerations.

LID BMP feasibility criteria are listed below. More specific guidance on determining infiltration infeasibility related to groundwater protection is provided in Appendix VIII. More specific guidance on determining the feasibility of rainwater harvesting is provided in Appendix X.

Infiltration Feasibility

Stormwater infiltration is infeasible if any of the following conditions apply:

- Seasonally high groundwater or mounded groundwater is less than 5 feet below the designed bottom of the infiltration facility. (See Appendix VIII for specific guidance.)
- Seasonally high groundwater or mounded groundwater is less than 10 feet below the designed bottom of the infiltration facility and significant treatment is not provided in the BMP before groundwater injection (e.g., infiltration basins, infiltration trenches, dry wells, subsurface vaults, and similar BMPs) and the receiving aquifer supports beneficial uses. (See Appendix VIII for specific guidance.)
- The infiltration facility is less than 100 feet horizontally from a water supply well, non-potable well, drain field, or spring. (See Appendix VIII for specific guidance.)
- The BMP tributary area contains high risk land use activities which would result in significant risks to drinking water quality and groundwater quality that cannot be reasonably and technically mitigated through methods such as isolation of sources and/or pre-treatment of runoff to address pollutants of concern prior to infiltration. (See Appendix VIII for specific guidance)
- For brownfield sites or adjacent sites, where stormwater infiltration would result in a significant risk of mobilizing or moving contamination that cannot be reasonably and

technically avoided, as documented by a site-specific or available watershed study. The documenting study shall have sufficient resolution to positively identify areas of the property where unremediated contamination is located and where stormwater infiltration should be restricted to prevent pollutant mobilization. (See Appendix VIII for specific guidance.)

- Where a groundwater pollutant plume (man-made or natural) is under the site or in close proximity and there is substantial evidence that stormwater infiltration would cause or contributing to plume movement that cannot be reasonably and technically avoided, as documented by a site-specific study or available watershed study. The documenting study shall have sufficient resolution to positively identify areas where stormwater infiltration should be restricted. (See Appendix VIII for specific guidance))
- Where there is substantial evidence that stormwater infiltration would result in significantly increased risks of geotechnical hazards, such as liquefaction or landslides, that cannot be reasonably and technically mitigated to an acceptable level, as documented in a geotechnical report prepared by the geotechnical expert for the project. Stormwater infiltration in a given location is deemed to result in a significant risk to geotechnical hazards if any of the following conditions apply:
  - The location is less than 50 feet away from slopes steeper than 15 percent
  - The location is less than eight feet from building foundations or an alternative setback established by the geotechnical expert for the project.
  - A study prepared by a geotechnical professional or an available watershed study determines that stormwater infiltration would result in significantly increased risks of geotechnical hazards on or adjacent to the project site that cannot be reasonably and technical mitigated. The documenting study shall have sufficient resolution to positively identify locations on a project site where stormwater infiltration should be restricted.
- Where infiltration of runoff from the project would violate downstream water rights. While it is not anticipated that infiltration of runoff would violate water rights in Orange County, water law in California is complex, and this TGD does not exclude the possibility that a rightful water rights claim could restrict infiltration of stormwater. The **South County Permit** contemplates the potential for stormwater management activities to violate water rights at F.3.d.(6)(d).
- If the project is located in HSG D soils per regional maps (Appendix XV), the project meets criteria to use regional maps for infiltration screening per Appendix VII, and the site geotechnical investigation, if otherwise required, and/or other available data identifies presence of soil characteristics which support categorization as D soils. For projects that meet the criteria to use regional maps, geotechnical investigation will not be required to include infiltration testing to confirm mapped categorization as HSG D soils; however, if other site-specific information is readily available, such as bore logs, relevant information therein must be used.

- If the *measured infiltration rate* after accounting for soil amendments is less than 0.3 inches per hour in the vicinity of proposed BMPs. Infiltration must be measured using the methods described in Appendix VII, which includes protocols that account for the effect of soil amendments. Soil amendments would not be expected to increase the effective infiltration rate of a soil if the limiting horizon for infiltration lies below the amended zone (in this case, it would increase storage, but not infiltration rate). Soil amendments would be expected to effectively increase infiltration rates if the limiting horizon for infiltration occurs near the proposed bottom of the infiltration basin and the entire depth of this layer can be amended. This criterion shall be evaluated using a factor of safety of 2.0 on testing results.
- If there is substantial evidence that an increase in infiltration over predeveloped conditions would cause impairments to downstream beneficial uses, such as change of seasonality of ephemeral washes or increased discharge of contaminated groundwater to surface waters. The level of allowable increase in infiltration must be documented in a site-specific study or watershed plan, and it must be demonstrated that stand-alone infiltration BMPs would exceed the allowable level of increase in infiltration or what level could be infiltrated as a partial consideration.
- If there is substantial evidence that infiltration from the project would result in increase in inflow and infiltration (I&I) to the sanitary sewer that cannot be sufficiently mitigated, and it is beyond the reasonable scope of the project to rehabilitate the sanitary sewer to mitigate for I&I. It is anticipated that maps will be made available to identify areas of the sanitary sewer system where high I&I has been observed, however these maps shall be used for reference purposes only.

In the event that any of these conditions apply, infiltration BMPs are not required to be implemented. Infiltration feasibility screening shall be documented using **Table 2.7.**

Table 2.7: Infeasibility BMP Feasibility Worksheet

	Infeasibility Criteria	*Yes*	*No*
1	**Would Infiltration BMPs pose significant risk for groundwater related concerns?** Refer to Appendix VIII (Worksheet I) for guidance on groundwater-related infiltration feasibility criteria.		
Provide basis: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
2	Would Infiltration BMPs **pose significant risk of increasing risk of geotechnical hazards that cannot be mitigated to an acceptable level**? (Yes if the answer to any of the following questions is yes, as established by a geotechnical expert): • The BMP can only be located less than 50 feet away from slopes steeper than 15 percent • The BMP can only be located less than eight feet from building foundations or an alternative setback. • A study prepared by a geotechnical professional or an available watershed study substantiates that stormwater infiltration would potentially result in significantly increased risks of geotechnical hazards that cannot be mitigated to an acceptable level.		
Provide basis: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
3	Would infiltration of the DCV from drainage area **violate downstream water rights**?		
Provide basis: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			

Table 2.7: Infiltration BMP Feasibility Worksheet (continued)

	Partial Infeasibility Criteria	*Yes*	*No*
4	Is proposed infiltration facility **located on HSG D soils** or the site geotechnical investigation identifies presence of soil characteristics which support categorization as D soils?		
Provide basis: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
5	Is **measured infiltration rate below proposed facility less than 0.3 inches per hour**? This calculation shall be based on the methods described in Appendix VII.		
Provide basis: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
6	Would **reduction of over predeveloped conditions cause impairments to downstream beneficial uses, such as change of seasonality of ephemeral washes or increased discharge of contaminated groundwater to surface waters?**		
Provide citation to applicable study and summarize findings relative to the amount of infiltration that is permissible: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
7	Would **an increase in infiltration over predeveloped conditions cause impairments to downstream beneficial uses, such as change of seasonality of ephemeral washes or increased discharge of contaminated groundwater to surface waters?**		
Provide citation to applicable study and summarize findings relative to the amount of infiltration that is permissible: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			

Table 2.7: Infiltration BMP Feasibility Worksheet (continued)

Infiltration Screening Results (check box corresponding to result):		
8	1. If any answer from row 1-3 is yes: infiltration of any volume is **not feasible** onsite. Provide basis: Summarize findings of infeasibility screening	
9	2. If any answer from row 4-7 is yes, infiltration is **permissible but is not presumed to be feasible for the entire DCV.** Criteria for designing biotreatment BMPs to achieve the maximum feasible infiltration and ET shall apply. Provide basis: Summarize findings of infeasibility screening	
10	3. If all answers to rows 1 through 11 are no, infiltration of the full DCV is potentially feasible, BMPs must be designed to infiltrate the full DCV to the maximum extent practicable.	

Harvest and Use Feasibility

Harvest and use infeasibility criteria include:

- If inadequate demand exists for the use of the harvested rainwater. See Appendix X for guidance on determining harvested water demand and applicable feasibility thresholds.
- If the use of harvested water for the type of demand on the project violates codes or ordinances most applicable to stormwater harvesting in effect at the time of project application and a waiver of these codes and/or ordinances cannot be obtained. It is noted that codes and ordinances most applicable to stormwater harvesting may change with time, and this TGD does not intend to restrict harvest and use BMPs to the codes and ordinances in effect at its date of publication.
- If harvest and use of runoff would violate downstream water rights. While it is not anticipated that harvest and use of runoff would violate water rights in Orange County, water law in California is complex, and this TGD does not exclude the possibility that a rightful water rights claim could restrict harvest and use of stormwater. The South County Permit contemplates the potential for stormwater management activities to violate water rights at F.3.d.(6)(d). Water rights could potentially be violated by reduction in infiltrated volume or reduction of surface runoff.

If harvest and use BMPs are used, they shall comply with Orange County Sanitation District Wastewater Discharge Regulations, where applicable. The Orange County Department of Health and Orange County Health Care Agency should be involved in this process, as applicable, at the discretion of project engineer and plan reviewer, to ensure that harvest and use systems do not pose a significant risk to human health. Considerations relative to harvest and use systems and public health are anticipated to be project-specific, and specific guidance is not provided in this TGD at this time.

Designing BMPs to Achieve Maximum Feasible Evapotranspiration

ET is a significant volume reduction process in HSCs, infiltration BMPs exposed to atmosphere, and biotreatment BMPs. BMPs must be designed to achieve the maximum feasible ET, where required to demonstrate that the maximum amount of water has been retained on-site. This should be done as follows:

- Per Appendix XI, if a project cannot be designed to infiltrate and/or harvest and use the full DCV, the following criteria must be met before evaluating biotreatment BMPs:
    - All applicable HSCs, such as downspout disconnects and other HSCs described in Section 4.2, must be considered (ET is a principal process in all HSCs)
    - The project must demonstrate that at least minimum site design practices for available open space have been met (ET is strongly a function of available ET area)
- Biotreatment BMPs, if needed to address remaining unmet volume, must be designed to achieve the maximum feasible infiltration and ET per criteria contained in Appendix XI and Appendix XII.

Conformance with these criteria is presumed to result in a suite of BMPs that achieves the maximum feasible ET under conditions where it is necessary to provide the maximum feasible ET to meet LID performance criteria.

Incorporation of Feasibility Findings from Watershed-Based Plans into BMP Selection

The scope of watershed-based planning efforts, such as WHIMPs, may include the assessment of watershed-scale water quality, groundwater recharge, hydromodification, and habitat considerations to determine the feasibility of on-site LID versus subregional/regional LID approaches. Section 2.4.2.2 of the Model WQMP describes the conditions under which a watershed-based plan could contain an embedded assessment of feasibility and describe preferred approaches for the project. Section 2.4.2.2 of the Model WQMP also describes the applicability of watershed-based plans to the selection of BMPs for a project.

2.4.2.5. Selecting Biotreatment and Treatment Control BMPs to Address Pollutants of Concern

BMPs must be selected to address pollutants of concern. Retention BMPs are assumed to address all pollutants of concern. In cases where biotreatment and/or treatment controls are used, these BMPs must be selected to address pollutants of concern based on the following stepwise method:

1. Identify pollutants of concern and primary pollutants of concern based on methods described in **Section 2.3.3**.
2. Based on the BMP performance information provided in **Section 4.9**, select a BMP that provides medium or high effectiveness for all pollutants of concern.
3. If a single BMP does not provide medium or high effectiveness for all pollutants of concern, select a BMP that provides medium or high effectiveness for all primary pollutants of concern.
4. If a single BMP does not provide medium or high effectiveness for all primary pollutants of concern, select multiple BMPs for use in a treatment train that collectively provides medium or high effectiveness for all primary pollutants of concern.

2.4.2.6. Meet Remaining Hydromodification Control Requirements through Additional On-site or Off-site Controls

In many cases, LID BMPs provide full or partial compliance with hydromodification requirements. All retention BMPs provide volume reduction to fully or partially satisfy the volume matching criteria applicable to projects in the NOC permit area. In addition, both retention and biotreatment BMPs can provide flow control benefits to fully or partially satisfy hydromodification requirements applicable in the NOC and SOC permit areas.

In general, once the LID BMPs have been selected and sized, the BMP plan can be assessed for compliance with the hydromodification control requirements. Remaining hydromodification control requirements are determined and calculated as described in **Section 5.3** and Appendix IV, respectively (North Orange County) and **Section 5.4** and Appendix V (South Orange County). This general approach is intended to organize the process in a linear way, however it is not intended to imply that LID requirements must considered before hydromodification in all cases. In many cases, it is necessary to select BMPs for LID and hydromodification control should be done concurrently.

The recommended project planning approach for addressing hydromodification requirements depends on the relative magnitude of hydromodification requirements compared to LID requirements. Relative magnitudes are a function of the applicable Permit, the susceptibility of receiving waters, and the existing condition of the project. Appendices I and II provide guidance for integrated BMP sizing strategies where cases LID and hydromodification requirements control the BMP design process.

2.4.3. Project Conformance Analysis

The purpose of this section is to provide technical guidance for how a typical project would demonstrate conformance with project performance criteria.

2.4.3.1. Minimum Requirements for Conformance Analysis

Conceptual/Preliminary and Project WQMPs shall demonstrate conformance with all applicable standards. The WQMP shall list the performance criteria that are applicable to the project, the design requirements that result from these standards, where applicable, and the project design features that are proposed to address these design requirements. A comparison between the design requirements and the proposed project design features is the basis for demonstrating conformance.

The Project WQMP must document conformance with all standards that are applicable to the project on an individual standard basis and at the scale that the standard applies (e.g., project-based, or drainage area-based). The following sections provide guidance for how to demonstrate that the project conforms with each standard.

2.4.3.2. Source Controls

Source controls requirements pertain the structural and non-structural source controls that are intended to minimize the introduction of pollutants in to stormwater runoff. The project WQMP must demonstrate that all applicable pollutant source controls are used. Project conformance with pollutant source control requirements should be demonstrated by identifying the source controls that are applicable to the project and by using the checklist provided in the Section IV of the WQMP Template, or equivalent, to document the Project commitment to utilize these source controls. Where a source control is not applicable, this should be noted with a brief rationale. Conformance with source control obligations must be demonstrated at the project or planning area scale.

Section 6 of this TGD provides a description of source control measures to assist in determining whether source controls are applicable based on project land uses and land use activities. **Section 6.2** and **Section 6.3** are applicable primarily to private development projects, while **Section 6.4** is applicable primarily to municipal projects.

2.4.3.3. Hydrologic Source Controls

There are no numeric standards requiring the use of HSCs. Therefore, for projects that fully conform to LID sizing requirements and fully address HCOCs, the use of HSCs is optional.

However, if a projects cannot feasibility meet LID sizing requirements or cannot fully address HCOCs, all applicable HSCs must be considered as part of demonstrating that the BMP system has been designed to retain the maximum feasible portion of the DCV. Under these cases, the Project WQMP must demonstrate conformance with the requirement to select and use all applicable HSCs. This conformance analysis generally must take the following form, or equivalent methods of documenting that the requirements of the Model WQMP are met:

- Conformance should be demonstrated for each drainage area within the project
- Using the checklist of HSCs contained in Section IV of the WQMP Template, or equivalent, note all HSCs that have been provided for the drainage area.
- For HSCs that have not been provided, provide rationale for why they are not applicable or mutually exclusive with another more effective BMP.
- Using Worksheet A in Appendix XV, the effect of HSCs should be accounted in tabulating overall system performance. The use of HSCs results in smaller design volumes for downstream BMPs. Appendix III provides guidance accounting for the benefits of HSCs.

2.4.3.4. LID BMPs (Retention and Biotreatment)

LID BMPs must be selected based on a hierarchy of controls and sized to capture the maximum feasible portion of the DCV using with the higher priority type control (e.g., retention), before attempting to address the remaining volume with the next lower priority control (biotreatment).

Therefore, to demonstrate conformance with performance criteria for LID BMPs, the Project WQMP must demonstrate that BMPs have been selected according to the hierarchy of controls, and have been designed to achieve the maximum feasible retention of the DCV before biotreatment can be used (see Figure 2.1). When biotreatment is used after retention has been used to the MEP, it must be demonstrated that the maximum feasible retention plus biotreatment has been achieved before considering an alternative compliance program.

Demonstrating conformance with LID BMP selection and sizing requirements can follow a large number of different paths. The following general scenarios will encompass many projects. Guidance is provided for documenting conformance for these general scenarios.

Scenario 1*:* The project is able to feasibly retain the DCV. The Project WQMP should demonstrate conformance with the Model WQMP in the following stepwise manner:

- *Demonstrate conformance at the drainage area scale.* Conformance should be demonstrated for each drainage area within the project.
- *Demonstrate that the selected BMPs are retention-based LID BMPs.* Using the checklist of Infiltration and Harvest and Use BMPs contained in Section IV of the WQMP Template, or equivalent, identify the LID BMP(s) that have been selected for the drainage area.
- *Demonstrate the selected BMPs are feasible.* Document the feasibility of the selected BMPs by comparing to <u>infeasibility screening factors</u> to site conditions and providing supporting information, as applicable. This screening should be documented using **Table 2.7**, or equivalent.
- *Demonstrate that the selected BMPs retain the DCV for each drainage area.* Calculate and document the required BMP sizes to retain the DCV based on guidance provided in Appendix I, II and III, by reference from the applicable <u>**BMP Fact Sheet**</u>(s).Using

tabular summaries and reference to the Drainage Map (WQMP Template Section VI) demonstrate that the provided retention volume in the BMPs in the drainage area meets or exceeds the required DCV.

Project WQMP must included the necessary content to document these items by providing a completed checklists, worksheets, tables, and narrative discussion, and other relevant forms of documentation.

Scenario 2: The project cannot feasibly retain the full DCV, but biotreatment BMPs can be used to treat all or a portion of the remaining volume. The Project WQMP should demonstrate conformance with the Model WQMP in the following stepwise manner:

- *Demonstrate conformance at the drainage area scale.* Conformance should be demonstrated for each drainage area within the project.
- *Demonstrate that the selected retention BMP are LID BMPs.* Using the checklist of Infiltration and Harvest and Use BMPs contained in Section IV of the WQMP Template, or equivalent, identify the LID BMP(s) that have been selected and provided for the drainage area.
- *Demonstrate that the selected retention BMPs are the most likely to be feasible.* Provide a narrative description of why the selected BMPs were chosen and why they are the most likely to be technically feasible for the drainage area. For BMPs that were not selected, indicate why.
- *Demonstrate the selected BMPs are feasible.* Document the feasibility of the selected BMPs by comparing to infeasibility screening factors and providing supporting information, as applicable. This screening must be documenting in **Table 2.7**, or equivalent.
- *Demonstrate that retention BMPs have been provided to the MEP.* Based on comparison to the criteria for designing BMPs to achieve the maximum feasible retention volume (Appendix XI), demonstrate that the sizing provided for retention BMPs meets minimum criteria contained in Appendix XI.
- *Demonstrate that the selected BMPs retain plus biotreat the DCV from the drainage area.* Using the BMP sizing guidance provided in Appendix I, II, and III, by reference from the applicable **BMP Fact Sheet**(s), calculate the remaining volume to be biotreated. Using tabular summaries and reference to the Drainage Map (WQMP Template Section VI) demonstrate that the provided retention and biotreatment volumes meet or exceeds the required retention and biotreatment volumes.

Project WQMP must included the necessary content to document these items by providing a completed checklists, worksheets, tables, and narrative discussion, and other relevant forms of documentation.

Scenario 3: The project cannot feasibly retain the full DCV and cannot feasibly biotreat the remaining volume. The Project WQMP should demonstrate conformance with the Model WQMP in the following stepwise manner:

- *Demonstrate conformance at the drainage area scale.* Infeasibility of on-site retention should be demonstrated for each drainage area within the project.
- *Demonstrate that the selected retention BMP are LID BMPs.* Using the checklist of Infiltration and Harvest and Use BMPs contained in Section IV of the WQMP Template, or equivalent, identify the LID BMP(s) that have been selected and provided for the drainage area.
- *Demonstrate that the selected retention BMPs are the most likely to be feasible.* Provide a narrative description of why the selected BMPs were chosen and why they are the most likely to be technically feasible for the drainage area. For BMPs that were not selected, indicate why.
- *Demonstrate the selected BMPs are feasible.* Document the feasibility of the selected BMPs by comparing to <u>infeasibility screening factors</u> and providing supporting information, as applicable. This screening must be documented using **Table 2.7**, or equivalent.
- *Demonstrate that retention plus biotreatment has been provided to the MEP.* Based on comparison to the criteria for designing BMPs to achieve the maximum feasible retention plus biotreatment of the DCV (Appendix XI), demonstrate that the sizing provided for retention and biotreatment BMPs meets minimum criteria. Use tabular summaries and reference to the Drainage Map (WQMP Template Section VI) demonstrate that the provided retention and biotreatment volumes meet or exceeds the maximum feasible volume pursuant to the criteria in Appendix XI.
- *Report the remaining unmet volume to be addressed by alternative compliance.* This should be calculated as the difference between the DCV and the provided volume.

Project WQMP must included the necessary content to document these items by providing a completed checklists, worksheets, tables, and narrative discussion, and other relevant forms of documentation.

Scenario 4: The project cannot feasibly retain the entire DCV because there are not any feasible retention BMPs. The Project WQMP should demonstrate conformance with the Model WQMP in the following stepwise manner:

- *Demonstrate conformance at the drainage area scale.* Conformance should be demonstrated for each drainage area within the project.
- *Demonstrate that no retention BMP are feasible.* Using the checklist of Infiltration and Harvest and Use BMPs contained in Section IV of the WQMP Template, or equivalent, identify why each of the BMPs is not feasible for the entire DCV. Document the infeasibility of fully retaining the DCV by comparing site and project characteristics to <u>**infeasibility screening factors**</u> and providing supporting information, as applicable. This screening should be documenting in **Table 2.7**, or equivalent.
- *Demonstrate the selected biotreatment BMPs capture the entire DCV from the drainage area.* Using the BMP sizing guidance provided in Appendix I, II, and III, by reference from the applicable <u>**BMP Fact Sheet**</u>(s), calculate the sizing requirements for biotreatment BMPs. Using tabular summaries and reference to the Drainage Map (WQMP Template Section VI) demonstrate that the provided biotreatment volume meets or exceeds the required biotreatment volume.

- *Demonstrate that biotreatment BMPs are designed to achieve the maximum feasible infiltration and ET.* Demonstrate via narrative discussion and comparison to criteria contained in Appendix XI and Appendix XII, that the biotreatment BMPs have been designed with design elements that will achieve the maximum feasible infiltration and ET. If incidental infiltration would cause a significant documented hazard, then demonstrate why biotreatment BMPs restrict infiltration by comparing site and project characteristics to **infeasibility screening factors**.

Project WQMP must included the necessary content to document these items by providing a completed checklists, worksheets, tables, and narrative discussion, and other relevant forms of documentation.

2.4.3.5. Documenting Partial Retention and Biotreatment to the MEP

In cases where retention BMPs are technically feasible but are constrained by site conditions such that it is only feasible to retain a portion of the DCV, it is necessary to demonstrate that the partial level of retention and/or biotreatment is consistent with the MEP standard. Appendix XI provides minimum criteria that must be met to demonstrate that BMPs have been designed to achieve the maximum feasible retention or retention plus biotreatment of the DCV. Conformance should be demonstrated based on a comparison of the BMP design parameters and drainage area characteristics to the minimum criteria contained in Appendix XI.

2.4.3.6. Demonstrating Primary Conformance using Regional BMP Systems

Regional systems meeting specific criteria can be used as a primary path for compliance with LID and treatment control criteria for projects that participate in these projects. Section 2.4.2.2 of the Model WQMP describes the applicability of watershed-based plans to the selection of BMPs for a project. To demonstrate conformance with LID and treatment control criteria via this pathway, the Project WQMP should cite and/or attach the applicable watershed-based planning documentation to the Project WQMP that demonstrate that the criteria described in Section 2.4.2.2 of the Model WQMP are met.

2.4.3.7. Determining Remaining Treatment Control Sizing Requirements.

If retention and biotreatment BMPs are provided to fully capture the DCV, then conformance with treatment controls sizing requirements is inherently achieved. It is sufficient to note this equivalency in the Project WQMP as the means to demonstrate conformance.

In cases where an unmet volume remains following the application of retention and biotreatment BMPs, treatment control BMPs must be used to address pollutants of concern for the remaining unmet volume. The conformance analysis for treatment control BMPs should include:

- *Demonstrate that treatment control BMPs address pollutants of concern.* Documentation that BMPs have been selected to address the pollutants of concern per instructions contained in Section 2.4.2.

- ***Demonstrate that treatment controls address the remaining volume.*** First, calculate the remaining unmet volume. The approved methods contained in Appendix VI should be used, with documentation provided in the form of tables and worksheets. Compare the unmet volume with the provided volume or flowrate of treatment control BMPs. Appendix VI describes the methodology for converting remaining volume to remaining flowrate as necessary. Demonstrate that the treatment control BMPs meet or exceed treatment for the unmet volume or flowrate.

2.4.3.8. Demonstrating Conformance with Hydromodification Control Criteria

Hydromodification control criteria are expressed in terms of hydrologic conditions that must be met do demonstrate that HCOCs do not exist. Therefore the Project WQMP conformance analysis for hydromodification must demonstrate that these conditions are addressed. The Project WQMP must demonstrate that HCOCs do not exist through an evaluation of receiving channel susceptibility and/or hydrologic calculations in comparison to permit definitions of HCOCs. This demonstration will depend on receiving water susceptibility, site characteristics, project characteristics, and permit region.

Section 5 and Appendices I and II, provide references for sizing and design of hydromodification controls to address HCOCs. Appendices IV and V describe the approved hydrologic calculation methods for quantifying HCOCs.

2.4.4. <u>Alternative Compliance Plan</u>

Alternative compliance plan requirements are described in Section 3.0 of the Model WQMP. Guidance on technical calculations for determining alternative compliance requirements are provided in Appendix VI.

This Section IV of the Project WQMP should include all applicable alternative compliance-related calculations, as applicable.

2.5. Inspection/Maintenance Responsibility for BMPs

Requirements for inspection and maintenance of the selected BMPs are provided **in** Model WQMP Section 4.0. Specific guidance for operations and maintenance planning are contained **in Section** 7 of this TGD.

2.6. Site Plan and Drainage Plan

2.6.1. <u>Site Plan and Drainage Plan Sheet Set</u>

Attach the following figures to the Project WQMP:

1) Project location map that identifies receiving water bodies.
2) Project site plan that identifies land uses / activities.

3) Project site plan that identifies infiltration infeasibility criteria (if applicable), including surficial soil properties, depth to groundwater, and geotechnical hazards.
4) Drainage plan that delineates each drainage management area, shows all stormwater management infrastructure and storm drains, ands identifies the selected BMP type(s).
5) BMP details for all structural BMPs (only applicable for Project WQMPs and Conceptual/Preliminary BMPs where the level of design detail warrants the inclusion of BMP details).

2.6.2. Electronic Data Submittal.

This section is reserved for future guidance.

2.7. Incorporating USEPA Green Streets Guidance to the MEP

This section provides guidance for preparation of a Project WQMP that incorporates USEPA **Managing Wet Weather with Green Infrastructure: Green Streets** in a manner consistent with the MEP standard. This section is applicable only as described in Section 2.4.2.1 of the Model WQMP; applicable projects are referred to in this section as "applicable Green Streets projects." A copy of the USEPA Green Streets Guidance is included as Appendix B of the Model WQMP.

2.7.1. Site Assessment Considerations for Applicable Green Streets Projects

Site assessment for applicable Green Streets projects includes many of the same considerations as described in **Section 2.3.2**. In addition to those elements described in **Section 2.3.2**, specific elements which should be given special consideration in the site assessment process for applicable Green Streets include:

- **Ownership of land adjacent to right of ways.** The opportunity to provide stormwater treatment may depend on the ownership of land adjacent to the right-of-way. Acquisition of additional right-of-way and/or access easements may be more feasible if land bordering the project is owned by relatively few land owners.
- **Location of existing utilities.** The location of existing storm drainage utilities can influence the opportunities for Green Streets infrastructure. For example, stormwater planters can be designed to overflow along the curb-line to an existing storm drain inlet, thereby avoiding the infrastructure costs associated with an additional inlet. The location of other utilities will influence the ability plumb BMPs to storm drains, therefore, may limit the allowable placement of BMPs to only those areas where a clear pathway to the storm drain exists.
- **Grade differential between road surface and storm drain system.** Some BMPs require more head from inlet to outlet than others; therefore, allowable head drop may be an important consideration in BMP selection. Storm drain elevations may be constrained by a variety of factors in a roadway project (utility crossings, outfall elevations, etc.) which may override stormwater management considerations.
- **Longitudinal slope.** The suite of LID BMPs which may be installed on steeper road sections is more limited. Specifically, permeable pavement and swales are more suitable for gentle grades. Other BMPs may be more readily terraced to be used on steeper slopes.

- **Potential access opportunities.** A significant concern with installation of BMPs in major right of ways is the ability to safely access the BMPs for maintenance considering traffic hazards. The site assessment should identify vehicle travel lanes and areas of specific safety hazards for maintenance crews and subsequent steps of the Project WQMP preparation process should attempt avoid placing BMPs in these areas.

Infiltration may be considered for applicable Green Streets projects provided that **infeasibility screening criteria** are observed, with specific attention to protection of groundwater quality as discussed in Appendix VIII and the structural integrity of adjacent road bed.

POCs and HCOCs should be determined as described in Sections **2.2** and **2.3**, respectively.

2.7.2. BMP Selection and Site Design for Applicable Green Streets Projects

The fundamental tenants of the approach described by the USEPA Green Streets guidance include:

- Selecting LID BMPs to the opportunities of the site and to attempt to address pollutants of concern and HCOCs,
- Developing innovative stormwater management configurations integrating "green" with "grey" infrastructure,
- Sizing BMPs opportunistically to provide stormwater pollution reduction to the MEP, accounting for the many competing considerations in right of ways.

Applicable Green Streets projects should apply the following LID site design measures to the MEP and as specified in the local permitting agency's codes:

- Minimize street width to the appropriate minimum width for maintaining traffic flow and public safety.
- Add tree canopy by planting or preserving trees/shrubs.
- Use porous pavement or pavers for low traffic roadways, on-street parking, shoulders or sidewalks.
- Integrate traffic calming measures in the form of bioretention curb extensions.

Applicable Green Streets projects should select BMPs consistent with the Green Streets guidance. Table 2.8 provides an inventory of LID BMPs which may be appropriate for applicable Green Streets projects. The performance criteria for applicable Green Streets projects do not require retention BMPs to be considered to the MEP before considering biotreatment and treatment control BMPs. A formal process of BMP prioritization and selection is not required for applicable Green Streets projects, however **infiltration infeasibility criteria** still apply; only feasible BMPs may be selected.

BMPs should be prioritized based on a comparison of drainage area characteristics to the opportunity criteria listed in Table 2.8. The USEPA Green Streets guidance describes how some of these BMPs may be used in combination to achieve optimal benefits in runoff reduction and water quality improvement. Specific examples and applications for residential streets, commercial streets, arterials streets, and alleys are provided in the USEPA guidance.

The drainage patterns of the project should be developed so that drainage can be routed to areas with BMP opportunities before entering storm drains. For example, if a median strip is present, a reverse crown should be considered, where allowed, so that stormwater can drain to a median swale. Likewise, standard peak-flow curb inlets should be located downstream of areas with potential for stormwater planters so that water can first flow into the planter, and then overflow to the downstream inlet if capacity of the planter is exceeded. It is more difficult to apply green infrastructure after water has entered the storm drain.

Conceptual drainage plans for redevelopment projects should identify tributary areas outside of the project site generates runoff that comingles with on-site runoff. The project is not required to treat off-site runoff; however treatment of comingled off-site runoff may be used to off-set the inability to treat areas within the project for which significant constraints prevent the ability to provide treatment.

Table 2.8: Potential BMPs for Applicable Green Streets Projects

BMP Type	Opportunity Criteria for Applicable Green Streets Projects
Street Trees, Canopy Interception	• Access roads, residential streets, local roads and minor arterials • Drainage infrastructure, sea walls/break waters • Effective for projects with any slope • Trees may be prohibited along high speed roads for safety reasons or must be setback behind the clear zone or protected with guard rails and barriers
Stormwater Curb Extensions / Stormwater Planters	• Access roads, residential streets, and local roads with parallel or angle parking and sidewalks • Can be designed to overflow back to curbline and to standard inlet • Shape is not important and can be integrated wherever unused space exists • Can be installed on relatively steep grades with terracing
Bioretention Areas	• Low density residential streets without sidewalks • Requires more space than curb extensions/ planters, most feasibly implemented in combination with minimized road widths
Permeable Pavement	• Parking and sidewalk areas of residential streets, and local roads • Should not receive significant run-on from major roads • Should not be subject to heavy truck/ equipment traffic • Light vehicle access roads
Permeable Friction Course Overlays	• High speed roadways unsuitable for full depth permeable pavement • Suitable for parking lots and all roadway types
Vegetated Swales (compost amended were possible)	• Roadways with low to moderate slope • Residential streets with minimal driveway access • Minor to major arterials with medians or mandatory sidewalk set- • Access roads • Swales running parallel to storm drain can have intermittent discharge points to reduce required flow capacity
Filter strips (amended road shoulder)	• Access roads • Major roadways with excess ROW • Not practicable in most ROWs because of excessive width requirements
Proprietary Biotreatment	• Constrained ROWs • Typically have small footprint to tributary area ratio • Simple install and maintenance • Can be installed on roadways of any slope • Can be designed to overflow back to curb line and to standard inlet

Table 2.8: Potential BMPs for Applicable Green Streets Projects

BMP Type	Opportunity Criteria for Applicable Green Streets Projects
Infiltration Trench	• Constrained ROWs • Can require small footprint where soils are suitable • Low to moderate traffic roadways • Infiltration trenches are not suitable for high traffic roadways • Requires robust pretreatment
Cartridge Media Filters	• Highly constrained ROW with little available surface area • Installed in underground vaults, manholes, or catch basins • Require minimum available head loss • Simple installation and maintenance
WSDOT Media Filter Drains	• See : **http://www.ecy.wa.gov/programs/wq/stormwater/newtech/use_designations/091022EcologyEmbankmentGULD.pdf**

2.7.3. BMP Sizing for Applicable Green Streets Projects

The following steps are used to size BMPs for applicable Green Streets projects:

1. Delineate drainage areas tributary to BMP locations and compute imperviousness.
2. Look up the recommended sizing method for the BMP selected in each drainage area and using the respective BMP Fact Sheets (Appendix XIV) calculate target sizing criteria.
3. Design BMPs per the guidance provided in the BMP Fact Sheets (Appendix XIV)
4. Attempt to provide the calculated sizing criteria for the selected BMPs.
5. If sizing criteria cannot be achieved, document the constraints that override the application of BMPs, and provide the largest portion of the sizing criteria that can be reasonably provided given constraints.

If BMPs cannot be sized to provide the calculated volume for the tributary area, it is still essential to design the BMP inlet, energy dissipation, and overflow capacity for the full tributary area to ensure that flooding and scour is avoided. It is strongly recommended that BMPs which are designed to less than their target design volume be designed to bypass peak flows.

2.7.4. Alternative Compliance Options for Applicable Green Streets Projects

Applicable Green Streets projects are not required to meet alternative compliance options if stormwater management controls described in this section, or equivalent, are installed in a manner consistent with the MEP standard.

Alternative compliance programs should be considered for applicable Green Streets projects if on-site green infrastructure approaches cannot practicably treat the design volume. The primary alternative compliance option for applicable Green Streets projects is the completion of off-site mitigation projects. The proponent would implement a project to reduce stormwater pollution for other portions of roadway or similar land uses to the project in the same hydrologic unit, ideally as close to the project as possible and discharging to the same outfall.

SECTION 3. SITE DESIGN PRINCIPLES AND TECHNIQUES

3.1. Introduction

This section focuses on LID site design practices; LID BMPs are discussed in **Section 4**.

The primary objective of site design principles and techniques is to reduce the hydrologic and water quality impacts associated with land development. The benefits derived from this approach include:

- Reduced size of downstream BMPs and conveyance systems;
- Reduced pollutant loading; and
- Reduced hydromodification impacts to receiving streams.

Site Design Principles and Techniques include the following design features and considerations:

- Site planning and layout;
- Vegetative protection, revegetation, and maintenance;
- Slopes and channel buffers;
- Techniques to minimize land disturbance;
- LID BMPs at scales from single parcels to watershed: and
- Integrated Water Resource Management Practices.

Detailed descriptions for each of these Site Design Principles and Techniques are presented in the following sections.

3.2. Site Planning and Layout

3.2.1. Minimize Impervious Area

One of the principal causes of the environmental impacts of development is the creation of impervious surfaces. Impervious cover can be minimized through identification of the smallest possible land area that can be practically impacted or disturbed during site development. Below is a partial list of techniques that can reduce the amount of impervious area that will be created as part of a project. It is important to note that local land use ordinances and building codes may dictate minimum requirements for road widths, building setbacks and accessibility requirements which may not be overridden. However, in certain situations, it may be possible to modify local codes and ordinances or for a project proponent to obtain a waiver to promote less impervious area, such as allowing narrower road widths, sidewalks on one side of the street, shared driveways, reciprocal parking, and reduced building set-backs. Some strategies for minimizing impervious surfaces may serve multiple functions by supporting other local planning objectives such as providing traffic-calming measures and promoting walkable and healthy communities.

3.2.1.1. Limit Overall Coverage of Paving and Roofs

This can be accomplished by designing compact, taller structures, narrower and shorter streets and sidewalks, smaller parking lots (fewer stalls, smaller stalls, and more efficient drive lanes), and indoor or underground parking. Examine site layout and circulation patterns and identify areas where landscaping can be substituted for pavement.

3.2.1.2. Detain and Retain Runoff Throughout the Site

On flatter sites, it typically works best to intersperse landscaped areas and integrate small scale retention practices among the buildings and paving. On hillside sites, drainage from upper areas may be collected in conventional catch basins and piped to landscaped areas and BMPs in lower areas. Or use low retaining walls to create terraces that can accommodate BMPs.

3.2.1.3. Example Planning Phase Techniques

- Build vertically rather than horizontally - add floors to minimize building footprint.
- Cluster development to reduce requirements for roads and preserve green space.
- Minimize lot setbacks (which in turn minimize driveway lengths).
- Reduce road widths to minimum necessary for emergency vehicles.
- Utilize shared driveways.

3.2.1.4. Example Design Phase Techniques

- Install sidewalks on only one side of private roadways to the extent allowed by accessibility requirements.
- Use alternative materials such as permeable paving blocks or porous pavements on driveways, sidewalks, parking areas, etc. Practices should be selected such that they do not present health and safety hazards, such as tripping hazards.
- Create smaller parking spaces intended for compact cars.

3.2.1.5. Example Construction Phase Techniques

- Minimize unnecessary compaction where possible. The infiltrative capacity of soils can be greatly reduced when they are compacted, often to the point that they perform similarly to impervious surfaces. Where possible, remediate compacted soils.
- Minimize construction footprint.
- Preserve existing vegetable and trees as feasible.

3.2.2. <u>Maximize Natural Infiltration Capacity</u>

A key component of LID is taking advantage of a site's natural infiltration and storage capacity. This will limit the amount of runoff generated, and therefore the need for mitigation BMPs. A site soils/geology assessment will help to define areas with higher potential for infiltration and surface storage.

These areas are typically characterized by:

- Principally Hydrologic Soil Group A or B soils and in some cases Group C soils.
- Mild slopes or depressions.
- Historically undeveloped areas.

3.2.2.1. Example Planning Phase Techniques

- Avoid placing buildings or other impervious surfaces on highly permeable areas.
- Cluster buildings and other impervious areas onto the least permeable soils.

3.2.2.2. Example Design Phase Techniques

- Where paving of permeable soils cannot be avoided, loss of infiltration capacity can be minimized by using permeable paving materials.

3.2.2.3. Example Construction Phase Techniques

- Minimize construction footprint.
- Minimize incidental and unnecessary compaction where it is not necessary to meet the applicable grading code requirements.

3.2.3. <u>Preserve Existing Drainage Patterns and Time of Concentration</u>

Integrating existing drainage patterns into the site plan will help maintain a site's predevelopment hydrologic function. Preserving existing drainage paths and depressions will help maintain the time of concentration and infiltration rates of runoff, decreasing peak flows. The best way to define existing drainage patterns is to visit the site during a rain event and to directly observe runoff flowing over the site. If this is impossible, drainage patterns can be inferred from topographic data, though it should be noted that depression micro-storage features are often not accurately mapped in topographic surveys. Analysis of the existing site drainage patterns during the site assessment phase of the project can help to identify the best locations for buildings, roadways, and stormwater BMPs.

Where possible, add additional depression "micro" storage throughout the site's landscaping that mimics natural drainage patterns. Mild gradients can be used to extend the time of concentration, which reduces peak flows and increases the potential for additional infiltration. While risk of serious flooding must be minimized, the persistence of temporary "puddles" during storms is beneficial to infiltration. If a site is visited during dry weather, these areas can sometimes be identified by looking for surficial dried clay deposits.

Use drainage as a design element. Use depressed landscape areas, vegetated buffers, and bioretention areas as amenities and focal points within the site and landscape design. Bioretention areas can be almost any shape and should be located at low points. When configured as swales, bioretention areas can detain and treat low runoff flows and also convey higher flows.

3.2.3.1. Example Planning Phase Techniques

- Avoid channelization of natural streams.
- Establish set-backs and buffer areas from natural streams.
- Where natural streams will be converted to engineered streams, provide sinuosity to increase the time of concentration.
- Develop an effective conceptual drainage plan.

3.2.3.2. Example Design Phase Techniques

- Avoid channelization of natural streams.
- When designing channels, use mild slopes and increase channel roughness to extend time of concentration.
- When possible, use pervious channel linings to maximize opportunity for infiltration.
- Use vegetated, un-hardened conveyance elements.
- Intersperse localized retention features throughout site.

3.2.3.3. Example Construction Phase Techniques

- Minimize construction footprint.

Micro-scale on-lot retention is a component of preserving existing drainage patterns and times of concentration. Micro-scale on-lot retention is a HSC for the purpose of this TGD. A BMP fact sheet for localized on-lot retention is found in Appendix XIV. The fact sheet describes recommended design criteria and methods of quantifying the performance of this practice.

3.2.4. <u>Disconnect Impervious Areas</u>

Runoff from 'connected' impervious surfaces commonly flows directly to a paved surface (driveway, sidewalk, or to the curb line) and from there to the stormwater collection system with no opportunity for infiltration into the soil. For example, roofs and sidewalks commonly drain onto parking lots, and the runoff is conveyed by the curb and gutter to the nearest storm inlet. Runoff from numerous impervious drainage areas may converge, combining their volumes, peak runoff rates, and pollutant loads. Disconnecting impervious areas from conventional stormwater conveyance systems allows runoff to be collected and managed at the source or redirected onto pervious surfaces such as vegetated areas. This reduces the amount of directly connected impervious area (DCIA), and will reduce the peak discharge rate by increasing the time of concentration, maximize the opportunity for infiltration by reducing the velocity of flows and providing for greater contact time with the soil, and maximize the opportunity for ET during transport.

Disconnection practices may be applied in almost any location, but impervious surfaces must discharge into a suitable receiving area for the practices to be effective. Information gathered during the site assessment will help determine appropriate receiving areas. Typical receiving areas for disconnected impervious runoff include landscaped areas and/or LID BMPs (i.e., filter strips or bioretention). Runoff must not flow toward building foundations or be redirected onto adjacent private properties. Setbacks from buildings or other structures may be required to ensure soil stability. Consult with the project geotechnical engineer to identify areas where infiltration can be accommodated.

It is important to bear in mind that water flows down hill; therefore receiving areas must be located down gradient from runoff discharges. In a residential setting, this could mean that roof runoff discharges to either the front yard or the back yard, depending on the site configuration. As compared to conventional development, some potential techniques for redirecting flows to vegetated areas may require local design standards to be revisited or a waiver obtained.

3.2.4.1. Example Planning Phase Techniques

- Plan site layout and mass grading to allow for runoff from impervious surfaces to be directed into distributed permeable areas such as turf, recreational areas, medians, parking islands, planter boxes, etc.
- Use vegetated swales for stormwater conveyance instead of traditional concrete pipes.
- Avoid channelization of natural on-site streams.

3.2.4.2. Example Design Phase Techniques

- Provide permeable areas within medians and parkways that are designed to accept runoff from adjacent areas (i.e. via curb cuts).
- Construct roof downspouts to drain to pervious areas such as planter boxes or adjacent landscaping. This approach is further described in **Section 4**.
- Use permeable paving materials such as paving blocks or porous pavements on driveways, sidewalks, parking areas, etc.

To minimize stormwater-related impacts, apply the following design principles to the layout of newly developed and redeveloped sites:

- Define the development envelope and protected areas, identifying areas that are most suitable for development and areas that should be left undisturbed.
- Set back development from creeks, wetlands, and riparian habitats.
- Preserve established trees as practicable (see **Section 3.3**)

Impervious area disconnection is characterized as a HSC for the purpose of this TGD. BMP fact sheets for localized on-lot retention and impervious area dispersion are found Appendix XIV. These fact sheets include recommended design criteria and methods of quantifying the benefits of impervious area disconnection.

3.3. Vegetative Protection, Selection Revegetation, and Soil Stockpiling

3.3.1. Protect Existing Vegetation and Sensitive Areas

A thorough site assessment will identify any areas containing dense vegetation or well-established trees. When planning the site, avoid disturbing these areas. Soils with thick, undisturbed vegetation have a much higher capacity to store and infiltrate runoff than do disturbed soils. Reestablishment of a mature vegetative community can take decades. Sensitive areas, such as wetlands, streams, floodplains, or intact forest, should also be avoided. Development in these areas is often restricted by federal, state and local laws.

Vegetative cover can also provide additional volume storage of rainfall by retaining water on the surfaces of leaves, branches, and trunks of trees during and after storm events. This capacity is rarely considered, but on sites with a dense tree canopy it can provide additional volume mitigation.

3.3.1.1. Example Planning Phase Techniques

- Establish set-backs and buffer zones surrounding sensitive areas.
- Incorporate established trees into site layout.

3.3.1.2. Example Design Phase Techniques

- Design site to deter human activity within sensitive areas (i.e. fences, signs, etc).

3.3.1.3. Example Construction Phase Techniques

- Provide and maintain highly visible flagging and/or fencing around sensitive areas or vegetation that is to be protected.

3.3.1.4. Example Occupancy Phase Techniques

- Establish use/access restrictions to sensitive areas.

3.3.2. Revegetate Disturbed Areas

Maximizing plant cover protects the soil and improves ability of the site to retain stormwater, minimize runoff, and help to prevent erosion. Plants have multiple impacts on downstream water quality. First, the presence of a plant canopy (plus associated leaf litter and other organic matter that accumulates below the plants) can intercept rainfall, which reduces the erosive potential of precipitation. The Canopy Cover Fact Sheet provided in Appendix XIV facilitates quantification of the retention benefits of canopy cover. With less eroded material going to receiving waters, turbidity, chemical pollution, and sedimentation are reduced. Second, a healthy plant and soil community can help to trap and remediate chemical pollutants and filter particulate matter as water percolates into the soil. This occurs through the physical action of water movement through the soil, as well as through biological activity by plants and the soil microbial community that is supported by plants. Third, thick vegetative cover can maintain and even improve soil infiltration rates.

When selecting plants for re-vegetation, preference should be given to native vegetation, which is uniquely suited to the local soils and climate. However, consideration of the location of the plants in the landscape with regards to wildfire safety can sometimes make the use of native species unsuitable. The Orange County Fire Authority requires "fuel modification zones" adjacent to development and restricts species of plant that may be used in these zones. Additional information can be found by contacting local Master Gardeners or seeking the advice of local plant nurseries, which will have specific knowledge of plants suitable for your particular application. The Las Pilitas Nursery in Santa Margarita has compiled a detailed database of California native plants which is accessible online at: **http://www.laspilitas.com/comhabit/california_communities.html**. The website can be used to aid in determining the correct plant communities by searching by either ZIP code or town. In cases where use of native vegetation is impractical or impossible, use of non-natives adapted to similar climate regimes, such as the Mediterranean, may be appropriate. This strategy will maximize the successful establishment of plantings, and minimize the need for supplemental irrigation.

3.3.3. Soil Stockpiling and Site Generated Organics

The regeneration of disturbed topsoil can take years under optimal conditions, and sometimes can take many decades (Brady and Weil, 2002[9]). Proper stockpiling, storage, and reapplication of disturbed topsoil can greatly accelerate this process. Improper soil storage and restoration can significantly decrease the biological activity of the soil, decrease the successful establishment of plantings, and increase the ability of undesirable invasive species to dominate the disturbed landscape. Proper stockpiling generally includes protecting the stockpile to prevent excessive compaction and covering the stockpile to prevent significant erosion and leaching of nutrients.

Soil stockpiling and the use of in situ grubbed plant material and duff as mulch or soil amendments is encouraged. This will reduce the need for importation of top soil to improve soil quality, and will encourage reestablishment of soil flora and fauna after site disturbance. Successful soil stockpiling and reuse begins in the early stages of project planning.

The use of topsoil harvested from the local site can improve the productivity and rate of re-vegetation of a disturbed site. In addition to stockpiled soil, vegetative material grubbed from the site and free of invasive species can be tilled back into the soil to increase organic content.

[9] The Nature and Properties of Soils, 13th Edition, Nyle C. Brady, Ray R. Weil, 2002.

Restoration of disturbed areas using native soils which have been properly stockpiled during the construction phase of the project is the preferred method of post construction soil restoration. Proper assessment of the site during the design phase of the project is critical to maintaining soil quality, both structural and biological, during the period the soil is stockpiled. Determination of the volume of soil to be stockpiled and designating an area large enough on site to accommodate the stockpiled soil should be considered early in project design.

Consideration must be given to maintenance of the flora and fauna present in the stockpiled soil in addition to its physical condition. Improper storage such as soil that is too wet or stockpiled too deeply, can render what were active biological soil communities sterile. This will severely impact the ability of the soil to support a healthy plant community. If necessary, a local soil scientist familiar with regional soils can provide testing services to evaluate soil condition prior to and after construction and recommend appropriate remediation steps to restore the soil's predevelopment ability to infiltrate stormwater runoff and support a healthy plant community.

Additional information about the impact of soil stockpiling can be found in the following document which was prepared for the District 11 office of the California Department of Transportation:

Restoration in the California Desert - **http://www.sci.sdsu.edu/SERG/techniques/topsoil.html**

3.3.4. Firescaping

Fire is a part of the ecosystems of Southern California. Over the years, wildfires have repeatedly destroyed homes and caused loss of life. In response to this natural phenomenon, extensive research has been done and, in the interest of public safety, guidelines have been codified into law. When considering any planting or re-vegetation plan, consideration must be given to minimizing the risks of fire with proper plant selection and maintenance. Keep in mind that all plants are flammable given the right conditions; selection and maintenance of plants to mitigate flammability go hand-in-hand. A plant with a low flammability rating which is allowed to accumulate dead wood or excessive levels of duff in and around the plant will elevate the risk of flammability significantly.

California law (Public Resources Code 4291) requires a minimum 100-foot space around homes on level ground to protect the structure and provide a safe area for firefighters. If a home is located on a slope, additional distance is required and plant spacing, selection, and design must be modified to maintain proper fire safety margins.

A four zone system has been developed to create a maximum buffer around structures located in high risk wildfire zones. Each zone has very specific landscaping and management requirements to minimize flammability of the landscape. The four zones are broken down as follows:

- Zone One – The garden or clean and green zone

- Zone Two – The greenbelt or reduced fuel zone
- Zone Three – The transition zone
- Zone Four – Native or Natural Zone / Open Space

The landscape plant selection and design for any bioretention or re-vegetation project should be compliant with the requirements of the specific zone in which it will be located. For assistance in determining the correct zone plant selection and spacing, contact your local fire department or insurance company for assistance.

3.3.5. Xeriscape Landscaping

As water use, the frequency of drought, and the impact of organic waste generated from landscape management increases in California, methods to deal with these problems have been developed. The concept of xeriscape was originally developed by the Denver Water Department in 1978. The word was coined by combining the Greek word xeros ("dry") with landscape. Since 1978, the xeriscape has become a widely-accepted alternative to traditional landscape design in dry areas.

Xeriscape landscaping is a landscape design and plant selection scheme that is used to minimize required resources and waste generated from a landscape. Defined as "quality landscaping that conserves water and protects the environment" the principles of xeriscape should be employed in any project that creates or restores the landscape. Consulting local resources, such as your local county extension agent, Master Gardeners, Landscape Architects, or local garden centers and nurseries, will help to select plant material suitable for a specific geographic location.

Xeriscape landscaping is based on seven principles:

- Soil analysis
- Planning and design
- Appropriate plant selection
- Practical turf areas
- Efficient irrigation
- Use of mulches
- Appropriate maintenance

Xeriscape landscaping has many benefits which include:

- Reduced water use
- Decreased energy use
- Reduced heating and cooling costs resulting from optimal placement of trees and plants
- Minimal runoff from both stormwater and irrigation resulting in reduction of sediment, fertilizer and pesticide transport
- Reduction in yard waste that would normally be landfilled

- Creation of habitat for wildlife
- Lower labor and maintenance costs
- Extended life of existing water resources infrastructure.

A xeriscape-type landscape can reduce outdoor water consumption by as much as 50 percent without sacrificing the quality and beauty of landscaped areas. It is also an environmentally sound landscape, requiring less fertilizer and fewer chemicals. Xeriscape-type landscape is low maintenance, saving time, effort and money.

Street trees/canopy cover are elements of vegetative protection, revegetation, and maintenance and are characterized as a HSC for the purpose of this TGD. A BMP fact sheet for street trees/canopy interception is found in Appendix XIV. Fact sheets include recommended design criteria and methods of quantifying the benefits of street trees/canopy interception.

The selection and design of vegetative-based LID BMPs that are specifically sized to treat the DCV is discussed further in **Section 4**.

3.4. Slopes and Channel Buffers

Project plans should include site design BMPs to decrease the potential for erosion of slopes and/or channels. The following design principles should be considered, and incorporated and implemented where determined applicable and feasible by the Permittee:

1. Convey runoff safely from the tops of slopes.
2. Avoid disturbing steep or unstable slopes.
3. Avoid disturbing natural channels.
4. Install permanent stabilization BMPs on disturbed slopes as quickly as possible.
5. Vegetate slopes with native or drought tolerant vegetation.
6. Control and treat flows in landscaping and/or other controls prior to reaching existing natural drainage systems, unless infiltration would cause geotechnical hazards.
7. If hydromodification control is not provided before discharge to the channel, install permanent stabilization BMPs in channel crossings as quickly as possible, and ensure that increases in runoff velocity and frequency caused by the project do not erode the channel.
8. 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 should be installed in such a way as to minimize impacts to receiving waters.
9. Instead of discharging to steep reaches, consider collecting and conveying runoff to downgradient discharge points.
10. On-site conveyance channels should be lined, 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. Irrigation demand of vegetated systems should be considered. If velocities in the channel are large enough to erode grass or other vegetative linings, rock, riprap, concrete soil cement or geo-grid stabilization may be substituted or used in combination with grass or other vegetation stabilization.

11. Other design principles which are comparable and equally effective.

These practices should be implemented, as feasible, consistent with local codes and ordinances. Projects involving an alteration to bed, bank, or channel of a Water of the US may require approval of regulatory agencies with jurisdiction over water bodies, (e.g., the U.S. Army Corps of Engineers, the Regional Boards and the California Department of Fish and Game).

3.5. Techniques to Minimize Land Disturbance

Minimizing the amount of site clearing and grading can dramatically reduce the overall hydrologic impacts of site development. This applies primarily to new construction but the principles can be adapted to retrofit and infill projects as well.

Soil compaction resulting from the movement of heavy construction equipment can reduce soil infiltration rates by 70-99% (Gregory et al; 2006)[10]. Even low levels of compaction caused by light construction equipment can significantly reduce infiltration rates. In addition, compaction can destroy the complex network of biota in the soil profile that support the soil's ability to capture and mitigate pollutants. Soil compaction severely limits the establishment of healthy root systems of plants that may be used to revegetate the area. For these reasons, it is very important to avoid unnecessary damage to soils during the construction process. The use of clearly defined protection areas will help to preserve the existing capacity of the site to store, treat and infiltrate stormwater runoff.

3.5.1.1. Example Planning Phase Techniques

- Many of the planning techniques identified in the above sections will help minimize the construction footprint.

3.5.1.2. Example Construction Phase Techniques

- Minimize the size of construction easements.
- Locate material storage areas and stockpiles within the development envelope.
- Limit ground disturbance outside of areas that require grading.
- Identify and clearly delineate access routes for the movement of heavy equipment.
- Establish and delineate vegetation and soil protection areas.

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[10] Gregory, J.H.; Dukes, M.D.; Jones, P.H.; and G.L. Miller, 2006. Effect of urban soil compaction on infiltration rate. *Journal of Soil and Water Conservation 2006 61(3):117-124 Online at:* http://www.floridadep.org/water/wetlands/erp/rules/stormwater/docs/compaction.pdf

Additional techniques for minimizing disturbance and protecting or restoring site conditions during construction phase include:

Establish Vegetation and Soil Protection Areas

Vegetative protection areas (e.g. stream, river, lake and other watercourse buffers, vegetation protection areas, existing trees) should be clearly delineated with highly visible fencing materials to prevent incursion of equipment or the stockpiling of materials during construction. Tree trunks should be sheathed during construction to prevent or minimize damage to the bark.

Use of Mulch and Load Distributing Matting

Mulch blankets can be used to protect soil from compaction during construction. The use of timbers or other types of load distributing materials can also be used to limit the effect of heavy equipment movement on the site.

Pre / Post Construction Soil and Plant Treatments

Consideration should be given to pre-construction treatment of the soil to mitigate the stresses on existing shrubs and trees. This can include soil aeration and specific fertilization protocols that would encourage plant vitality. A local restoration ecologist should be engaged well in advance of the start of construction to develop a plan based on specific site conditions since some of these practices are carried out prior to construction.

Inspection Guidelines and Procedures

Management of soil, water, and vegetation protection measures during the construction process will only be effective if it is carefully implemented and meticulously policed during all phases of construction. Significant damage can be done in a short timeframe, and the cost of damage remediation tends to be far greater than the cost of avoiding it. Areas intended for infiltration should be treated especially carefully. Avoid the use of heavy machinery or discharge of sediment-laden runoff in these areas. Heavy machinery will compact the soils and fine grained materials in sediment will reduce the soil's infiltration capability.

Techniques implemented on the construction site to minimize the construction footprint should be included in the project documentation. Contractors working on the project should review and agree to comply with them while working on the jobsite. Construction site inspections should include inspection of such protocols to ensure they are maintained throughout construction.

3.6. LID BMPs at Scales from Single Parcels to Watershed

While the above techniques and approaches are primarily aimed at project-specific planning and design efforts on individual parcels or sites, they are equally applicable when planning projects or activities on a larger scale. The application of LID site planning principles and practices on a watershed scale may be reflected in the promotion of high density development and infill, protection of drainage courses, land use planning with consideration for areas most suitable for development, preservation of native vegetation, and the implementation of LID BMPs on a sub-regional or regional basis. Such approaches and opportunities are expected to be evaluated and identified in future watershed-scale plans that integrate water quality, hydrologic, fluvial, water supply, and habitat considerations. A discussion of the potential role of watershed-scale plans in BMP selection should is provided in Section 2.4.2.2 of the Model WQMP. A project proponent is not precluded from organizing and implementing LID BMPs on a regional scale.

3.7. Integrated Water Resource Management Practices

Selection and incorporation of site design principles into new development and significant redevelopment projects, whether on-site or off-site can have significant multiple benefits on a subwatershed, watershed and county-wide basis. For example, Orange County Water District is supportive of regional/sub-regional infiltration BMPs as an approach to retaining more urban runoff in the groundwater basin. As another example, the San Diego Creek Natural Treatment System (NTS) Master Plan (**www.irwd.com/environment/natural-treatment-system.html**) includes, among other concepts, constructed wetlands integrated with flood control facilities. These types of facilities would provide retention and biotreatment as well as treatment of retrofit dry weather flows while maintaining the original flood control functionality of the basin. Wetland facilities also provide habitat for many bird species, including endangered species, can provide aesthetic benefits, and in some cases may also provide recreational benefits. Finally, LID and hydromodification control BMPs may provide significant flood control benefits, therefore the system design processes described in this TGD should be coordinated with flood control design (not covered by this TGD) to most efficiently support both functions.

SECTION 4. LID AND TREATMENT CONTROL BMP DESIGN

4.1. Introduction

LID BMPs are required in addition to site design measures and source controls to reduce pollutants in stormwater discharges. LID BMPs are engineered facilities that are designed to retain or biotreat runoff on the project site. HSCs can be considered to be a hybrid between site design and LID BMPs which are designed to manage stormwater runoff similar to LID BMPs, but are less rigorously designed and maintained than LID BMPs. Treatment control BMPs are required if it is not feasible to design LID BMPs for the full DCV. Treatment control BMPs are structural, engineered facilities that are designed to remove pollutants from stormwater runoff using treatment processes that do not incorporate significant biological methods. Both LID BMPs and treatment control BMPs can also partially or fully satisfy hydromodification performance criteria, depending on their design and functions.

The BMP designs described in these fact sheets and in the referenced design manuals shall constitute what are intended as LID and Treatment Control BMPs for the purpose of meeting stormwater management requirements. Other BMP types and variations on these designs may be approved at the discretion of the reviewing agency if documentation is provided demonstrating that the BMP is functionally equivalent to those described in this TGD or published design standards. Water quality monitoring data may be required by local jurisdictions to validate the performance of a proposed BMP type not described in this section.

BMPs are categorized as described in Table 4.1.

This section provides an introduction to each category of BMP and provides links to fact sheets that contain recommended criteria for the design and implementation of these BMPs. Criteria specifically described in these fact sheets override guidance contained in referenced documents. Where criteria are not specified, the user should defer to best professional judgment based on the recommendations of the referenced guidance material or other published and generally accepted sources. When an outside source is used, the preparer must document the source in the project WQMP.

Table 4.1. Categories of LID BMPs and Treatment Control BMPs

HSCs[1]	Infiltration[1]	Harvest and Use	Evapotranspiration	Biotreatment[2]	Treatment Control
➢ Localized on-lot infiltration ➢ Impervious area dispersion (e.g. roof top disconnection) ➢ Street trees(canopy interception) ➢ Residential rain barrels (not actively managed) ➢ Green roofs/ brown roofs ➢ Blue roofs ➢ Impervious area reduction (permeable pavers, site design)	➢ Infiltration basins ➢ Infiltration trenches ➢ Bioretention without underdrains ➢ Bioinfiltration ➢ Drywells ➢ Permeable pavement ➢ Underground infiltration	*Storage options:* ➢ Above-ground cisterns and basins ➢ Underground detention *Potential demand:* ➢ Irrigation ➢ Toilet flushing ➢ Vehicle/ equipment washing ➢ Evaporative cooling ➢ Industrial processes ➢ Dilution water ➢ Other non-potable uses	*ET is a significant volume reduction process in:* ➢ All HSCs ➢ Surface-based infiltration BMPs ➢ Biotreatment BMPs[2]	➢ Bioretention with Underdrains ➢ Vegetated Swale ➢ Vegetated Filter Strip ➢ Wet Detention Basin ➢ Constructed Wetland ➢ Dry Extended Detention Basin ➢ Proprietary Biotreatment	➢ Sand Filters (media bed filters) ➢ Cartridge Media Filters **Pretreatment** ➢ Hydrodynamic Separators ➢ Catch Basin Inserts ➢ Biotreatment BMPs[3]

General note: Lists are not exhaustive; BMPs with similar unit processes may be approved at the discretion of local jurisdictions.

1 - Soil amendments are critical components of some HSCs and infiltration BMPs. Soil amendments may be used to improve infiltration capacity of low permeability soils where the limiting soil horizon lies within the depth that can be feasibly amended. Where the entire thickness of the limiting horizon cannot be amended, the use of soil amendments would increase storage volume but not increase effective infiltration rates.

2 - Biotreatment BMPs shall be designed and maintained per the criteria contained in Appendix XII and shall designed to achieve the maximum feasible ET and infiltration per the criteria contained in Appendix XI. BMPs not meeting these criteria shall be considered treatment control BMPs.

3 - Biotreatment BMPs may be used as pretreatment for other BMP categories. If biotreatment is used as pretreatment, the overflow from these facilities shall be considered biotreated.

4.2. Hydrologic Source Controls

HSCs can be considered to be a hybrid between site design practices and LID BMPs. HSCs are distinguished from site design BMPs in that they do not reduce the tributary area or reduce the imperviousness of a drainage area; rather they reduce the runoff volume that would result from a drainage area with a given imperviousness compared to what would result if HSCs were not used. HSCs are differentiated from LID BMPs in that they tend to be more highly integrated with site designs and tend to have less defined design and operation. For example, it may not be possible to precisely describe the storage volume and drawdown rate of a pervious area receiving drainage from downspout disconnects; however these systems can be very effective at reducing runoff.

Appendix XIV.1 provides fact sheets for several types of HSCs.

HSC-1: Localized On-Lot Infiltration
HSC-2: Impervious Area Dispersion
HSC-3: Street Trees
HSC-4: Residential Rain Barrels
HSC-5: Green Roof / Brown Roof
HSC-6: Blue Roof

Permeable pavement (INF-6) is considered to be an HSC in cases where the permeable pavement it is designed to manage only rainfall that falls directly on the pavement and a small adjacent tributary area no more than 50 percent of the size of the permeable pavement footprint.

4.3. Infiltration BMPs

Infiltration BMPs are LID BMPs that capture, store and infiltrate stormwater runoff. These BMPs are engineered to store a specified volume of water and have no design surface discharge (underdrain or outlet structure) until this volume is exceeded. These types of BMPs may also lose some water to ET, but are characterized by having their most dominant volume losses due to infiltration. Appendix XIV.2 provides fact sheets for several types of infiltration BMPs.

INF-1: Infiltration INF-2: Infiltration Trench
INF-3: Bioretention with no Underdrain
INF-4: Bioinfiltration
INF-5: Drywell
INF-6: Permeable Pavement (concrete, asphalt, and pavers)
INF-7: Underground Infiltration

4.4. Harvest and Use BMPs

Harvest and Use (aka Rainwater Harvesting) BMPs are LID BMPs that capture and store stormwater runoff for later use. These BMPs are engineered to store a specified volume of water and have no design surface discharge until this volume is exceeded. The utilization of captured water used should comply with codes and regulations and should not result in runoff to storm drains or receiving waters (except indirectly via the sanitary sewer/municipal wastewater treatment system). Potential uses of captured water may include irrigation demand, indoor non-potable demand, industrial process water demand, or other demands. Appendix XIV.3 provides fact sheets for two types of harvest and use configurations.

HU-1: Above-Ground Cisterns
HU-2: Underground Detention

4.5. Evapotranspiration BMPs

ET is a significant volume reduction process in HSCs, surface-based infiltration BMPs, and biotreatment BMPs. Because ET is not the sole process in these BMPs, specific fact sheets have not been developed for ET-based BMPs. However the criteria contained in this TGD and Appendices ensure that BMP systems will achieve the maximum feasible ET, as necessary, to demonstrate that the maximum feasible retention has been provided on-site, as summarized below:

- If a project cannot be designed to infiltrate and/or harvest and use the full DCV, the following criteria must be met before evaluating biotreatment BMPs:
    - All applicable HSCs must be considered (ET is a principal process in all HSCs)
    - The project must demonstrate that at least minimum site design practices for available open space have been met (ET is strongly a function of available ET area)
- Biotreatment BMPs, if needed to address remaining unmet volume, must be designed to achieve the maximum feasible infiltration and ET per criteria contained in Appendix XI and Appendix XII.

Therefore, HSC, Infiltration, and Biotreatment BMP fact sheets are applicable for ET as well.

4.6. Biotreatment BMPs

Biotreatment BMPs are a broad class of LID BMPs that reduce stormwater volume to the maximum extent practicable, treat stormwater using a suite of treatment mechanisms characteristic of biologically active systems, and discharge water to the downstream storm drain system or directly to receiving waters. Treatment mechanisms include media filtration (though biologically-active media), vegetative filtration (straining, sedimentation, interception, and stabilization of particles resulting from shallow flow through vegetation), general sorption processes (i.e., absorption, adsorption, ion-exchange, precipitation, surface complexation), biologically-mediated transformations, and other processes to address both suspended and dissolved constituents. Biotreatment BMPs include both flow-based and volume-based BMPs.

Conceptual criteria for biotreatment BMP selection, design, and maintenance Appendix XII. These criteria are generally applicable to the design of biotreatment BMPs in Orange County and BMP-specific guidance is provided in the following fact sheets.

Note: Note: Biotreatment BMPs shall be designed to provide the maximum feasible infiltration and ET based on criteria contained in Appendix XI.

Appendix XIV.4 provides fact sheets for several types of biotreatment BMPs.

BIO-1: Bioretention with Underdrains
BIO-2: Vegetated Swale
BIO-3: Vegetated Filter Strip
BIO-4: Wet Detention Basin
BIO-5: Constructed Wetland
BIO-6: Dry Extended Detention Basin
BIO-7: Proprietary Biotreatment

4.7. Treatment Control BMPs

Treatment control BMPs provide treatment mechanisms but do not sustain significant biological processes. In addition to the treatment control BMPs listed by this TGD, all biotreatment BMPs can be used to fulfill treatment control criteria.

Appendix XIV.5 provides fact sheets for several types of treatment control BMPs as well as references to other guidance documents containing design criteria.

TRT-1: Sand Filters
TRT-2: Cartridge Media Filter

4.8. Pretreatment/Gross Solids Removal BMPs

Pretreatment and gross solids removal is a desirable first step in optimizing BMP selection for a variety of urban runoff situations. In most cases, implementation of pretreatment BMPs will improve the performance and reduce the maintenance associated with downstream BMPs. In fact, pretreatment may be necessary for some BMPs to perform as intended (i.e. trash and debris removal prior to sand filtration).In some cases, BMPs normally considered as a pretreatment BMP may be the only BMP measure feasible before runoff enters receiving waters. An example of this type of situation could be catch basin inserts within roadways adjacent to storm drain channels or waterways. Appendix XIV.6 provides fact sheets for several types of pretreatment/gross solids removal BMPs as well as references to other guidance documents containing design criteria.

PRE-1: Hydrodynamic Separation Device
PRE-2: Catch Basin Insert Fact Sheet

4.9. BMP Performance Summaries

Table 4.2 and **Table 4.3** provides rankings of relative performance or LID BMPs and Treatment Control BMPs, respectively, to support the BMP selection criteria described in Section **2.4.2**.

These tables are based on literature and recent analysis of BMP performance monitoring data. The performance ratings in this table are based on observed effluent quality, observed differences between influent and effluent quality (magnitude and significance), and assumed unit operations and processes (UOPs) provided by each BMP. In order for a BMP to achieve the level of performance anticipated by this table, the BMP must:

- Be designed to contemporary design standards based on the criteria contained in the BMP Fact Sheets (Appendix XIV), the guidance manuals referenced from these fact sheets, and Appendix XII (Conceptual Biotreatment Design, Operation and Maintenance Criteria).
- Include the assumed UOPs listed in this table. BMPs not found on this list may be acceptable on the basis of the UOPs they provide.

Table 4.4 relates UOPs to the pollutant classes they address. **Table 4.4** provides the basis for assessments of expected performance described in **Table 4.2** and **Table 4.3** where monitoring data were not available or inconclusive.

Table 4.2 Relative Treatment Performance Ratings of Biotreatment BMPs

Unit Operations and Process	Assumed Principal Unit Operations and Processes Provided	Suspended solids / sediment/ turbidity	Nitrogen compounds	Phosphorus	Heavy metals	Microbial / viral pathogens	Oils and grease	Dissolved toxic organic compounds	Trash and debris
Bioretention system	• Particulate Settling • Size Exclusion • Inert Media Filtration • Sorption/Ion Exchange • Microbial Competition/Predation • Biological Uptake • Volume loss (via infiltration, ET)	H	L	L	H	M	H	M	H
Bioretention system with internal water storage zone and nutrient sensitive media design	Bioretention UOPs, plus: • Microbially Mediated Transformations (if designed with internal water storage zone)	H	M	M	H	M	H	M	H
Dry extended detention basin	• Particulate Settling • Size Exclusion • Floatable Capture • Vegetative Filtration (with low-flow channel) • Volume loss (via infiltration, ET)	M	L	M	M	L	M	L	H
Dry extended detention basin with vegetated sand filter outlet structure	Dry extended detention basin UOPs, plus: • Inert Media Filtration	H	L	M	M	M	M	L	H
Vegetated Swale	• Vegetative Filtration • Sorption/Ion Exchange • Volume loss (via infiltration, ET)	M	L	L	M	L	M	M	M
Vegetated Filter Strip	• Vegetative Filtration • Sorption/Ion Exchange • Volume loss (via infiltration, ET)	M	L	L	M	L	M	M	L

Table 4.2 Relative Treatment Performance Ratings of Biotreatment BMPs

Unit Operations and Process	Assumed Principal Unit Operations and Processes Provided	Suspended solids / sediment/ turbidity	Nitrogen compounds	Phosphorus	Heavy metals	Microbial / viral pathogens	Oils and grease	Dissolved toxic organic compounds	Trash and debris
Wet detention basins and constructed stormwater wetlands	• Particulate Settling • Size Exclusion • Floatable Capture • Sorption/Ion Exchange • Microbially Mediated Transformations • Microbial Competition/Predation • Biological Uptake • Solar Irradiation • Volume loss (via infiltration, ET)	H	M	M	M	M	H	M	H
Proprietary Biotreatment and Treatment Control	• Varies by product.	Expected performance should be based on evaluation of unit processes provided by BMP and available testing data. Approval is based on the discretion of the reviewing agency.							

Sources

Strecker, E.W ., W.C Huber, J.P. Heaney, D. Bodine, J.J. Sansalone, M.M. Quigley, D. Pankani, M. Leisenring, and P. Thayumanavan, "Critical assessment of Stormwater Treatment and Control Selection Issues." Water Environment Research Federation, Report No. 02-SW-1. ISBN 1-84339-741-2. 290pp

International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary: Bacteria. http://www.bmpdatabase.org/Docs/BMP%20Database%20Bacteria%20Paper%20Dec%202010.pdf

International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary: Nutrients. http://www.bmpdatabase.org/Docs/BMP%20Database%20Nutrients%20Paper%20December%202010%20Final.pdf

International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary: Sediment (Pre-publication).

Overview of Performance by BMP Category and Common Pollutant Type, International Stormwater Best Management Practices (BMP) Database [1998-2008] http://www.bmpdatabase.org/Docs/Performance%20Summary%20Cut%20Sheet%20June%202008.pdf

Oil and grease, Organics, and Trash and Debris based on review of unit operations and processes; comprehensive dataset not generally available. BMP must include design elements to address pollutants of concern.

Table 4.3 Relative Treatment Performance Ratings of Treatment Control BMPs

Unit Operations and Process	Assumed Principal Unit Operations and Processes Provided	Suspended solids / sediment/ turbidity	Nitrogen compounds	Phosphorus	Heavy metals	Microbial / viral pathogens	Oils and grease	Dissolved toxic organic compounds	Trash and debris
Sand Filter (inert)	• Size Exclusion • Floatable Capture • Inert Media Filtration	H	L	M	L\M	M	H	L	H
Sand Filter (specialized Media)	Sand Filter UOPs, plus: • Sorption/Ion Exchange	H	L	M	M/H	M	H	M	H
Cartridge Media Filter	• Size Exclusion • Floatable Capture • Inert Media Filtration • Sorption/Ion Exchange	M	L	M	M	M	H	M	H
Hydrodynamic Separator	• Particulate Settling (coarse only) • Size Exclusion • Floatable Capture	M	L	L	L	L	M	L	H
Catch Basin Insert	• Size Exclusion	L	L	L	L	L	M	L	H

Sources

Strecker, E.W ., W.C Huber, J.P. Heaney, D. Bodine, J.J. Sansalone, M.M. Quigley, D. Pankani, M. Leisenring, and P. Thayumanavan, "Critical assessment of Stormwater Treatment and Control Selection Issues." Water Environment Research Federation, Report No. 02-SW-1. ISBN 1-84339-741-2. 290pp

International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary: Bacteria. **http://www.bmpdatabase.org/Docs/BMP%20Database%20Bacteria%20Paper%20Dec%202010.pdf**

International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary: Nutrients. **http://www.bmpdatabase.org/Docs/BMP%20Database%20Nutrients%20Paper%20December%202010%20Final.pdf**

International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary: Sediment (Pre-publication).

Overview of Performance by BMP Category and Common Pollutant Type, International Stormwater Best Management Practices (BMP) Database [1998-2008] **http://www.bmpdatabase.org/Docs/Performance%20Summary%20Cut%20Sheet%20June%202008.pdf**

Oil and grease, Organics, and Trash and Debris based on review of unit operations and processes; comprehensive dataset not generally available. BMP must include design elements to address pollutants of concern.

Table 4.4 Pollutants Address by Unit Operations and Processes

Unit Operations and Process	Suspended solids / sediment	Particulate-bound pollutants	Dissolved Fraction			Microbial / viral pathogens	Oils and grease	Toxic organic compounds	Trash and debris
			Nitrogen compounds	Phosphorus	Heavy metals				
Volume Loss (via Infiltration and ET)	X	X	X	X	X	X	X	X	
Particulate Settling (Density separation)	X	X							X
Size exclusion (trash racks, outlet structures. Media filtration)	X	X							X
Floatable Capture (Density separation -outlet structures designed to remove floatables)							X		X
Vegetative Filtration	X	X					X		X
Inert Media Filtration	X	X			X[1]	X	X		X
Sorption/Ion Exchange within media or soils				X	X		X	X	
Microbially Mediated Transformation (oxidation, reduction, or facultative processes)			X	X	X		X	X	
Microbial Competition/ Predation						X			
Biological Uptake			X	X	X	X	X	X	
Solar Irradiation						X		X	

1 – Inert media filters (i.e. sand) in fact have shown the ability to remove dissolved constituents either after they have been "seasoned" (i.e. organics have built up in the media) or they contain specialized inorganic media (e.g., iron coated sand) which can result in dissolved metals removals.

Principal Source

Strecker, E.W ., W.C Huber, J.P. Heaney, D. Bodine, J.J. Sansalone, M.M. Quigley, D. Pankani, M. Leisenring, and P. Thayumanavan, "Critical assessment of Stormwater Treatment and Control Selection Issues." Water Environment Research Federation, Report No. 02-SW-1. ISBN 1-84339-741-2. 290pp

SECTION 5. HYDROMODIFICATION CONTROL DESIGN

5.1. Introduction

This section describes methods of designing systems to address HCOCs. HCOCs are defined differently in the North and South Orange County permits and therefore different approaches are required for designing systems to address HCOCs. Hydromodification control refers to the methods used to address HCOCs and in the context of this TGD, the term hydromodification is interchangeable with HCOCs.

5.2. Hydromodification Control Concepts

The physical response of stream channels to changes in catchment runoff and sediment yield caused by land use modifications is referred to as hydromodification. Unless managed, hydromodification can cause channel erosion, migration, or sedimentation, as well as biologic impacts to streams. Such impacts may be associated with impairment of beneficial uses and degradation of stream condition.

Control approaches have evolved over time, with efforts first focused on managing peak flows and then on matching the peak, volume, and timing of an event hydrograph. The current understanding is that the long term frequency, magnitude, and durations of the range of sediment transporting flows needs to be managed. This can be accomplished through the use of structural BMPs designed to control the duration, frequency, and magnitude of the entire hydrograph from the project (i.e., flow duration control). In-stream measures, such as grade control structures, can also be used to prevent excess erosion due to increased flow durations. In-stream measures are desirable where stream channels are already degraded due to hydromodification caused by existing development.

There are various alternatives for siting hydromodification control measures, including on-site, regional, and in-stream (described later in this section); each of which has advantages and disadvantages. The choice of control measure siting will be strongly determined by site-specific considerations, including existing stream conditions, local development patterns, permitting requirements, and future growth plans.

Control measure sizing is also highly influenced by local characteristics including rainfall, climate, soils, topography, geology, and stream type. These factors determine the extent to which development changes the natural hydrologic processes and the potential for stream impacts. Therefore, hydromodification management requires a suite of strategies that are tailored to local circumstances and stream conditions.

Maintenance is key to sustaining the performance of hydromodification control measures and these concerns will factor into decisions on control measure siting and the implementation of easements or maintenance agreements between municipalities and property owners.

5.3. System Design to Address HCOCs in North Orange County

This section describes an approach for developing a hydromodification control design to address HCOCs in the North Orange County permit area. This section is intended to be used following the LID and treatment control system design process. The LID and treatment control system design process requires on-site retention and biotreatment to the extent feasible, followed by consideration of off-site LID options and treatment controls.

Figure 5.1 illustrates the general approach for developing a hydromodification control design to address HCOCs in the North Orange County permit area.

5.3.1. Determine Whether HCOCs Exist

HCOCs in the North Orange County permit area can be mitigated by to managing runoff such that the post-development runoff volume for the 2-year, 24-hr storm event ($V_{2\text{-yr, POST}}$) does not exceed that of the pre-development condition ($V_{2\text{-yr, PRE}}$) by more than 5%. This can be expressed as:

$$(V_{2\text{-yr, POST}} / V_{2\text{-yr, PRE}}) \leq 1.05$$

The post-development time of concentration (T_c) must also be managed such that:

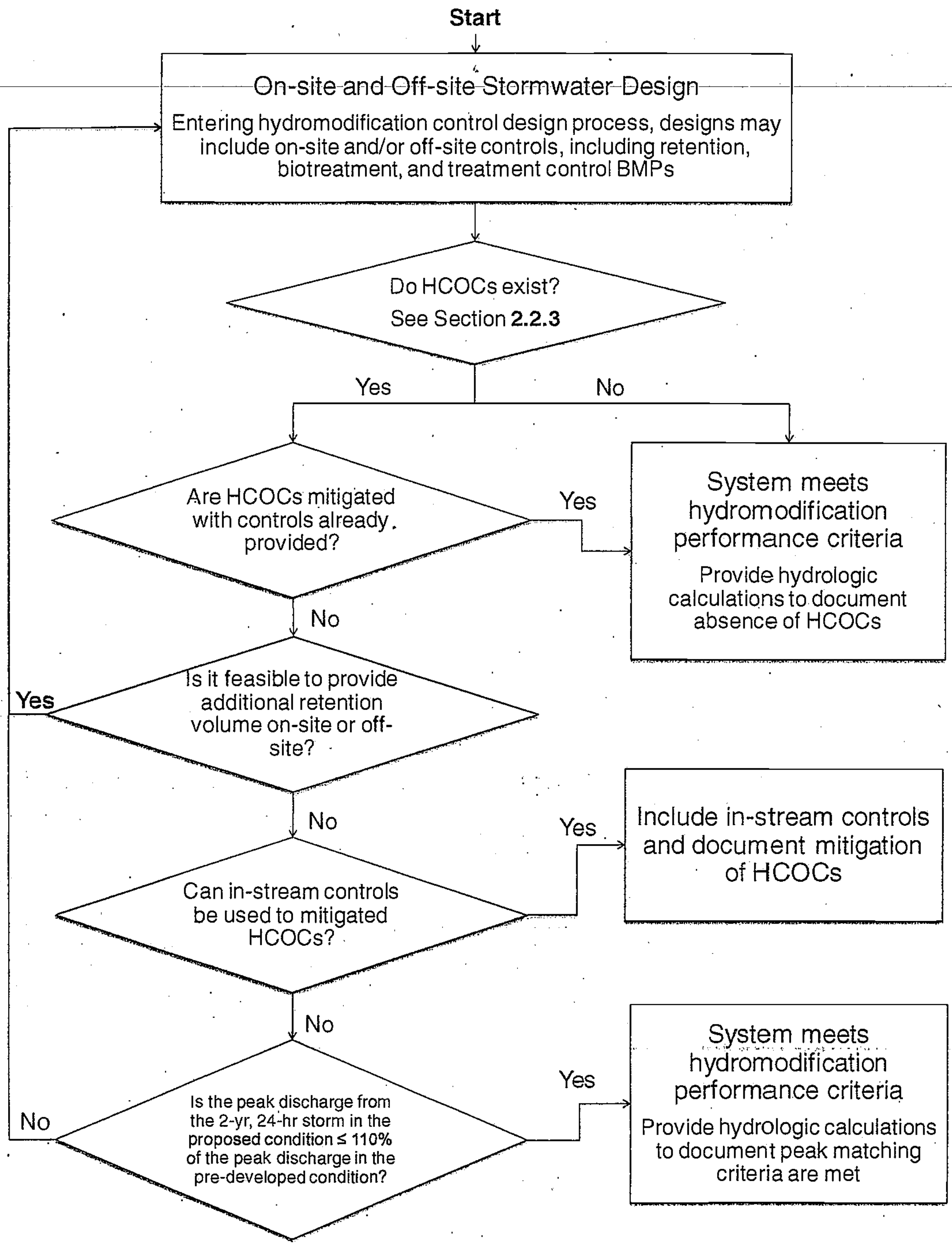
$$(Tc_{2\text{-yr, POST}} / Tc_{2\text{-yr, PRE}}) \leq 1.05 \text{ (See } \textbf{Footnote 4}\text{)}$$

Site design, HSCs, LID BMPs, and treatment control BMPs will contribute to meeting hydromodification control requirements. The volume of runoff retained in LID BMPs serves to reduce $V_{2\text{-yr, POST}}$ and increase $Tc_{2\text{-yr, POST}}$ compared to post-developed conditions without stormwater controls.

The LID and treatment control BMPs selected for the project should be evaluated using the hydrologic methods described in Appendix IV to evaluate the above criteria. In order to achieve their intended function, hydromodification control BMPs must be able to accept runoff from sequential storm events. Therefore, if BMPs draw down in greater than 48 hours, only the portion of the system volume that drains in 48 hours may be counted as retained for the purpose of hydromodification control volume matching calculations. This is a simplified method of accounting for the recovery rate of BMPs that could be refined as part of a project-specific hydrologic analysis.

If the results indicate that HCOCs do not exist, then hydromodification requirements are met. The Project WQMP should document these calculations.

Figure 5.1. North Orange County Hydromodification Design Process



The compliance point for assessment of pre- and post-development runoff volume and time of concentration is located where runoff leaves the project site. However, the project proponent may use this same assessment technique for a point of compliance further downstream as part of a geomorphically-based project-specific evaluation of whether the project will adversely impact downstream erosion, sedimentation, or stream habitat. For example, if a site is mapped as potentially having a HCOC, but the nearest susceptible channel segment is miles downstream, then the hydromodification impact due to developing the site may be that the project adds negligible amounts of flow to the tail ends of the receiving water's hydrograph and would not result in significant increase in peak flow or significant decrease time of concentration, rendering hydrologic impacts negligible In this case, it would be appropriate to use a point of analysis located at the nearest susceptible channel for the geomorphically-based impact evaluation. An analysis of the cumulative impacts from other developments that may occur concurrently or in the future may be required for projects as part of the CEQA process.

The rigor of the hydrologic assessment documented in the Project WQMP should be commensurate to the magnitude of potential impacts. If the project would clearly not have significant impacts on the nearest susceptible channel, then a relatively simple hydrologic analysis may be sufficient to demonstrate that HCOCs do not exist.

If HCOCs still exist, then the project proceeds to the next step.

5.3.2. Evaluate Additional On-site and Off-site Controls

The Project WQMP should consider increasing the size of on-site and off-site controls to attempt to meet the volume- and time of concentration-matching criteria expressed in **Section 5.3.1**.

If additional volume can be provided, the project should return to the system design phase and modify designs to add this volume. If additional volume cannot be provided, then the project proceeds to the next step. One could also consider multiple objectives that include HCOCs at the outset of the overall design process to reduce the need for design iterations.

5.3.3. Site Specific Evaluation of In-stream Control Options

A site specific evaluation may be conducted to determine whether opportunity exists to mitigate potential impacts through in-stream controls. The site specific evaluation may find that in-stream controls can be feasibly implemented in combination with on-site and regional controls such that the project will not adversely impact downstream erosion, sedimentation, or stream habitat. If this finding is made, in-stream controls may be designed and included in the Project WQMP along with documentation demonstrating that the project and proposed system will not adversely impact downstream erosion, sedimentation, or stream habitat. This approach, including its effectiveness in addressing HCOCs and the environmental impacts of any in-stream controls must be analyzed by the local jurisdiction pursuant to CEQA and the necessary permits from regulatory agencies must be obtained. The use of instream controls is generally more applicable as part of a watershed-based plan that for a single development project.

5.3.4. Provide Peak Design for Peak Matching

Where the Project WQMP documents that the excess runoff volume from the 2-yr runoff event cannot feasibly be retained, the project must implement on-site or regional hydromodification controls to:

- Retain the excess volume from the 2-yr runoff event to the MEP.
- Reduce post-development runoff 2-yr peak flow rate to no greater than 110% of the pre-development runoff 2-yr peak flow rate.

Hydrologic calculations demonstrating satisfaction of peak matching criteria should be based on methods described in Appendix IV. If the system as proposed cannot satisfy this criterion, the project must return to the system design phase and make the changes necessary such that this criterion is met.

5.4. System Design to Address HCOCs in South Orange County

A separate guidance document and BMP sizing tool has been prepared for implementation of the Interim Hydromodification Control Criteria in the South Orange County Permit: *Technical Guidance Document For The South Orange County Hydromodification Control BMP Sizing Tool* (provided in Appendix V). A Hydromodification Management Plan will be available for South Orange County in December 2011.

5.5. Hydromodification Control BMPs

5.5.1. On-Site / Distributed Controls

A variety of volume / flow management structural BMPs are available that utilize the following two basic principles:

- Detain runoff and release it in a controlled way that either mimics pre-development flow rates and durations or reduces flow rates and durations to account for a reduction in sediment supply.
- Manage excess runoff volumes through one or more of the following pathways: infiltration, ET, storage and use, discharge at a rate below the critical rate for adverse impact, or discharge downstream to a non-susceptible water body.

Distributed facilities are small scale facilities, typically treating runoff from less than ten acres. These types of facilities include, but are not limited to, bioretention areas, permeable pavement, green roofs, cisterns, vegetated swales, and filter strips. These types of facilities will also help to achieve the LID performance standard.

Design guidance for on-site controls LID BMPs and treatment control BMPs are provided in **Section 4**.

5.5.2. Detention/Retention Basins

Detention/retention basins are stormwater management facilities that are designed to detain and infiltrate runoff from one or multiple projects or project areas. These basins are typically shallow with flat, vegetated bottoms. Detention/retention basins can be constructed by either excavating a depression or building a berm to create above ground storage, such that runoff can drain into the basin by gravity. Runoff is stored in the basin as well as in the pore spaces of the surface soils. Pretreatment BMPs such as swales, filter strips, and sedimentation forebays minimize fine sediment loading to the basins, thereby reducing maintenance frequencies.

Detention/retention basins for hydromodification management incorporate outlet structures designed for flow duration control. These basins can also be designed to support flood control and water quality treatment objectives in addition to hydromodification. If underlying soils are not suitable for infiltration, the basin may be designed for flow detention only, with alternative practices to manage increased volumes, such as storage and use, discharge at a rate below the critical rate for adverse impacts, or discharge to a non-susceptible water body.

Detention/retention basins should be designed to receive flows from developed areas only, for both design optimization as well as to avoid intercepting coarse sediments from open spaces that should ideally be passed through to the stream channel. Reduction in coarse sediment loads contributes to downstream channel instability.

5.5.3. In-Stream Controls

Hydromodification management can also be achieved by in-stream controls, including drop structures, bed and bank reinforcement, and grade control structures.

5.5.3.1. Drop Structures

Drop structures are designed to reduce the channel slope, thereby reducing the shear stresses generated by stream flows. These controls can be incorporated as natural appearing rock structures with a step-pool design which allows drop energy to be dissipated in the pools while providing a reduced longitudinal slope between structures.

5.5.3.2. Grade Control Structures

Grade control structures are designed to maintain the existing channel slope while allowing for minor amounts of local scour. These control measures are often buried and would entail a narrow trench across the width of the stream backfilled with concrete or similar material, as well as the creation of a "plunge pool" feature on the downstream side of the sill by placing boulders and vegetation. A grade control option provides a reduced footprint and impact compared to drop structures, which are designed to alter the channel slope.

5.5.3.3. Bed and Bank Reinforcement

Channel reinforcement serves to increase bed and bank resistance to stream flows. In addition to conventional techniques such as riprap and concrete, a number of vegetated approaches are increasingly utilized, including products such as vegetated reinforcement mats. This technology provides erosion control with an open-weave material that stabilizes bed and bank surfaces and allows for re-establishment of native plants, which serves to further increase channel stability.

SECTION 6. SOURCE CONTROL MEASURES

This section provides guidance on the selection and design of structural source control measures.

6.1. Introduction

Source Control BMPs reduce the potential for stormwater runoff and pollutants from coming into contact with one another. Source Control BMPs are defined as any administrative action, design of a structural facility, usage of alternative materials, and operation, maintenance, inspection, and compliance of an area to eliminate or reduce stormwater pollution. Each new development and significant redevelopment project is required to implement appropriate Source Control BMP(s) pursuant to Section 2.4.5 of the Model WQMP.

Applicable Source Control BMPs (which includes subcategories of routine non-structural BMPs, routine structural BMPs and BMPs for individual categories/project features) are required to be incorporated into all new development and significant redevelopment projects regardless of their priority, including those identified in an applicable regional or watershed program, unless they do not apply due to the project characteristics. California Stormwater Quality Association (CASQA) BMP Fact Sheet numbers are included in parentheses where applicable.

6.2. Non-Structural Measures

N1 Education for Property Owners, Tenants and Occupants

For developments with no Property Owners Association (POA) or with POAs of less than fifty (50) dwelling units, practical information materials will be provided to the first residents/occupants/tenants on general housekeeping practices that contribute to the protection of stormwater quality. These materials will be initially developed and provided to first residents/occupants/tenants by the developer. Thereafter such materials will be available through the Permittees' education program. Different materials for residential, office commercial, retail commercial, vehicle-related commercial and industrial uses will be developed.

For developments with POA and residential projects of more than fifty (50) dwelling units, project conditions of approval will require that the POA periodically provide environmental awareness education materials, made available by the municipalities, to all of its members. Among other things, these materials will describe the use of chemicals (including household type) that should be limited to the property, with no discharge of wastes via hosing or other direct discharge to gutters, catch basins and storm drains. Educational materials available from the County of Orange can be downloaded here:
http://www.ocwatersheds.com/PublicEd/resources/default.aspx

N2 Activity Restrictions

If a POA is formed, conditions, covenants and restrictions (CCRs) must be prepared by the developer for the purpose of surface water quality protection. An example would be not allowing car washing outside of established community car wash areas in multi-unit complexes. Alternatively, use restrictions may be developed by a building operator through lease terms, etc. These restrictions must be included in the Project WQMP.

N3 (SC-73) Common Area Landscape Management

Identify on-going landscape maintenance requirements that are consistent with those in the County Water Conservation Resolution (or city equivalent) that include fertilizer and/or pesticide usage consistent with Management Guidelines for Use of Fertilizers (DAMP Section 5.5). Statements regarding the specific applicable guidelines must be included in the Project WQMP.

N4 BMP Maintenance

The Project WQMP shall identify responsibility for implementation of each non-structural BMP and scheduled cleaning and/or maintenance of all structural BMP facilities.

N5 Title 22 CCR Compliance

Compliance with Title 22 of the California Code of Regulations (CCR) and relevant sections of the California Health & Safety Code regarding hazardous waste management is enforced by County Environmental Health on behalf of the State. The Project WQMP must describe how the development will comply with the applicable hazardous waste management section(s) of Title 22.

N6 Local Water Quality Permit Compliance

The Permittees, under the Water Quality Ordinance, may issue permits to ensure clean stormwater discharges from fuel dispensing areas and other areas of concern to public properties.

N7 (SC-11) Spill Contingency Plan

A Spill Contingency Plan is prepared by building operator or occupants for use by specified types of building or suite occupancies. The Spill Contingency Plan describes how the occupants will prepare for and respond to spills of hazardous materials. Plans typically describe stockpiling of cleanup materials, notification of responsible agencies, disposal of cleanup materials, documentation, etc.

N8 Underground Storage Tank Compliance

Compliance with State regulations dealing with underground storage tanks, enforced by County Environmental Health on behalf of State.

N9 Hazardous Materials Disclosure Compliance

Compliance with Permittee ordinances typically enforced by respective fire protection agencies for the management of hazardous materials. The Orange County, health care agencies, and/or other appropriate agencies (i.e., Department of Toxics Substances Control) are typically responsible for enforcing hazardous materials and hazardous waste handling and disposal regulations.

N10 Uniform Fire Code Implementation

Compliance with Article 80 of the Uniform Fire Code enforced by fire protection agency.

N11 (SC-60) Common Area Litter Control

For industrial/commercial developments and for developments with POAs, the owner/POA should be required to implement trash management and litter control procedures in the common areas aimed at reducing pollution of drainage water. The owner/POA may contract with their landscape maintenance firms to provide this service during regularly scheduled maintenance, which should consist of litter patrol, emptying of trash receptacles in common areas, and noting trash disposal violations by tenants/homeowners or businesses and reporting the violations to the owner/POA for investigation.

N12 Employee Training

Education program (see N1) as it would apply to future employees of individual businesses. Developer either prepares manual(s) for initial purchasers of business site or for development that is constructed for an unspecified use makes commitment on behalf of POA or future business owner to prepare. An example would be training on the proper storage and use of fertilizers and pesticides, or training on the implementation of hazardous spill contingency plans.

N13 (SD-31) Housekeeping of Loading Docks

Loading docks typically found at large retail and warehouse-type commercial and industrial facilities should be kept in a clean and orderly condition through a regular program of sweeping and litter control and immediate cleanup of spills and broken containers. Cleanup procedures should minimize or eliminate the use of water if plumed to the storm sewer. If wash water is used, it must be disposed of in an approved manner and not discharged to the storm drain system. If there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered only if allowed by the local sewerage agency through a permitted connection.

N14 (SC-74) Common Area Catch Basin Inspection

For industrial/commercial developments and for developments with privately maintained drainage systems, the owner is required to have at least 80 percent of drainage facilities inspected, cleaned and maintained on an annual basis with 100 percent of the facilities included in a two-year period. Cleaning should take place in the late summer/early fall prior to the start of the rainy season. Drainage facilities include catch basins (storm drain inlets) detention basins, retention basins, sediment basins, open drainage channels and lift stations. Records should be kept to document the annual maintenance.

N15 (SC-43, SC-70) Street Sweeping Private Streets and Parking Lots

Streets and parking lots are required to be swept prior to the storm season, in late summer or early fall, prior to the start of the rainy season or equivalent as required by the governing jurisdiction.

N16 (SD-30, SC-20) Retail Gasoline Outlets

Retail gasoline outlets (RGOs) are required to follow the guidelines of this TGD and Model WQMP and non-structural source control operations and maintenance BMPs shown in the CASQA Structural Source Control Fact Sheet SD-30, and Non-structural Source Control Fact Sheet (SC-20).

Other Non-structural Measures for Public Agency Projects

As required by the Model WQMP other non-structural measures shall be implemented and included in the Project WQMP as applicable for new public agency Priority Projects as described in the Municipal Activity fact sheets **http://www.ocwatersheds.com/MunicipalActivities.aspx**. These include BMPs FF-1 through FF-13 for Fixed Facilities and DF-1 for Drainage Facilities. These are listed in **Section 6.4**, below.

6.3. Structural Measures

The following measures are applicable to all project types. CASQA BMP Fact Sheet numbers are included in parentheses where applicable; these fact sheets provide further detail on these BMPs.

S1 (SD-13) Provide Storm Drain System Stenciling and Signage

Storm drain stencils are highly visible source control messages, typically placed directly adjacent to storm drain inlets. The stencils contain a brief statement that prohibits the dumping of improper materials into the municipal storm drain system. Graphical icons, either illustrating anti-dumping symbols or images of receiving water fauna, are effective supplements to the anti-dumping message. Stencils and signs alert the public to the destination of pollutants discharged into stormwater. The following requirements should be included in the project design and shown on the project plans:

1. Provide stenciling or labeling of all storm drain inlets and catch basins, constructed or modified, within the project area with prohibitive language (such as: "NO DUMPING-DRAINS TO OCEAN") and/or graphical icons to discourage illegal dumping.
2. Post signs and prohibitive language and/or graphical icons, which prohibit illegal dumping at public access points along channels and creeks within the project area.

3. Maintain legibility of stencils and signs.

See CASQA Stormwater Handbook BMP Fact Sheet SD-13 for additional information.

S2 (SD-34) Design Outdoor Hazardous Material Storage Areas to Reduce Pollutant Introduction

Improper storage of materials outdoors may increase the potential for toxic compounds, oil and grease, fuels, solvents, coolants, wastes, heavy metals, nutrients, suspended solids, and other pollutants to enter the municipal storm drain system. Where the plan of development includes outdoor areas for storage of hazardous materials that may contribute pollutants to the municipal storm drain system, or include transfer areas where incidental spills often occur, the following stormwater BMPs are required:

1. Hazardous materials with the potential to contaminate urban runoff shall either be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with storm water or spillage to the municipal storm drain system; or (2) protected by secondary containment structures (not double wall containers) such as berms, dikes, or curbs.
2. The storage area shall be paved and sufficiently impervious to contain leaks and spills.
3. The storage area shall have a roof or awning to minimize direct precipitation and collection of stormwater within the secondary containment area.
4. Any stormwater retained within the containment structure must not be discharged to the street or storm drain system.
5. Location(s) of installations of where these preventative measures will be employed must be included on the map or plans identifying BMPs.

See CASQA Stormwater Handbook Section 3.2.6 and BMP Fact Sheet SD-34 for additional information.

S3 (SD-32) Design Trash Enclosures to Reduce Pollutant Introduction

Design trash storage areas to reduce pollutant introduction. All trash container areas shall meet the following requirements (limited exclusion: detached residential homes):

1. Paved with an impervious surface, designed not to allow run-on from adjoining areas, designed to divert drainage from adjoining roofs and pavements diverted around the area, screened or walled to prevent off-site transport of trash; and
2. Provide solid roof or awning to prevent direct precipitation.

Connection of trash area drains to the municipal storm drain system is prohibited.

Potential conflicts with fire code and garbage hauling activities should be considered in implementing this source control.

See CASQA Stormwater Handbook Section 3.2.9 and BMP Fact Sheet SD-32 for additional information.

S4 (SD-12) Use Efficient Irrigation Systems and Landscape Design

Projects shall design the timing and application methods of irrigation water to minimize the runoff of excess irrigation water into the municipal storm drain system. (Limited exclusion: detached residential homes.) The following methods to reduce excessive irrigation runoff shall be considered, and incorporated on common areas of development and other areas where determined applicable and feasible by the Permittee:

1. Employing rain shutoff devices to prevent irrigation after precipitation.
2. Designing irrigation systems to each landscape area's specific water requirements.
3. Using flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.
4. Implementing landscape plan consistent with County Water Conservation Resolution or city equivalent, which may include provision of water sensors, programmable irrigation times (for short cycles), etc.
5. The timing and application methods of irrigation water shall be designed to minimize the runoff of excess irrigation water into the municipal storm drain system.
6. Employing other comparable, equally effective, methods to reduce irrigation water runoff.
7. 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 other design features, such as:

    - Use mulches (such as wood chips or shredded wood products) in planter areas without ground cover to minimize sediment in runoff.
    - Install appropriate plant materials for the location, in accordance with amount of sunlight and climate, and use native plant material where possible and/or as recommended by the landscape architect.
    - Leave a vegetative barrier along the property boundary and interior watercourses, to act as a pollutant filter, where appropriate and feasible.
    - Choose plants that minimize or eliminate the use of fertilizer or pesticides to sustain growth.

Irrigation practices shall comply with local and statewide ordinances related to irrigation efficiency.

S5 Protect Slopes and Channels

Projects shall protect slopes and channels as described in **Section 3.4** of this TGD.

S6 (SD-31) Loading Dock Areas

Loading / unloading dock areas shall include the following:

1. Cover loading dock areas, or design drainage to preclude run-on and runoff, unless the material loaded and unloaded at the docks does not have potential to contribute to stormwater pollution, and this use is ensured for the life of the facility.
2. Direct connections to the municipal storm drain system from below grade loading docks (truck wells) or similar structures are prohibited. Stormwater can be discharged through a permitted connection to the storm drain system with a treatment control BMP applicable to the use.
3. Other comparable and equally effective features that prevent unpermitted discharges to the municipal storm drain system.
4. Housekeeping of loading docks shall be consistent with N13.

See CASQA Stormwater Handbook Section 3.2.8 for additional information.

S7 (SD-31) Maintenance Bays

Maintenance bays shall include the following:

1. Repair/maintenance bays shall be indoors; or, designed to preclude urban run-on and runoff in an equally effective manner.
2. Design a repair/maintenance bay drainage system to capture all wash water, leaks and spills. Provide impermeable berms, drop inlets, trench catch basins, or overflow containment structures around repair bays to prevent spilled materials and wash-down waters from entering the storm drain system. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the municipal storm drain system is prohibited. If there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered only if allowed by the local sewerage agency through permitted connection.

Other features which are comparable and equally effective that prevent discharges to the municipal storm drain system without appropriate permits.

See CASQA Stormwater Handbook Fact Sheet SD-31 for additional information.

S8 (SD-33) Vehicle Wash Areas

Projects that include areas for washing / steam cleaning of vehicles shall use the following:

1. Self-contained or covered with a roof or overhang.
2. Equipped with a wash racks, and with the prior approval of the sewerage agency (Note: Discharge monitoring may be required by the sewerage agency).
3. Equipped with a clarifier or other pretreatment facility.
4. If there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered only allowed by the local sewerage agency through permitted connection. Alternately, non-storm water discharges may require a separate NPDES

permit in order to discharge to the MS4. Some local jurisdictions also have permitting systems in place for these situations.

5. Other features which are comparable and equally effective that prevent unpermitted discharges, to the municipal storm drain system.

See CASQA Stormwater Handbook Sections 3.2.7 and 3.2.10 and Fact Sheet SD-33 for additional information.

S9 (SD-36) Outdoor Processing Areas

Outdoor process equipment operations, such as rock grinding or crushing, painting or coating, grinding or sanding, degreasing or parts cleaning, landfills, waste piles, and wastewater and solid waste handling, treatment, and disposal, and other operations determined to be a potential threat to water quality by the Permittee shall adhere to the following requirements.

1. Cover or enclose areas that would be the sources of pollutants; or, slope the area toward a sump that will provide infiltration or evaporation with no discharge; or, if there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered only allowed by the local sewerage agency through permitted connection.
2. Grade or berm area to prevent run-on from surrounding areas.
3. Installation of storm drains in areas of equipment repair is prohibited.
4. Other features which are comparable or equally effective that prevent unpermitted discharges to the municipal storm drain system.
5. Where wet material processing occurs (e.g. Electroplating), secondary containment structures (not double wall containers) shall be provided to hold spills resulting from accidents, leaking tanks or equipment, or any other unplanned releases (Note: If these are plumbed to the sanitary sewer, the structures and plumbing shall be in accordance with Section 7.II - 8, Attachment D, and with the prior approval of the sewerage agency). Design of secondary containment structures shall be consistent with "Design of Outdoor Material Storage Areas to Reduce Pollutant Introduction".

Some of these land uses (e.g. landfills, waste piles, wastewater and solid waste handling, treatment and disposal) may be subject to other permits including Phase I Industrial Permits that may require additional BMPs.

See CASQA Stormwater Handbook Section 3.2.5 for additional information.

S10 Equipment Wash Areas

Outdoor equipment/accessory washing and steam cleaning activities shall use the following:

1. Be self-contained or covered with a roof or overhang.
2. Design an equipment wash area drainage system to capture all wash water. Provide impermeable berms, drop inlets, trench catch basins, or overflow containment structures around equipment wash areas to prevent wash -down waters from entering the storm

drain system. Connect drains to a sump for collection and disposal. Discharge from equipment wash areas to the municipal storm drain system is prohibited. If there are no other alternatives, discharge of non-stormwater flow to the sanitary sewer may be considered, but only when allowed by the local sewerage agency through a permitted connection.

3. Other comparable or equally effective features that prevent unpermitted discharges to the municipal storm drain system.

S11 (SD-30) **Fueling Areas**

Fuel dispensing areas shall contain the following:

1. At a minimum, the fuel dispensing area must extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.
2. The fuel dispensing area shall be paved with Portland cement concrete (or equivalent smooth impervious surface). The use of asphalt concrete shall be prohibited.
3. The fuel dispensing area shall have an appropriate slope (2% - 4%) to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of stormwater.
4. An overhanging roof structure or canopy shall be provided. The cover's minimum dimensions must be equal to or greater than the area of the fuel dispensing area in the first item above. The cover must not drain onto the fuel dispensing area and the downspouts must be routed to prevent drainage across the fueling area. The fueling area shall drain to the project's Treatment Control BMP(s) prior to discharging to the municipal storm drain system.

See CASQA Stormwater Handbook Section 3.2.11 and BMP Fact Sheet SD-30 for additional information.

S12 (SD-10) **Site Design and Landscape Planning (Hillside Landscaping)**

Hillside areas that are disturbed by project development shall be landscaped with deep-rooted, drought tolerant plant species selected for erosion control, satisfactory to the local permitting authority.

S13 Wash Water Controls for Food Preparation Areas

Food establishments (per State Health & Safety Code 27520) shall have either contained areas or sinks, each with sanitary sewer connections for disposal of wash waters containing kitchen and food wastes. If located outside, the contained areas or sinks shall also be structurally covered to prevent entry of stormwater. Adequate signs shall be provided and appropriately placed stating the prohibition of discharging washwater to the storm drain system.

S14 Community Car Wash Racks

In complexes larger than 100 dwelling units where car washing is allowed, a designated car wash area that does not drain to a storm drain system shall be provided for common usage.

Wash waters from this area may be directed to the sanitary sewer (with the prior approval of the sewerage agency); to an engineered infiltration system; or to an equally effective alternative. Pre-treatment may also be required.

6.4. Municipal Non-Structural Source Control Measures

The following measures are applicable to fixed facility municipal projects such as maintenance yards, schools, and libraries. Generally, these controls are more applicable to municipal projects than the fact sheets contained in **Section 6.2**, however other structural and nonstructural controls described in **Section 6.2** and **6.3** shall be used where applicable. The links below contain the most recent versions of the Fixed Facility fact sheets, which can also be found at http://www.ocwatersheds.com/MunicipalActivities.aspx.

- FF-1, Bay/Harbor Activities
- FF-2, Building Maintenance and Repair
- FF-3 Equipment Maintenance and Repair
- FF-4, Fueling
- FF-5, Landscape Maintenance
- FF-6, Material Loading and Unloading
- FF-7, Material Storage, Handling, and Disposal
- FF-8, Minor Construction
- FF-9, Parking Lot Maintenance
- FF-10, Spill Prevention and Control
- FF-11, Vehicle and Equipment Cleaning
- FF-12, Vehicle and Equipment Storage
- FF-13, Waste Handling and Disposal

SECTION 7. OPERATION AND MAINTENANCE PLANNING

The sustained performance of BMPs over time depends on ongoing and proper maintenance. In order for this to occur, detailed operation and maintenance plans are needed that include specific maintenance activities and frequencies for each type of BMP. In addition, these should include indicators for assessing when "as needed" maintenance activities are required.

Requirements for operations and maintenance (O&M) planning are described in Section 4.0 of the Model WQMP. Maintenance agreements are one of the available tools described in this section.

This section provides guidance for the components of an effective maintenance agreement and provides references to published BMP maintenance guidelines.

7.1. How to Develop Maintenance Agreements

Maintenance agreements can be an effective tool for ensuring long-term maintenance of on-site BMPs. The most important aspect of creating these maintenance agreements is to clearly define the responsibilities of each party entering into the agreement. Basic language that should be incorporated into an agreement includes the following:

1. Performance of Routine Maintenance

Local governments often find it easier to have a property owner perform all maintenance according to the requirements of a Design Manual. Other communities require that property owners do aesthetic maintenance (i.e., mowing, vegetation removal) and implement Pollution Prevention Plans, but elect to perform structural maintenance and sediment removal themselves.

2. Maintenance Schedules

Maintenance requirements may vary, but usually governments require that all BMP owners perform at least an annual inspection and document that the maintenance and repairs are performed. An annual report must then be submitted to the government, who will to perform an inspection of the facility at a frequency specified in the Permit.

3. Inspection Requirements

Local governments may obligate themselves to perform an annual inspection of a BMP, or may choose to inspect when deemed necessary instead. Local governments may also wish to include language allowing maintenance requirements to be increased if deemed necessary to ensure proper functioning of the BMP.

4. Access to BMPs

The agreement should grant permission to a local government or its authorized agent to enter onto property to inspect BMPs. If deficiencies are noted, the government should then provide a copy of the inspection report to the property owner and provide a timeline for repair of these deficiencies.

5. Failure to Maintain

In the maintenance agreement, the government should repeat the steps available for addressing a failure to maintain situation. Language allowing access to BMPs cited as not properly maintained is essential, along with the right to charge any costs for repairs back to the property owner. The government may wish to include deadlines for repayment of maintenance costs, and provide for liens against property up to the cost of the maintenance plus interest.

6. Recording of the Maintenance Agreement

An important aspect to the recording of the maintenance agreement is that the agreement be recorded into local deed records. This helps ensure that the maintenance agreement is bound to the property in perpetuity.

Finally, some communities elect to include easement requirements into their maintenance agreements. While easement agreements are often secured through a separate legal agreement, recording public access easements for maintenance in a maintenance agreement reinforces a local government's right to enter and inspect a BMP. Examples of maintenance agreements include several available on the web at **http://www.stormwatercenter.net/**

7.2. How to Develop BMP Maintenance Activities

This section provides general guidance for the development of BMP maintenance activities. The following three factors should be considered:

- What maintenance activities are is needed based on BMP design features and operation?
- How frequently should this maintenance be performed, and what conditions should trigger these activities?
- Who are responsible for these activities?

Detailed descriptions of BMP maintenance activities relevant to Southern California are provided in the Los Angeles County Stormwater BMP Operations and Maintenance Manual:

http://dpw.lacounty.gov/DES/design_manuals/StormwaterBMPDesignandMaintenance.pdf

The use of other references are allowed, however care should be taken in the use of published references to ensure that recommendations are appropriate for the Southern California climate.

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<u>Key to Text Colors</u>

Blue = active internal hyperlink

Green = planned future link to other documents

APPENDIX I. SUMMARY OF BMP SIZING REQUIREMENTS FOR NORTH ORANGE COUNTY

The purpose of this appendix is to provide a concise overview of the BMP sizing requirements for Priority Projects in the North Orange County Permit Area. This summary is not intended to supersede the regulatory requirements contained in **Section 2.4 of the Model WQMP** or establish new/additional performance criteria. Rather, this summary is intended to provide functional descriptions of how these requirements are anticipated to be applied in the majority of projects. This summary is organized as follows:

- **Introduction to Integrated Structural BMP Sizing Approach in North Orange County**
- **Overview of Approach for LID BMP Sizing in North Orange County**
- **Overview of Approach for Treatment Control BMP Sizing in North Orange County**
- **Overview of Approach for Addressing HCOCs in North Orange County**
- **Role of HSCs in BMP Sizing**

I.1. Introduction to Integrated Structural BMP Sizing Approach in North Orange County

Priority Projects in the North Orange County Permit Area are required to implement LID, treatment control, and hydromodification control BMPs to achieve numeric performance criteria described in **Section 2.4 of the Model WQMP**. While Priority Projects must demonstrate compliance with LID, treatment control, and hydromodification control requirements separately, these provisions overlap significantly and some BMPs may fulfill or partially fulfill a portion of one or more of these requirements.

The relative role that the LID, treatment control, and hydromodification performance standards have on BMP sizing requirements depends on the existing condition of the site, the receiving water hydromodification susceptibility, and whether the project claims water quality credits. Depending on how these factors combine, different sizing standards will control the sizing of BMPs for the project. The term *stormwater design volume* is used to refer to the controlling sizing standard. This is not a precise term, as it varies from project to project depending on the controlling sizing standard.

Three distinct conditions relative to BMP sizing are anticipated to exist most commonly:

1. HCOC-controlled. This condition applies to projects that discharge to receiving waters susceptible to hydromodification and increase imperviousness such that the difference in runoff volume from the 2-year, 24-hour storm from pre- to post-project is greater than the runoff volume from the 85th percentile storm depth (i.e., the LID Design Capture

Volume, DCV) by at least 5 percent. In this case, the controlling *stormwater design volume* is the difference in the 2-year runoff volume (delta 2-year volume).

Delta 2-yr volume > DCV = WQDV

Design approach: design BMPs to retain the delta 2-yr volume. This will generally address all other applicable sizing criteria.

Alternate path: If full retention of the delta 2-yr volume is not feasible and a treated discharge is required, then select a biotreatment BMP to address pollutants of concern, and design it to treat the remaining DCV to the MEP. Design the biotreatment BMP with sufficient storage volume and hydraulic controls to match the peak flow from the 2-year storm to within 10 percent of the pre-project peak.

2. **DCV-controlled.** This condition applies to projects that do not have susceptible receiving waters, do not increase imperviousness, or increase imperviousness slightly such that the DCV is more than 95 percent of the delta 2-yr volume. In this case, the controlling *stormwater design volume* is the DCV.

DCV = WQDV > Delta 2-yr volume

Design approach: design BMPs to retain the DCV. This will generally address all other applicable sizing criteria.

Contingencies: If full retention is not possible, retain to the MEP, select a biotreatment BMP to address pollutants of concern, and design biotreatment for the remaining DCV to the MEP. Design the biotreatment BMP with sufficient volume and hydraulic controls to match the 2-year peak flow within 10 percent.

3. **Alternative Compliance**. This condition applies to projects that cannot feasibly retain or biotreat the entire DCV and choose to participate in an in-lieu/off-site program for LID. In this case, the water quality design volume or flowrate (WQDV or WQDF) would control the ultimate sizing of BMPs provided upstream of the receiving water.

WQDV > DCV achieved on-site > Delta 2-yr volume achieved on-site

Design approach: After demonstrating the infeasibility of retaining or biotreating the DCV, claim water quality credits as applicable to project. Size treatment control BMPs, as necessary, to treat the remaining WQDV or WQDF not already addressed with retention and biotreatment BMPs or offset by water quality credits. Claim LID credit for volume that is treated in treatment control BMPs with medium or high effectiveness for all primary pollutants of concern. If treatment control BMPs do not provide M or H effectiveness for all primary pollutants and/or the cost of treatment control BMPs greatly outweighs pollution control benefit; participate in alternative compliance program for remaining LID and treatment control obligation. Provide off-site or in-stream controls to address HCOCs, if present.

Note: this list of conditions is not exhaustive of all potential conditions that could be encountered. It is provided to illustrate the integration of different sizing criteria, and is anticipated to cover a large percentage of projects. Conformance with each sizing standard shall always be evaluated on a standard-by-standard basis.

I.2. Overview of Approach for LID BMP Sizing in North Orange County

This section describes three equivalent pathways a typical Priority Project would potentially follow to size LID BMPs for the DCV in the North Orange County permit area.

1) Design LID BMPs to retain on-site (infiltrate, harvest and use, or evapotranspire) 80 percent of the average annual stormwater runoff (i.e., 80 percent capture). The physical storage capacity of the BMP may be less than the DCV if, after considering routing effects (i.e., how quickly storage in the BMP becomes available; see **Appendix III.6**), the average annual capture percentage exceeds 80 percent. **Appendix III.3** and **III.4** provide simplified nomograph tools for calculating long term average annual capture efficiency.

   OR

2) Participate in a regional facility that provides average annual volume reduction and pollutant load reduction equivalent or better to that which would be achieved by retaining 80 percent of the average annual stormwater from the Project on-site. Regional facilities must be approved by the Regional Board Executive Officer as part of a watershed or sub-watershed scale plan (as described in **the Section 2.4.2.2 of the Model WQMP**) and equivalency shall be demonstrated by hydrologic and pollutant removal benefits estimated by water quality modeling.

   OR

3) Design LID BMPs to:

   a. Retain (infiltrate, harvest and use, or evapotranspire) stormwater runoff on-site, as feasible up to the DCV,

      AND

   b. Recover (i.e., draw down) the storage volume in less than or equal to 48 hours, if feasible. If not feasible, demonstrate based on feasibility criteria that storage cannot be recovered more quickly <u>or</u> provide additional storage volume beyond the DCV to offset longer drawdown time. *Note: Providing the DCV and drawing down this volume down in 48 hours achieves equivalent performance to 80 percent retention of average annual stormwater runoff. Other combinations of retention volume and drawdown can also be used to achieve 80 percent retention of average annual stormwater runoff if desired and feasible (See* ***Appendix*** *III.3 and III.4).*

      AND (if necessary)

c. Biotreat the remaining DCV[1] on-site to the MEP, if any[2] (cumulative, retention plus biotreatment),

   AND (if necessary)

d. Retain or biotreat, the remaining DCV (cumulative, retention plus biotreatment) in a regional facility designed per LID principals[3],

   AND (if necessary)

e. Claim water quality credits, if applicable, and fulfill alternative compliance obligations for runoff volume not retained or biotreated up to the target average annual capture efficiency of 80 percent (cumulative) or offset by water quality credits.

Infeasibility criteria for BMP selection are described in **TGD Section 2.4**, and criteria for design BMPs to retain and biotreat stormwater to the MEP are contained in **Appendix XI.** Conceptually, these criteria are intended to:

- Prevent significant risks to human health and environmental degradation as a result of compliance activities; and
- Describe circumstances under which regional and watershed-based strategies may be selected when they are consistent with the MEP standard considering such factors as technical feasibility, fiscal feasibility, societal concerns, and social benefits; and
- Define performance criteria to ensure that compliance does not result in undue fiscal or societal burdens, including such considerations as:
    - Cost-effectiveness of on-site stormwater management versus off-site stormwater management, including capital costs and maintenance cost and considerations, and
    - Incremental cost-benefit of additional BMPs in stormwater management systems, including capital costs and maintenance costs and considerations.

Functionally, these criteria provide the basis for moving from higher to lower levels of the LID BMP hierarchy outlined in Pathway 3, above.

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[1] The remaining design capture volume refers the remaining volume required for the BMP system to collectively store the entire design capture volume, or the remaining volume required for the system to collectively retain plus biotreat 80 percent of average annual runoff volume.

[2] If remaining volume = 0 after any step, then subsequent steps are not necessary.

[3] This option does not require Regional Board Executive Officer approval. This option is implemented after a project-specific finding of infeasibility of retaining or biotreating the entire DCV on the project site.

I.3. Overview of Approach for Treatment Control BMP Sizing in North Orange County

Where LID BMPs can be used to retain or biotreat the DCV, no additional volume of storm water is required to be treated. Therefore the use of LID BMPs to treat the DCV inherently fulfills treatment control requirements. In addition, if water quality credits are claimed by the project to offset remaining unmet portion of the DCV, these credits also serve to reduce the remaining WQDV for treatment control (See **Model WQMP Section 7.II-3.1**).

Treatment control BMPs must be provided for the remaining "unmet" volume for a project if the following conditions are met:

- Water quality credits do not fully off-set the remaining DCV/WQDV, and
- The pollution control benefits of treatment control BMPs is not outweighed by their cost.

In these cases, sizing of treatment control BMP(s) shall be provided based on the unmet volume/flow as calculated in **Section VI.1**, minus the contribution of water quality credits as calculated in **Section VI.2**.

I.4. Overview of Approach for Addressing HCOCs in North Orange County

Hydrologic Conditions of Concerns (HCOCs) are considered to exist if any streams located downstream from the project are determined to be potentially susceptible to hydromodification impacts and either of the following conditions exists:

- Post-development runoff volume for the 2-yr, 24-hr storm exceeds that of the pre-development[4] condition by more than 5 percent

  OR

- Time of concentration of post-development runoff for the 2-yr, 24-hr storm event is greater [5] than the time of concentration of the pre-development condition by more than 5 percent.

[4] In North Orange County (Order R8-2009-0030), predevelopment is defined as the existing conditions immediately prior to Project WQMP submittal.

[5] The North County Permit (Order R8-2009-0030), as adopted, provides the option of reducing Tc to less than the existing condition Tc (within 5 percent) as part of the primary and preferred option for mitigating HCOCs. However, a longer Tc is generally associated with natural conditions than urban conditions, and a longer Tc nearly universally results in lower concern for hydromodification impacts. In addition, it is not physically possible for a project to implement BMPs consistent with LID provisions of the permit without substantially increasing the Tc of the site. The use of retention BMPs results in water not discharged under design conditions, while the use of biotreatment BMPs general results in water not immediately discharged. Therefore, it would not generally be possible to mitigate HCOCs using the primary option for compliance described above while complying with LID requirements. This TGD therefore interprets this provision such that increases in Tc would be acceptable and reduction in Tc of more than 5 percent would not be acceptable. This interpretation is consistent with the overall goal of the permit to protect receiving waters from stormwater impacts to the MEP.

If these conditions to not exist or streams are not potentially susceptible to hydromodification impacts, an HCOC does not exist and hydromodification does not need to be considered further.

Streams susceptibility should be determined as described in **TGD Section 2.3**, which describes methods of determining susceptibility based on either mapping or site specific engineering analysis.

Priority Projects where there is an HCOC shall, as the first priority, implement on-site or regional hydromodification controls such that:

- Post-development runoff volume for the 2-yr, 24-hr storm event is no greater than 105 percent of that for the pre-development condition.

  AND

- Time of concentration of post-development runoff for the 2-yr, 24-hr storm event is no greater than 105 percent of that for the pre-development condition (see Footnote 5).

A project may implement a combination of additional site design practices, LID controls, structural treatment controls, sub-regional/regional controls, and/or in-stream controls to meet the hydromodification performance criteria stated above. In this case, the Project WQMP should include a project-specific evaluation with the pre- and post-development runoff volume and time of concentration for the 2-yr, 24-hr storm event. The Project WQMP must consider site design practices and on-site controls prior to proposing in-stream controls. If in-stream controls are selected, the Project WQMP should include a project-specific evaluation to demonstrate that the project will not adversely impact beneficial uses or result in sustained degradation of water quality of the receiving waters.

Where the Project WQMP documents that the excess runoff volume from the 2-yr, 24-hr runoff event cannot feasibly be retained (infiltrated, harvested and used, or evapotranspired), the project shall:

- Retain the excess volume from the 2-yr, 24-hr runoff event in on-site or regional controls to the MEP,

  AND

- Implement on-site or regional hydromodification controls such that the post-development runoff 2-yr, 24-hr peak flow rate is no greater than 110 percent of the pre-development runoff 2-yr, 24-hr peak flow rate.

The process of demonstrating that volume has been controlled to the MEP is the same as the process used to demonstrate that LID BMPs have been designed to retain and biotreat the maximum feasible amount of stormwater runoff (See **Appendix XI**).

Alternative performance criteria found within an RWQCB Executive Officer-approved Watershed Infiltration and Hydromodification Management Plan (WIHMP) may supersede these criteria for the area that the plan covers.

I.5. Role of HSCs in BMP Sizing

Hydrologic source controls (HSCs) can play an integral role in the sizing of LID and treatment control BMPs and addressing HCOCs. In the context of the TGD, HSCs are integrated and distributed micro-scale stormwater infiltration and evapotranspiration (ET) systems that are an integral part of LID site design. These systems are distinguished from LID BMPs because they are highly integrated with site designs, they are generally applied opportunistically, they are not governed by fixed sizing criteria, and they are less stringently engineered than the LID BMPs.

HSCs can impact BMP sizing in the following general ways:

- HSCs that retain the entire DCV can render portions of a project "self-retaining," meaning that no further LID BMPs or treatment control BMPs are needed for their respective drainage areas.
- Green roofs are considered to be self-retaining HSCs when designed to meet the criteria contained in **Appendix IX**.
- HSCs can also provide partial retention of the DCV, reducing the sizing requirements of downstream BMPs.
- For projects seeking to demonstrate that BMPs have been designed to retain the maximum feasible amount of the DCV, all feasible HSCs must be considered.

Appendix III provides calculation methods that allow projects to account for the benefits of HSCs when determining the amount of remaining requirements that must be met in downstream BMPs. BMP Fact Sheets contained in **TGD Section 4** provide design criteria for HSCs.

APPENDIX II. SUMMARY OF BMP SIZING REQUIREMENTS FOR SOUTH ORANGE COUNTY

The purpose of this appendix is to provide a concise overview of the BMP sizing requirements for Priority Projects in the South Orange County Permit Area. This summary is not intended to supersede the regulatory requirements contained in **Section 2.4 of the Model WQMP** or establish new/additional performance criteria. Rather, this summary is intended to provide functional descriptions of how these requirements are anticipated to be applied in the majority of projects. This summary is organized as follows:

- **Introduction to Integrated Structural BMP Sizing Approach in South Orange County**
- **Overview of Approach for LID BMP Sizing in South Orange County**
- **Overview of Approach for Treatment Control BMP Sizing in South Orange County**
- **Overview of Approach for Addressing HCOCs in South Orange County**
- **Role of HSCs in BMP Sizing**
- **Alternative Performance Criteria for Watershed-based Projects in South Orange County**

II.1. Introduction to Integrated Structural BMP Sizing Approach in South Orange County

Priority Projects in the South Orange County Permit Area are required to implement LID, treatment control, and hydromodification control BMPs to achieve numeric performance criteria described in **Section 2.4 of the Model WQMP**. While Priority Projects must demonstrate compliance with LID, treatment control, and hydromodification control requirements separately, these provisions overlap significantly and some BMPs may fulfill or partially fulfill a portion of one or more of these requirements.

The relative role that the LID, treatment control, and hydromodification performance standards have on BMP sizing requirements depends principally on the susceptibility of receiving channels to hydromodification.

Three distinct conditions relative to BMP sizing are anticipated to exist most commonly:

4. **HCOC-controlled.** This condition applies to any priority project that discharges to receiving waters susceptible to hydromodification. In this case, the <u>interim hydromodification criteria</u> would control the stormwater design.

    Interim HM Standard > DCV = WQDV

Design approach: design BMPs to comply with the interim hydromodification standard. This will generally address all other applicable sizing criteria.

Alternate path: There is no alternative compliance option for inability to meet the interim hydromodification standard. However, flow control could potentially be provided off-site.

5. **DCV-controlled.** This condition applies to projects that do not have susceptible receiving waters. In this case, the controlling *stormwater design volume* is the DCV.

   DCV = WQDV; HCOCs do not exist

   Design approach: design BMPs to retain the DCV. This will generally address treatment control sizing criteria.

   Contingencies: If full retention is not possible, retain to the MEP, select a biotreatment BMP to address pollutants of concern, and design biotreatment for the remaining DCV to the MEP.

6. **Alternative Compliance.** This condition applies to projects that cannot feasibly retain or biotreat the entire DCV and choose to participate in an in-lieu/off-site program for remaining LID requirements. In this case, the water quality design volume or flowrate (WQDV or WQDF) would control the ultimate sizing of on-site BMPs.

   WQDV > DCV achieved on-site

   Design approach: After demonstrating the infeasibility of retaining or biotreating the DCV, size treatment control BMPs, as necessary, to treat the remaining WQDV or WQDF not already addressed with retention and biotreatment BMPs. Claim full or partial pollutant offset credit based on pollutant load reduction achieved in treatment control BMPs. Participate in alternative compliance program for remaining LID obligation. Alternative compliance requirements are contained in **Section 3.0 of the Model WQMP**.

Note: this list of conditions is not exhaustive of all potential conditions that could be encountered. It is provided to illustrate the integration of different sizing criteria, and is anticipated to cover a large percentage of projects. Conformance with each sizing standard shall always be evaluated on a standard-by-standard basis.

II.2. Overview of Approach for LID BMP Sizing in South Orange County

This section describes three equivalent pathways a typical Priority Project would potentially follow to size LID BMPs for the DCV in the South Orange County permit area.

1) Design LID BMPs to retain on-site (infiltrate, harvest and use, or evapotranspire) 80 percent of the average annual stormwater runoff (i.e., 80 percent capture). The physical storage capacity of the BMP may be less than the DCV if, after considering routing

effects (i.e., the rate at which water is treated and storage volume is recovered), the average annual capture percentage exceeds 80 percent. **Appendix III.3** and **III.4** provide simplified nomograph tools for calculating long term average annual capture efficiency. In the South Orange County permit area, the pre-filter storage volume of the BMP may not be less than 75 percent of the DCV[6].

OR

2) Design LID BMPs to:

   a. Retain (infiltrate, harvest and use, or evapotranspire) stormwater runoff on-site, as feasible up to the DCV,

   AND

   b. Recover (i.e., draw down) the storage volume in less than or equal to 48 hours, if feasible. If not feasible, demonstrate based on feasibility criteria that storage cannot be recovered more quickly <u>or</u> provide additional storage volume beyond the DCV to offset longer drawdown time. *Note: Providing the DCV and drawing down this volume down in 48 hours achieves equivalent performance to 80 percent retention of average annual stormwater runoff. Other combinations of retention volume and drawdown can also be used to achieve 80 percent retention of average annual stormwater runoff if desired and feasible (See* ***Appendix*** **III.3** *and* **III.4***).*

   AND (if necessary)

   c. Biotreat the remaining DCV[7] on-site to the MEP, if any[8] (cumulative, retention plus biotreatment),

   d. Provided treatment controls for the remaining DCV, and fulfill alternative compliance obligations for runoff volume not retained or biotreated up to the target average annual capture efficiency of 80 percent (cumulative) or offset pollutant load reduction in treatment control BMPs.

Infeasibility criteria for BMP selection are described in **TGD Section 2.4,** and criteria for design BMPs to retain and biotreat stormwater to the MEP are contained in **Appendix XI.** Conceptually, these criteria are intended to:

[6] The pre-filter volume is defined as the physical storage provided in the BMP, not count volume that is routed during the storm event. The physical volume of the BMP must be at least 75 percent of the DCV.

[7] The remaining design capture volume refers the remaining volume required for the BMP system to collectively store the entire design capture volume, or the remaining volume required for the system to collectively retain plus biotreat 80 percent of average annual runoff volume.

[8] If remaining volume = 0 after any step, then subsequent steps are not necessary.

- Prevent significant risks to human health and environmental degradation as a result of compliance activities; and
- Describe circumstances under which regional and watershed-based strategies may be selected when they are consistent with the MEP standard considering such factors as technical feasibility, fiscal feasibility, societal concerns, and social benefits; and
- Define performance criteria to ensure that compliance does not result in undue fiscal or societal burdens, including such considerations as:
  - Cost-effectiveness of on-site stormwater management versus off-site stormwater management, including capital costs and maintenance cost and considerations, and
  - Incremental cost-benefit of additional BMPs in stormwater management systems, including capital costs and maintenance costs and considerations.

Functionally, these criteria provide the basis for moving from higher to lower levels of the LID BMP hierarchy outlined in Pathway 3, above.

II.3. Overview of Approach for Treatment Control BMP Sizing in South Orange County

Where LID BMPs can be used to retain or biotreat the DCV, no additional volume of storm water is required to be treated. Therefore the use of LID BMPs to treat the DCV inherently fulfills treatment control requirements.

If LID performance criteria have not been met through retention and biotreatment, then treatment control BMPs should be provided to address the remaining treatment control performance criteria. Two potential cases could arise with respect to performance criteria of treatment control BMPs:

1) LID performance criteria can be partially, but not fully met with LID BMPs.
   - Sizing of treatment control BMP(s) would be based on the unmet volume to achieve cumulative 80 percent average annual capture efficiency as calculated in Section **VI.1**.
2) The project or a drainage area cannot feasibly incorporate any LID BMPs.
   - Sizing of treatment control BMP(s) would be based one of the following criteria:
     - Capture and infiltrate or treat 80 percent of average annual runoff volume,

       OR
     - Capture and infiltrate or treat the runoff from the 24-hour, 85th percentile storm event, as determined from the County of Orange's 85th Percentile Precipitation Isopluvial Map and draw down the stored volume in no more than 48 hours following the end of precipitation,

       OR

- Treat the maximum flow rate of runoff produced by the 85th percentile hourly rainfall intensity, as determined from the local historical rainfall record, multiplied by a factor of two, or

  OR

- The maximum flow rate of runoff produced from a rainfall intensity of 0.2 inch of rainfall per hour, for each hour of a storm event.

II.4. Overview of Approach for Addressing HCOCs in South Orange County

II.4.1. Interim Criteria

HCOCs are not considered to exist if the downstream conveyance network is not susceptible to hydromodification impacts. Streams susceptibility should be determined as described in **TGD Section 2.3**, which requires methods of determining susceptibility based on either mapping or site specific engineering analysis.

For projects discharging to a downstream conveyance network that is susceptible to hydromodification impacts, an HCOC is assumed to exist, and projects shall as required by the **Model WQMP** mitigate this HCOC. An HCOC is considered to be mitigated when on-site or regional hydromodification controls are provided such that such that:

- For flow rates from 10 percent of the 2-year storm event to the 5-year storm event, the post-project flows do not exceed pre-development (naturally occurring) peak flows.
- For flow rates from the 5-year storm event to the 10-year storm event the post-project peak flows may exceed pre-development (naturally occurring) flows by up to 10 percent for a 1-year frequency interval.

II.4.2. Final Criteria

If a Hydromodification Management Plan (HMP) has been approved by the Regional Board and the project is located within a copermittee's jurisdiction that has incorporated the HMP into the LIP, then the project shall implement the criteria that have been incorporated into the HMP.

II.5. Role of HSCs in BMP Sizing

Hydrologic source controls (HSCs) can play an integral role in the sizing of LID and treatment control BMPs and addressing HCOCs. In the context of the TGD, HSCs are integrated and distributed micro-scale stormwater infiltration and ET systems that are an integral part of LID site design. These systems are distinguished from LID BMPs because they are highly integrated with site designs, they are generally applied opportunistically, they are not governed by fixed sizing criteria, and they are less stringently engineered than the LID BMPs.

HSCs can impact BMP sizing in the following general ways:

- HSCs that retain the entire DCV can render portions of a project "self-retaining," meaning that no further LID BMPs or treatment control BMPs are needed for these areas.
- Green roofs are considered to be self-retaining HSCs when designed to meet the criteria contained in **Appendix IX**.
- HSCs can also provide partial retention of the DCV, reducing the sizing requirements of downstream BMPs.
- For projects seeking to demonstrate that BMPs have been designed to retain the maximum feasible amount of the DCV, all feasible HSCs must be considered.

Appendix III provides calculation methods that allow projects to account for the benefits of HSCs when determining the amount of remaining requirements that must be met in downstream BMPs. BMP Fact Sheets contained in **TGD Section 4** provide design criteria for HSCs.

II.6. Alternative Performance Criteria for Watershed-based Projects in South Orange County

In the South Orange County permit area, development projects greater than 100 acres in total project size, or smaller than 100 acres in size yet part of a larger common plan of development that is over 100 acres, that have been prepared using watershed and/or sub-watershed-based water quality, hydrologic, and fluvial geomorphologic planning principles that implement regional LID BMPs in accordance with the sizing and location criteria of the South Orange County Permit and acceptable to the Regional Board, are deemed to satisfy the South County Permit's requirements for new development and do not have to conduct an on-site feasibility analysis. Regional BMPs in such plans should clearly exhibit that they will not result in a net impact from pollutant loadings over and above the impact caused by capture and retention of the design storm with on-site LID BMPs.

APPENDIX III. HYDROLOGIC CALCULATIONS AND SIZING METHODS FOR LID BMPS

III.1. Hydrologic Methods for Design Capture Storm

This section describes the hydrologic methods that shall be used to compute the design runoff volume or flowrate resulting from a given precipitation depth or intensity and a given imperviousness fraction. These methods are applicable to the Design Capture Storm (85th percentile, 24-hour) as well as the water quality design storm and water quality design intensity. These methods are not applicable for hydrologic analysis of the 2-year design storm.

III.1.1. Simple Method Runoff Coefficient for Volume-Based BMP Sizing

This hydrologic method shall be used to calculate the runoff volume associated with LID and water quality design storms. The runoff volume shall be calculated as:

$$V = C \times d \times A \times 43560\ sf/ac \times 1/12\ in/ft \qquad \text{Equation III.1}$$

Where:

V = runoff volume during the design storm event, cu-ft
C = runoff coefficient = $(0.75 \times imp + 0.15)$
  imp = impervious fraction of drainage area (ranges from 0 to 1)
d = storm depth (inches)
A = tributary area (acres)

Note: the tributary area includes the portions of the drainage area within the project and any run-on from off-site areas that comingles with project runoff.

An example of this calculation is provided in **Example III.1**. This method shall not be used for calculating the runoff volume from the 2-year design storm.

Example III.1: Design Runoff Volume Calculation using Simple Runoff Coefficient Method

Given:
• A drainage area consists of a 1 acre building roof surrounded by 0.25 acres of landscaping (80 percent composite imperviousness)
• The design capture storm depth is 0.75 inches .
Required:
• Find the DCV
Result:
1) From Equation I.1: $V = C \times d \times A \times 43560$ sf/ac × 1/12 in/ft
2) $C = (0.8 \times 0.75 + 0.15) = 0.75$
3) A = 1.25 ac
4) d = 0.75 inches
5) V = 0.75 × 0.75 in × 1.25 ac × 43560 sf/ac × 1/12 in/ft = **2,550 cu-ft**

In some BMP sizing calculations, it is necessary to "back-calculate" the design storm depth based on the runoff volume and a description of the watershed. The design storm depth can be calculated by rearranging Equation 2.1 above:

$$d = V \times 12\ in/ft / [C \times A \times 43560\ sf/ac] \qquad \text{Equation III.2}$$

Any subtraction from the designs storm depth claimed in Section **III.1.3** to account for HSCs should be added to the back-computed design storm depth after this calculation. **Example III.2** illustrates how a given volume of stormwater would be translated to an equivalent storm depth.

Example III.2: Back-computing Storm Depth from Runoff Volume

Given:
• A drainage area consists of a 1 acre building roof surrounded by 0.25 acres of landscaping (80 percent composite imperviousness)
• An LID BMP with 1,200 cu-ft of storage is provided.
Required:
• What is the equivalent design storm corresponding to this BMP volume?
Result:
1) From Equation 2.2: d = V × 12 in/ft/[C × A × 43560 sf/ac]
6) V = 1,200 cu-ft (given)
7) C = (0.8×0.75 + 0.15) = 0.75
8) A = 1.25 ac
9) d = 1,200 cu-ft × 12 in/ft / [0.75 × 1.25 ac × 43560 sf/ac] = **0.35 inches**

III.1.2. Simple Method Runoff Coefficient for Flow-based BMP Sizing

This hydrologic method shall be used to calculate the runoff flowrate associated with a water quality design storm intensity. Design flow calculations for flow-based BMPs should be calculated as:

$$Q = C \times i \times A \qquad \text{Equation III.3}$$

Where:

Q = design flowrate, cfs
C = runoff coefficient = $(0.75 \times imp + 0.15)$
imp = impervious fraction of drainage area (ranges from 0 to 1)
i = design intensity (inches)
A = tributary area (acres)

Note: the tributary area includes the portions of the drainage area within the project and any run-on from off-site areas that comingles with project runoff.

III.1.3. Sizing and Accounting for Hydrologic Source Controls (HSCs)

The effects of HSCs are accounted for in hydrologic calculations as an adjustment to the storm depth used in the calculations described above. Adjustments to design storm depth are based on the type and magnitude of HSCs employed for the drainage area. This section provides guidance for both elements of this calculation.

III.1.3.1. Calculating the Effective Storage Depth of HSCs

BMP Fact Sheets for HSCs include HSC-specific criteria for quantifying storm depth retained. There may be more than one HSC in a single drainage area, and the effect of the suite of HSCs over a drainage area should be combined and area weighted as follows.

$$d_{HSC\ total} = \sum d_{HSCi} \times IA_i \ / \ IA_{total}$$ Equation III.4

Where:

$d_{HSC\ total}$ = combined effect of HSCs in drainage area, inches
d_{HSCi} = effect of individual HSC_i per criteria in BMP Fact Sheets (Section **XIV.1**), inches
IA_i = impervious area tributary to individual HSC_i (for street trees this is the impervious area beneath a fully established perennial canopy); areas cannot be counted twice if more than one HSC captures runoff from the same impervious area (e.g., street trees covering a roof top that is disconnected).
IA_{total} = total impervious area in drainage area

Example III.1 provides a template for calculation of the combined effective of HSCs in the drainage area (expressed in inches reduction of the design capture storm depth).

Example III.3: Hydrologic Source Control Calculation Form (Worksheet A)

Drainage area ID	A
Total drainage area	2.1 acres
Total drainage area Impervious Area (IA_{total})	1.3 acres

HSC ID	HSC Type/ Description/ Reference Section	Effect of individual HSC_i per criteria in HSC BMP Fact Sheets (**TGD Section 4.2**) (d_{HSCi})	Impervious Area Tributary to HSC_i (IA_i)	$d_i \times IA_i$
A-1	Downspout Dispersion, 1:2 ratio (0.5) of rooftop to pervious area for 0.38 acres	0.25"	0.38	0.095
A-2	Street Trees, perennial canopy over 0.25 acres of impervious area	0.05"	0.25	0.0125
A-3	Downspout Infiltration, 10-15 cu-ft storage per 1000 sf of roof for 0.21 acres	0.15"	0.21	0.032
A-4	Residential Rain Barrels, four 55 gallon barrels per 1000 sf of roof (4*55*50%=110 gal/1000 sf) for 0.2 acres	0.18"	0.2	0.036

Box 1:	$\sum d_i \times IA_i =$	0.175
Box 2:	$IA_{total} =$	1.3
[Box 1]/[Box 2]:	$d_{HSC\ total} =$	0.135
	*Percent Capture Provided by HSCs (*Table III.1 *lowlands, interpolated)*	26%

III.1.3.2. Computing Remaining Runoff Volume after HSCs

To compute the remaining runoff volume after HSCs, runoff volume calculations are performed exactly as described in Section **III.1.1**, with the exception that the storm depth used in the calculation is adjusted prior to the calculation. **Example III.4** illustrates the approach for accounting for HSCs in hydrologic calculations and the effect that HSCs can have on reducing the required volume of downstream BMPs.

Example III.4: Accounting for HSCs in Hydrologic Calculations

Given:

- A drainage area consists of a 2.1 acres with 1.3 acres of impervious surface (62% imperviousness)
- The mix of HSCs shown in Example III.3 are used in the drainage area, resulting in an area-weighted average HSC effective retention depth of 0.14 inches
- The unadjusted design storm depth at the project site is 0.85 inches.

Result:

1) The designer uses 0.85 inches – 0.14 inches = 0.71 inches in the calculation of runoff from the design storm depth

10) DCV (with HSCs) =
2.1 ac × 0.71 inches × (0.62×0.75 + 0.15) × 43560 sf/ac × 1/12 in/ft = 3,330 cu-ft

11) DCV (without HSCs) =
2.1 ac × 0.85 inches × (0.62×0.75 + 0.15) × 43560 sf/ac × 1/12 in/ft = 3,990 cu-ft

III.1.3.3. Computing the Fraction of Average Long Term Runoff Reduced by HSCs

Table III.1 provides fraction of average annual runoff volume reduced by HSCs based on the effective storage volume of HSCs computed per Section **III.1.3.1**.

Table III.1: Fraction of Average Long Term Runoff Reduced (Capture Efficiency) by HSCs

Cumulative HSC Adjustment to Design Capture Storm Depth (d_{hsc})	Capture Efficiency Achieved Lowland Regions (<1,000 ft)	Capture Efficiency Achieved Mountainous Regions (>1,000 ft)
<0.05	0	0%
0.05"	8%	7%
0.1"	20%	16%
0.2"	37%	31%
0.3"	48%	42%
0.4"	57%	50%
0.5"	64%	57%
0.6"	70%	63%

Table III.1: Fraction of Average Long Term Runoff Reduced (Capture Efficiency) by HSCs

Cumulative HSC Adjustment to Design Capture Storm Depth (d_{hsc})	Capture Efficiency Achieved Lowland Regions (<1,000 ft)	Capture Efficiency Achieved Mountainous Regions (>1,000 ft)
0.7"	75%	68%
0.8"	80%	72%
0.9"	80%	76%
1.0"	80%	80%

Worksheet A: Hydrologic Source Control Calculation Form

Drainage area ID ____________

Total drainage area ____________ acres

Total drainage area Impervious Area (IA_{total}) ____________ acres

HSC ID	HSC Type/ Description/ Reference BMP Fact Sheet	Effect of individual HSC_i per criteria in **BMP Fact Sheets (TGD Section 4.2)** (d_{HSCi})[1]	Impervious Area Tributary to HSC_i (IA_i)	$d_i \times IA_i$
	Box 1:		$\sum d_i \times IA_i =$	
	Box 2:		$IA_{total} =$	
	[Box 1]/[Box 2]:		$d_{HSC\ total} =$	
			Percent Capture Provided by HSCs (Table III.1)	

1 - For HSCs meeting criteria to be considered self-retaining, enter the DCV for the project.

III.1.4. General Guidelines for Use of Continuous Simulation Modeling

For projects with complex hydrologic conditions or for evaluation of complex BMP designs, an appropriate public domain continuous flow model [such as Storm Water Management Model (SWMM) or Hydrologic Engineering Center – Hydrologic Simulation Program – Fortran (HEC-HSPF)], may be used to develop and evaluate BMP designs. The model should be run using a local precipitation record and project-specific information about soils, slopes, and BMP designs. Inputs should be thoroughly documented and conform to standards of engineering practice.

The acceptability of models is at the discretion of the reviewing agency, therefore the applicant should inquire with the reviewing agency regarding model preference and input assumptions.

III.2. Exhibits and Nomographs Used for LID and WQDV/WQDF Design Volume Calculations

Figure III.1 depicts the Design Capture Storm Depth[9] for Orange County. A higher resolution version of this figure is provided in **Appendix XVI**.

Figure III.2 presents a relationship between unit storage volume, drawdown time, and capture efficiency that is applicable across Orange County. The relationships are developed based on continuous simulation of hourly precipitation data per methods described in **Appendix III.6** and can be used in a variety of ways for design calculations as described in the following sections.

Figure III.3 presents a relationship between unit storage volume, unit demand (assuming drawdown rate varies with ET rate), and capture efficiency that is applicable across Orange County for systems with irrigation as their only demand. The relationships are developed based on continuous simulation of hourly precipitation data and daily ET data per methods described in **Appendix III.6** and can be used in a variety of ways for design calculations of harvest and use systems as described in the following sections. The effective irrigation area to tributary area ratio of the system (*EIATA*) is calculated as follows:

The EIATA ratio is calculated as follows:

$$EIATA = LA \times K_L / [IE \times \text{Tributary Impervious Area}]$$

Where:

---

[9] The Design Capture Storm Depth is calculated as the 85th percentile, 24 hour precipitation depth, determined from historic precipitation records, excluding days with less than or equal to 0.1 inches of precipitation.

EIATA = Effective Irrigated Area to Tributary Area ratio (ac/ac)
LA = landscape area irrigated with harvested water, sq-ft
K_L = Area-weighted landscape coefficient (see guidance and references in **Appendix X.2.5.2**)
IE = irrigation efficiency (assume 0.90)

Figure III.4 presents a relationship between design intensity, catchment time of concentration, and capture efficiency for off-line, flow-based BMPs. The relationships are developed based on analysis of hourly and 5-minute precipitation data as described in per methods described in **Appendix III.6** and can be used in a variety of ways for design calculations as described in the following sections. It is applicable across Orange County.

Figure III.1. Design Capture Rainfall Zones in Orange County

See **Exhibit XVI.1**

Figure III.2. Capture Efficiency Nomograph for Constant Drawdown Systems in Orange County

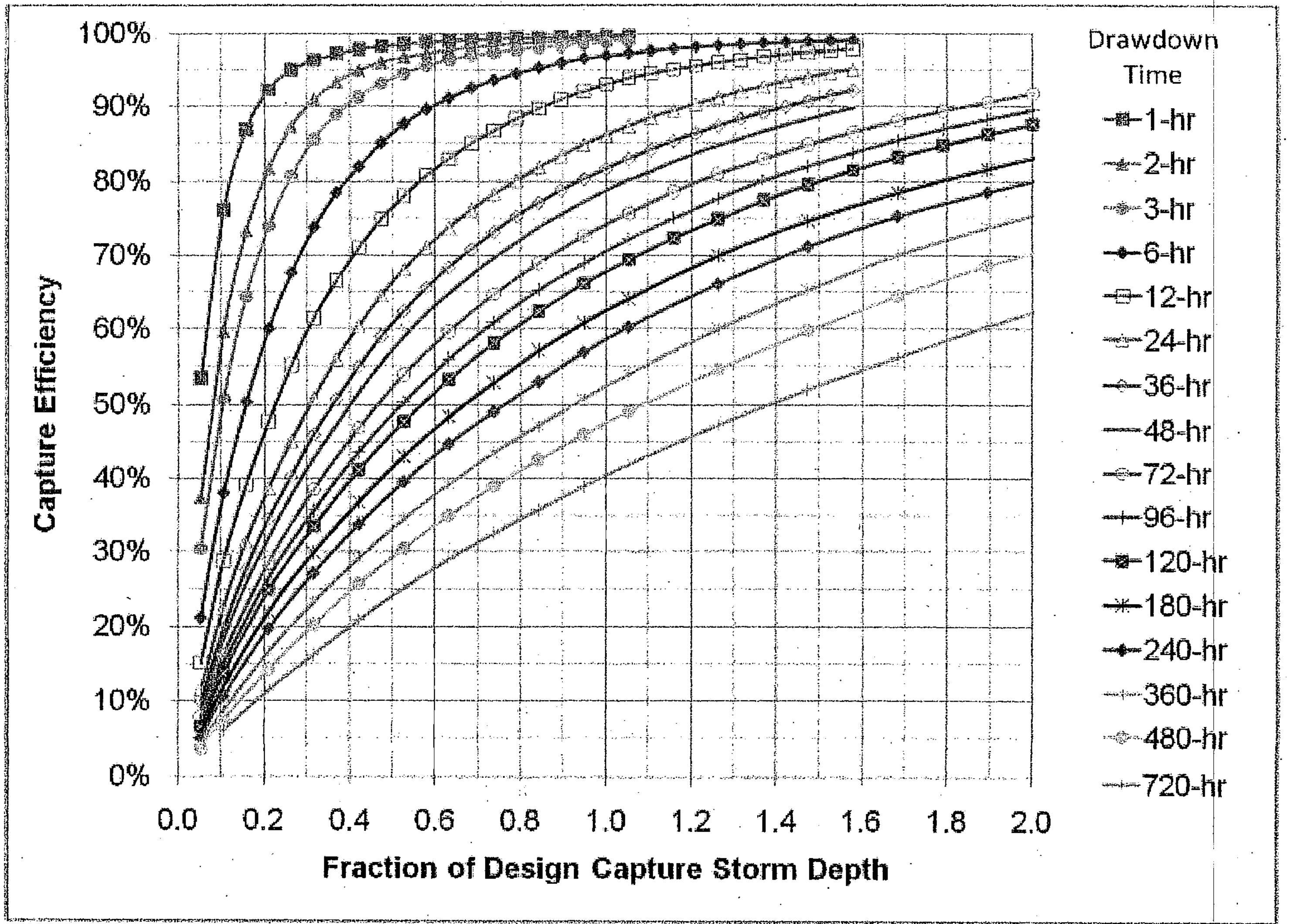


Figure III.3. Capture Efficiency Nomograph for Harvest and Use Systems with Irrigation Demand in Orange County

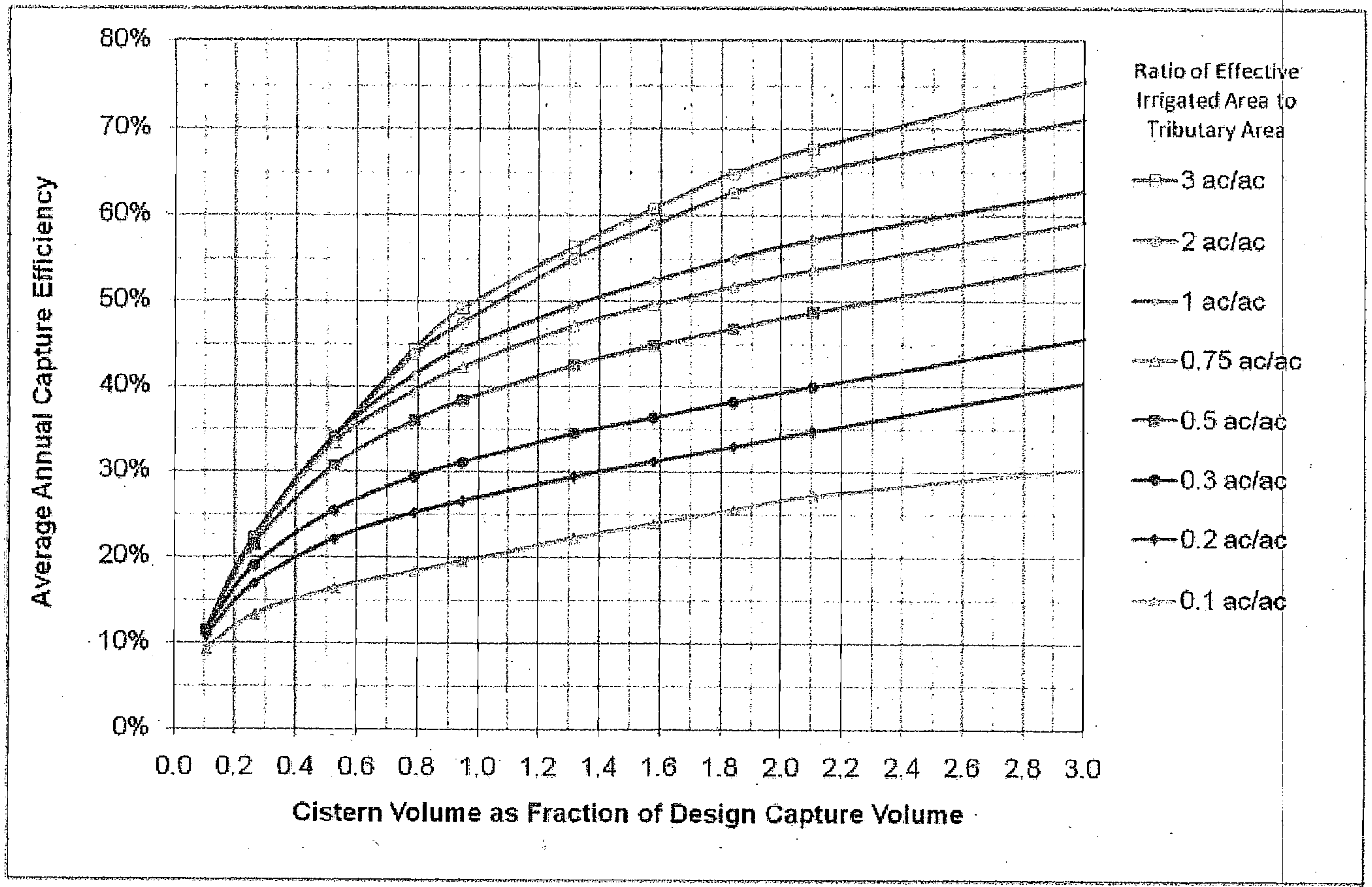
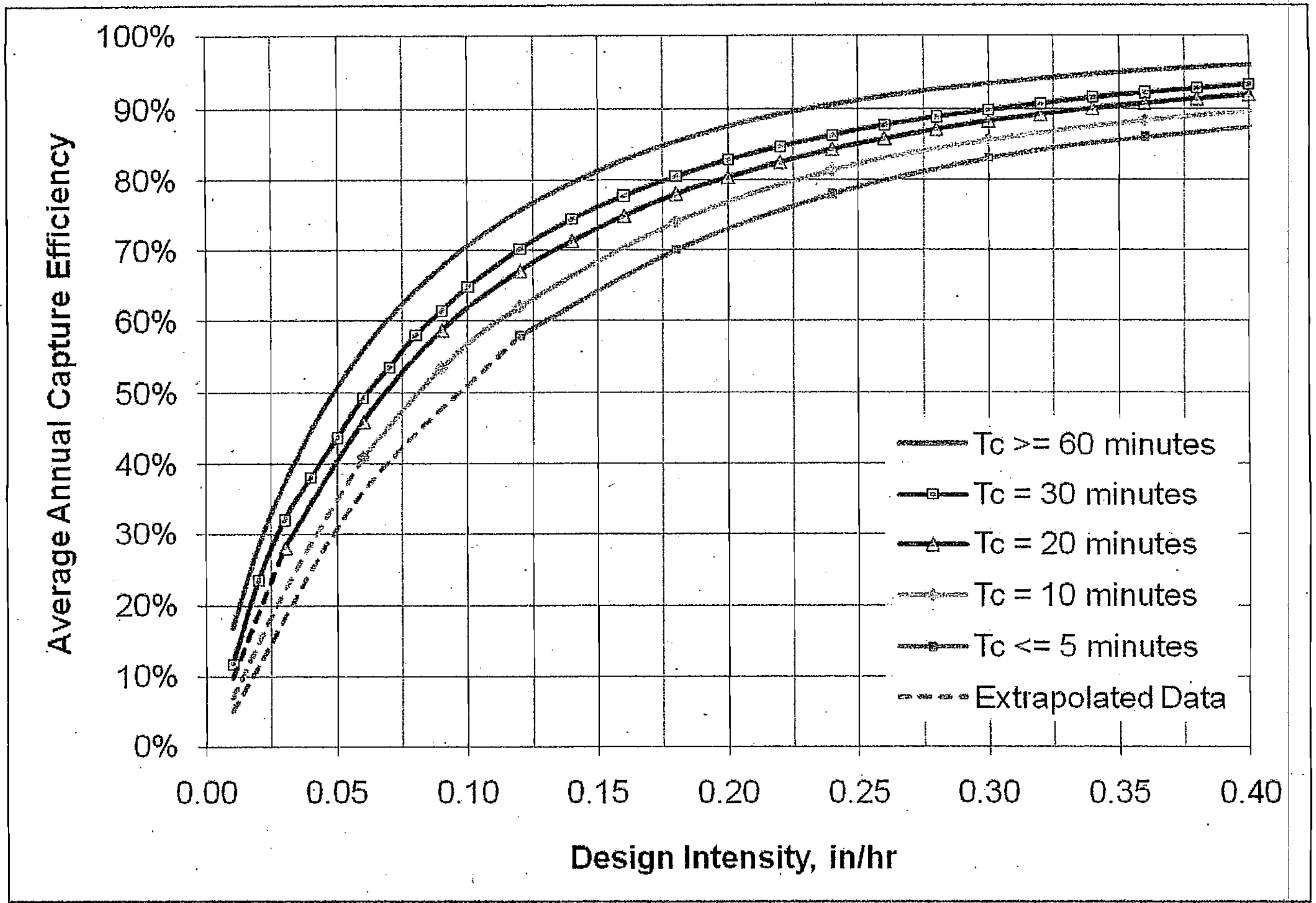


Figure III.4. Capture Efficiency Nomograph for Off-line Flow-based Systems in Orange County



III.3. Approved Methods for Calculating the LID Design Capture Volume

This section describes approved methods for calculating LID DCV.

III.3.1. Simple Design Capture Volume Sizing Method

This section describes the simplest method of sizing volume-based BMPs to manage the DCV. It may result in BMPs that achieve greater than 80 percent capture, therefore may be somewhat oversized to meet minimum performance criteria. This would result where the DCV can draw down in less than 48 hours. If the size of the BMP that results from this method is impracticable because it is oversized, the Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs (**Appendix** III.3.2) is recommended.

Stepwise Instructions:

1) Look up the design capture storm depth from **Figure III.1**.
2) Compute the DCV using the approved hydrologic methods described in Sections **III.1** accounting for HSCs implemented upstream.
3) Design BMP(s) to ensure that the DCV is fully retained (i.e., no surface discharge during the design event) and the stored volume draws down in no longer than 48 hours.

Treatment control performance criteria are fully met where this method is used.

Example III.5: Computing DCV using Simple Method

Given:

- Redevelopment project, 85th percentile, 24-hr storm depth = 0.85 inches
- Drainage Area = 1.5 acres
- Imperviousness = 80%
- Effective retention depth of HSCs (d_{HSC}) = 0.2 inches
- Design infiltration rate = 0.5 in/hr

Required:

- Determine LID DCV by Simple Method and check that this volume can be drawn down in less than or equal to 48 hours

Solution:

1) Design capture storm depth = 0.85 inches from **Figure III.1**.

12) Design capture storm depth, less HSCs = 0.85 inches – 0.2 inches = 0.65 inches

13) DCV = 1.5 ac × (0.8*0.75 + 0.15) × (0.65 inches) * 43,560 sf/ac × 1/12 in/ft = 2,650 cu-ft

14) Design BMP to provide remaining DCV and ensure ≤ 48 hour drawdown.

Minimum area required = [DCV] / [maximum retention depth that can draw down in 48 hours]

Max retention depth that can be drawn down in 48 hrs = 48 hrs × 0.5 in/hr = 24 inches = 2 ft

Minimum area required = 2,650 cu-ft / 2-ft = 1,325 sq-ft = 2.0 percent of project site. At least this effective area should be provided for infiltration to ensure that water is completely drawn down in no greater than 48 hours.

15) Retention depth may be provided through surface storage plus pore storage depending on BMP type. See **BMP Fact Sheets** for BMP-specific guidance on computing drawdown based on system geometry.

Worksheet B: Simple Design Capture Volume Sizing Method

Step 1: Determine the design capture storm depth used for calculating volume				
1	Enter design capture storm depth from Figure III.1, d (inches)	d=		inches
2	Enter the effect of provided HSCs, d_{HSC} (inches) (Worksheet A)	d_{HSC}=		inches
3	Calculate the remainder of the design capture storm depth, $d_{remainder}$ (inches) (Line 1 – Line 2)	$d_{remainder}$=		inches
Step 2: Calculate the DCV				
1	Enter Project area tributary to BMP (s), A (acres)	A=		acres
2	Enter Project Imperviousness, imp (unitless)	imp=		
3	Calculate runoff coefficient, $C = (0.75 \times imp) + 0.15$	C=		
4	Calculate runoff volume, $V_{design} = (C \times d_{remainder} \times A \times 43560 \times (1/12))$	V_{design}=		cu-ft
Step 3: Design BMPs to ensure full retention of the DCV				
Step 3a: Determine design infiltration rate				
1	Enter measured infiltration rate, $K_{measured}$ (in/hr) (Appendix VII)	$K_{measured}$=		In/hr
2	Enter combined safety factor from Worksheet H, S_{final} (unitless)	S_{final}=		
3	Calculate design infiltration rate, $K_{design} = K_{measured} \times S_{final}$	K_{design}=		In/hr
Step 3b: Determine minimum BMP footprint				
4	Enter drawdown time, T (max 48 hours)	T=		Hours
5	Calculate max retention depth that can be drawn down within the drawdown time (feet), $D_{max} = K_{design} \times T \times (1/12)$	D_{max}=		feet
6	Calculate minimum area required for BMP (sq-ft), $A_{min} = V_{design} / d_{max}$	A_{min}=		sq-ft

III.3.2. Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs

This section describes the recommended method of sizing volume-based BMPs to achieve the 80 percent capture performance criterion. This method has a number of potential applications in the Project WQMP preparation process, including:

- Use this method where a BMP can draw down in less than 48 hours and it is desired to demonstrate that 80 percent capture can be achieved using a BMP volume smaller than the DCV.
- Use this method to determine how much volume (greater than the DCV) must be provided to achieve 80 percent capture when the drawdown time of the BMP exceeds 48 hours.
- Use this method to determine how much volume should be provided to achieve 80 percent capture where upstream BMP(s) have achieved some capture, but have not achieved 80 percent capture.

By nature, this is an iterative process that requires some initial assumptions about BMP design parameters and subsequent confirmation that these assumptions are valid. For example sizing calculations depend on the assumed drawdown time, which depends on BMP depth, which may in turn need to be adjusted to provide the required volume within the allowable footprint. In general, the selection of reasonable BMP design parameters in the first iteration will result in minimal required additional iterations.

This method is only suitable for volumetric BMPs that have a drawdown rate can be approximated as constant throughout the year or over the wet season. For these BMPs, **Figure III.2** should be used with the instructions below. For flow-based BMPs, Section **III.4.3** should be used.

Stepwise Instructions:

1. Look up the 85th percentile, 24-hour storm depth for the project site from Figure III.1.
2. Estimate the drawdown time of the proposed BMP. See the applicable BMP Fact Sheet for specific guidance on how to convert BMP geometry to estimated drawdown time. On **Figure III.2**, locate where the line corresponding to the estimated drawdown time intersects with 80 percent capture. Pivot to the X axis and read the fraction of the DCV that needs to be provided in the BMP. This is referred to as X_1.
3. Determine the capture efficiency achieved upstream of the BMP and trace a horizontal line on **Figure III.2** corresponding to this value. Upstream capture would result from HSCs or upstream LID BMPs.
4. Find where the line traced in (3) intersects with the drawdown time estimated in (2). Pivot and read down to the horizontal axis to yield the fraction of the DCV already provided by upstream HSCs and BMPs. This is referred to as X_2.
5. Subtract X_2 from X_1 to determine the fraction of the design volume that must be provided to achieve 80 percent capture.

6. Multiply the result of (5) by the 85th percentile, 24-hour storm depth (1).
7. Compute runoff from the storm depth computed in (6) per guidance contained in Section III.1.1. This is the required BMP design volume.
8. Design the BMP to retain the required volume, and confirm that the drawdown time is no more than 25 percent greater than estimated in (2). If the computed drawdown time is greater than 125 percent of the estimated drawdown, then return to (2) and revise the initial drawdown time assumption.

See the respective BMP facts sheets for BMP-specific instructions for the calculation of volume and drawdown time.

Example III.6: Computing Design Criteria to Achieve Target Capture Efficiency, Bioretention BMP

Given:

- 85th percentile, 24-hr storm depth = 0.85 inches
- Drainage Area = 1.5 acres
- Imperviousness = 80%
- Effect of provided HSCs (d_{HSC}) = 0.2 inches
- Assume to priority BMP to be considered is bioretention without underdrains, 24-inch total retention depth (surface ponding + pore space)
- Design infiltration rate = 0.25 in/hr

Required:

- Determine volume required to achieve 80 percent capture.

Solution:

1) 85th percentile, 24-hr storm depth = 0.85 inches (**Figure III.1**)

16) BMP has total retention depth of 24 inches with 0.25 in/hr.
→24 in / 0.25 in/hr = 96 hour total drawdown
→From **Figure III.5**: $X_1 = 1.38$

17) Capture efficiency achieved by 0.2 inches of HSCs = 31% (From **Table III.1**).

18) From **Figure III.5**: $X_2 = 0.26$

19) Fraction of 85th percentile, 24-hour storm depth required ($X_1 - X_2$) = (1.38 – 0.26) = 1.12

20) Required design storm depth = 0.85 inches * (1.12) = 0.95 inches

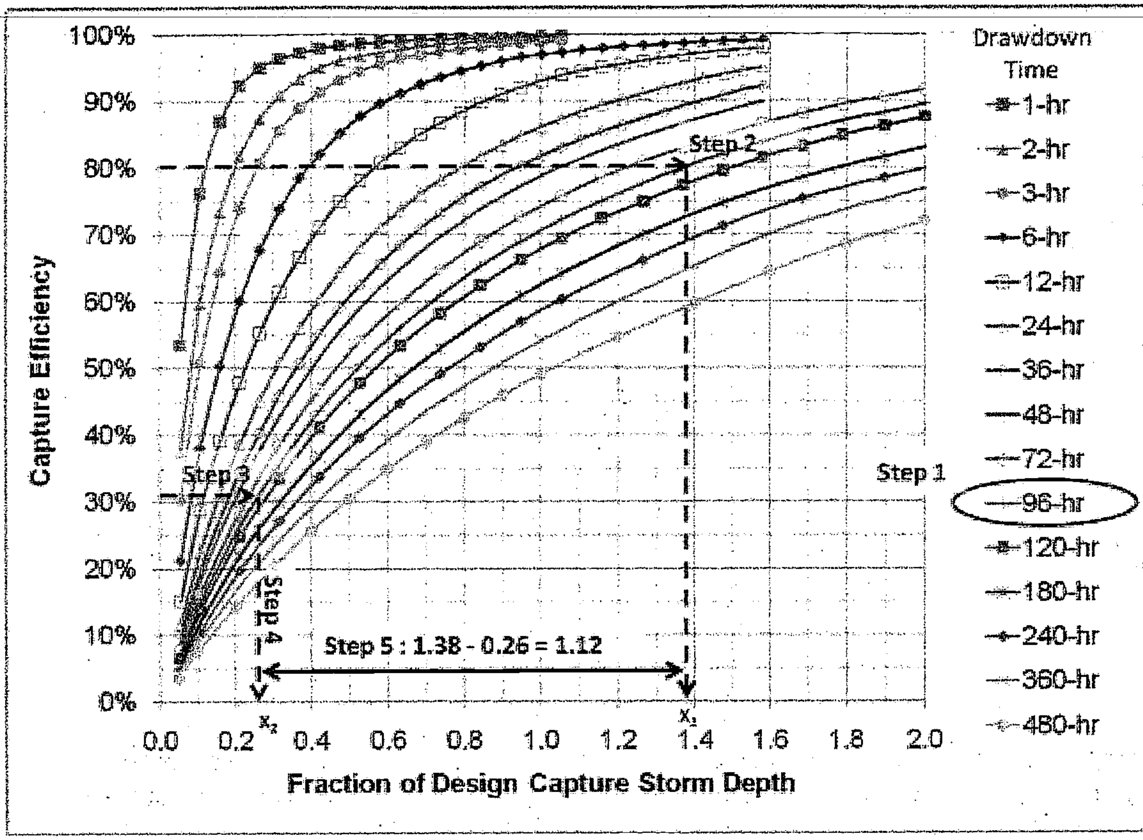
21) Required storage volume = 1.5 ac × 0.95 inches × (0.8×0.75 + 0.15) × 43560 sf/ac × 1/12 in/ft = 3,880 cu-ft

22) Check that 96 hour drawdown can be achieved for this volume. If recomputed drawdown time is more than 25% higher than original assumption, repeat steps starting with Step 2.

Graphical operations supporting solution:

Figure III.5

Graphical Operations Supporting Example III.6

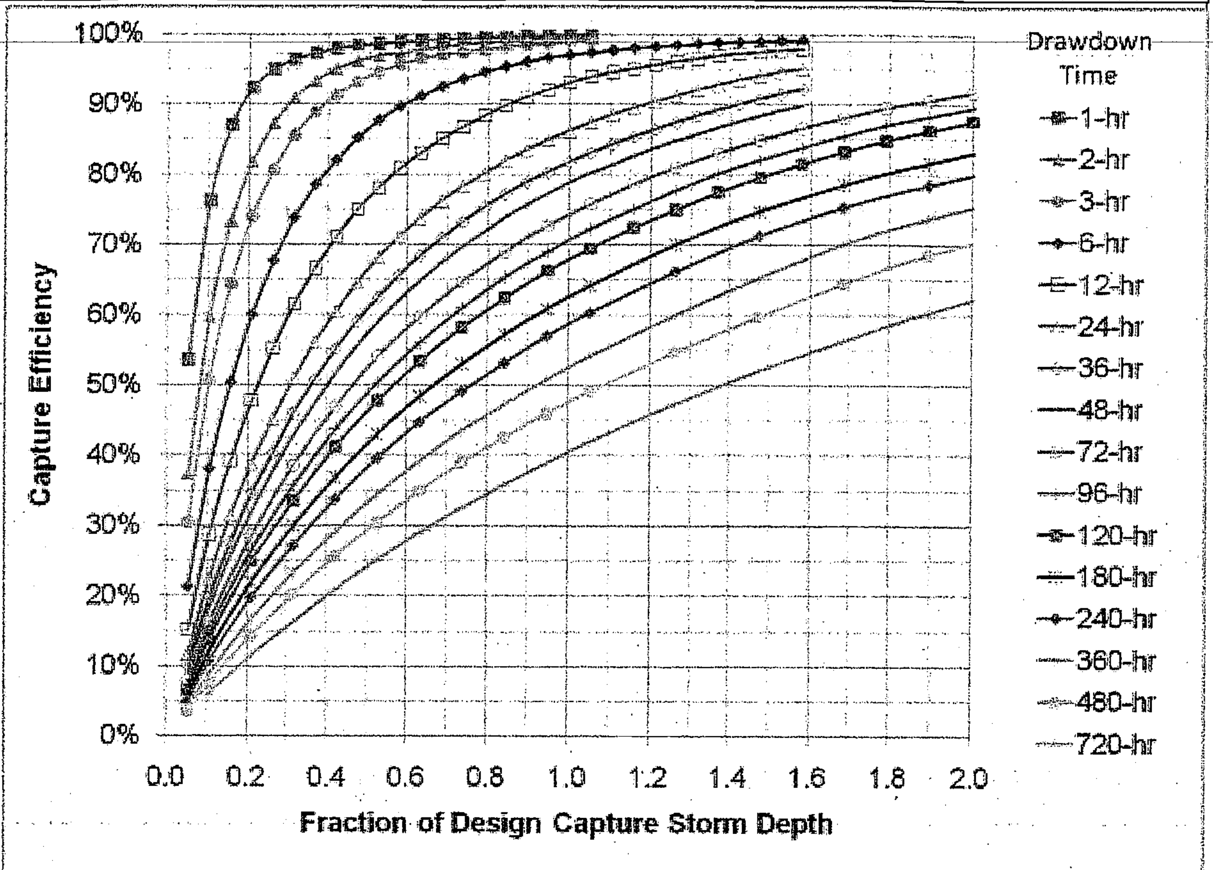


Worksheet C: Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs

Step 1: Determine the design capture storm depth used for calculating volume				
1	Enter design capture storm depth from **Figure III.1**, *d* (inches)	d=		inches
2	Enter calculated drawdown time of the proposed BMP based on equation provided in applicable BMP Fact Sheet, *T* (hours)	T=		hours
3	Using **Figure III.2**, determine the "fraction of design capture storm depth" at which the BMP drawdown time (T) line achieves 80% capture efficiency, X_1	X_1=		
4	Enter the effect depth of provided HSCs upstream, d_{HSC} (inches) (**Worksheet A**)	d_{HSC}=		inches
5	Enter capture efficiency corresponding to d_{HSC}, Y_2 (**Worksheet A**)	Y_2=		%
6	Using **Figure III.2**, determine the fraction of "design capture storm depth" at which the drawdown time (T) achieves the equivalent of the upstream capture efficiency(Y_2), X_2	X_2=		
7	Calculate the fraction of design volume that must be provided by BMP, $fraction = X_1 - X_2$	fraction=		
8	Calculate the resultant design capture storm depth (inches), $d_{fraction} = fraction \times d$	$d_{fraction}$=		inches
Step 2: Calculate the DCV				
1	Enter Project area tributary to BMP (s), *A* (acres)	A=		acres
2	Enter Project Imperviousness, *imp* (unitless)	imp=		
3	Calculate runoff coefficient, $C = (0.75 \times imp) + 0.15$	C=		
4	Calculate runoff volume, $V_{design} = (C \times d_{rfraction} \times A \times 43560 \times (1/12))$	V_{design}=		cu-ft
Supporting Calculations				
Describe system:				
Provide drawdown time calculations per applicable BMP Fact Sheet:				

Worksheet C: Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs

Graphical Operations



Provide supporting graphical operations. See Example III.6.

III.3.3. Capture Efficiency Method for Flow-based BMPs

This section describes the recommended method to compute the design flowrate for flow-based BMPs to achieve 80 percent average annual capture efficiency. This method allows accounting for the effects of HSCs and other BMPs upstream of the flow-based BMP. This method has a number of potential applications in the Project WQMP preparation process:

- Use this method to compute the design flowrate to achieve 80 percent capture when HSCs or other BMPs have been provided upstream that already manage a portion of the DCV.
- Use this method to add a flow-based component to a BMP that already has a retention component. This method results in the design flowrate for the flow-based component so that the BMP achieves a total of 80 percent capture between the volume-based and the flow-through component.

Stepwise Instructions:

1) Estimate the time of concentration (T_c) of the tributary area per Section **IV.2**.
2) Locate where the T_c line intersects with 80 percent capture on **Figure III.4**. Pivot and read to the horizontal axis to yield I_1.
3) Determine the capture efficiency achieved upstream of the BMP and trace a horizontal line on **Figure III.4** corresponding to this value. This will generally be the capture efficiency achieved by upstream HSCs (Section **III.1.3.3**), but may account for the effect of an upstream LID BMP as well if a treatment train is used.
4) Locate where the T_c line intersects with the line traced in (3). Pivot and read down to the horizontal axis to yield I_2.
5) Subtract I_2 from I_1 to yield the design intensity required to yield 80 percent capture.
6) Compute runoff flowrate from the design intensity as specified in Section **III.1.2**. This is the required design flowrate for the BMP.
7) Design the BMP to treat the required design flowrate.

Example III.7: Sizing to Achieve Target Average Annual Capture Efficiency, Flow-based BMPs

Given:
• 85th percentile, 24-hr storm depth = 0.95 inches
• Drainage Area = 3.5 acres
• Imperviousness = 95%
• Retention BMP provided upstream achieves 45 percent capture; does not fully meet requirements
• Assume swale is added as a biotreatment BMP downstream of retention
Required:
• Determine swale design flowrate required to achieve 80 percent capture cumulatively

Solution:

1) T_c = 10 minutes (calculation would be per **Appendix IV.2**)

23) From **Figure III.6** I_1 = 0.23 in/hr

24) Capture efficiency achieved in upstream BMPs = 45 percent (given)

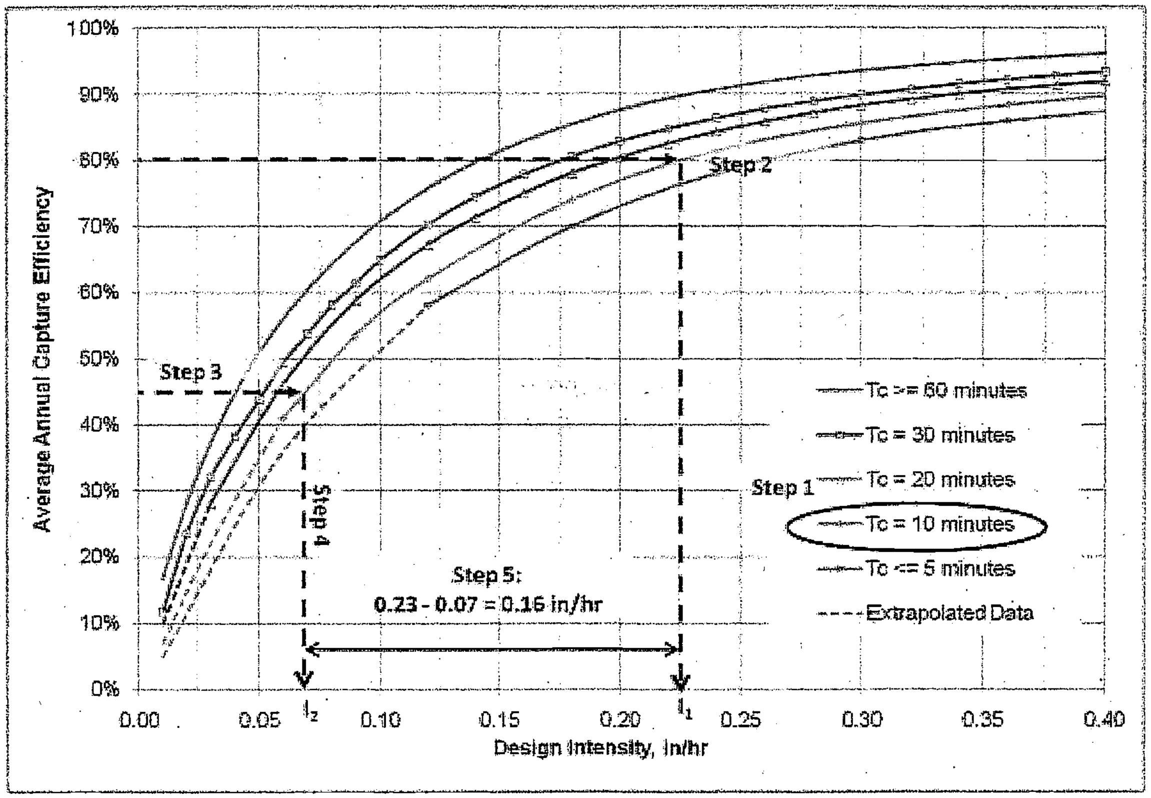
25) From **Figure III.6** I_2 = 0.07 in/hr

26) $I_1 - I_2$ = design intensity = 0.16 in/hr

27) $Q_{LID} = [(0.95 \times 0.75 + 0.15) \times 0.16$ in/hr $\times$ 3.5 ac $]$ = 0.48 cfs

Graphical operations supporting solution:

Figure III.6
***Graphical Operations Supporting* Example III.7**

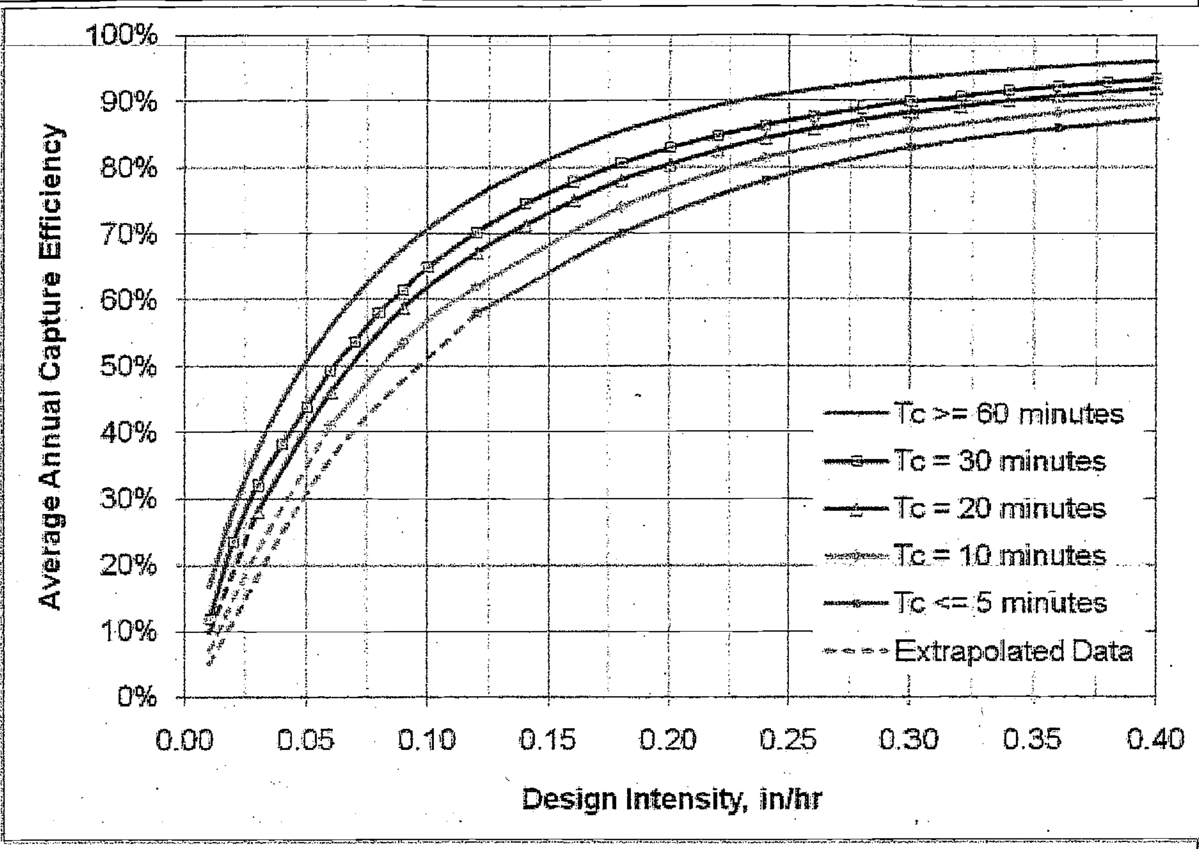


Worksheet D: Capture Efficiency Method for Flow-Based BMPs

Step 1: Determine the design capture storm depth used for calculating volume				
1	Enter the time of concentration, T_c (min) (See **Appendix IV.2**)	T_c=		
2	Using **Figure III.4**, determine the design intensity at which the estimated time of concentration (T_c) achieves 80% capture efficiency, I_1	I_1=		in/hr
3	Enter the effect depth of provided HSCs upstream, d_{HSC} (inches) (**Worksheet A**)	d_{HSC}=		inches
4	Enter capture efficiency corresponding to d_{HSC}, Y_2 (**Worksheet A**)	Y_2=		%
5	Using **Figure III.4**, determine the design intensity at which the time of concentration (T_c) achieves the upstream capture efficiency(Y_2), I_2	I_2=		
6	Determine the design intensity that must be provided by BMP, $I_{design}= I_1-I_2$	I_{design}=		
Step 2: Calculate the design flowrate				
1	Enter Project area tributary to BMP (s), *A* (acres)	A=		acres
2	Enter Project Imperviousness, *imp* (unitless)	imp=		
3	Calculate runoff coefficient, $C= (0.75 \times imp) + 0.15$	C=		
4	Calculate design flowrate, $Q_{design}= (C \times i_{design} \times A)$	Q_{design}=		cfs
Supporting Calculations				
Describe system:				
Provide time of concentration assumptions:				

Worksheet D: Capture Efficiency Method for Flow-Based BMPs

Graphical Operations



Provide supporting graphical operations. See Example III.7.

III.4. Nomograph Methods for BMP Performance Estimation

This section contains instructions for computing the performance of LID and treatment control BMPs based on the sizing and design of the system. These calculation methods are applicable where less than the full design volume is provided and it is necessary to quantify the level of control has been achieved (partial compliance) so that remaining design volume or flowrate can be calculated. The user enters these methods with a description of the system and the capture efficiency that has already been achieved by upstream BMPs. If it is desired to compute the the capture efficiency of a series of BMPs, the user starts with the upstream BMP and then repeats the steps for each sequential BMP provided.

III.4.1. Computing Capture Efficiency of Volume-based, Constant Drawdown BMP from Description of System Configuration

This section describes instructions for computing the capture efficiency for a given volume-based BMP configuration, considering the cumulative effects of upstream controls. This is applicable for BMPs that can be approximated to have a constant drawdown rate throughout the wet season and is applicable across Orange County.

Stepwise Instructions for Volume-based BMPs (without seasonally-varying use rate):

1) Determine the storage volume provided in the BMP, and use the equation presented in Section III.1.1 to back-compute the effective design storm depth provided. Divide the provided storm depth by the design capture storm depth so that it is expressed as a fraction of the DCV. For example, if 0.6 inches of storage is provided and the design capture storm depth is 0.9 inches, then the provided volume would be expressed as (0.6/0.9) = 0.67 of the DCV.
2) Compute the drawdown time of the provided storage volume per guidance provided for respective BMPs in BMP Fact Sheets (TGD Section 4).
3) Determine the capture efficiency that has already been provided upstream. This will have already been computed in a previous iteration of this method if upstream BMPs are provided. Trace a horizontal line corresponding to this capture efficiency on Figure III.2. Locate where this line intersects with the drawdown line (2). Pivot and read down to the horizontal axis. This is X_1.
4) Add the result of (1) to the result of (3). This is X_2.
5) Draw a vertical line at X_2 to intersect with the drawdown line.
6) Pivot and read to the vertical axis. This is the cumulative capture efficiency achieved by the BMP plus the upstream BMPs.

Example III.8: Determining the Capture Efficiency of a Volume-based, Constant Drawdown BMP Based on Description of System

Given:

- High Density Project in Rainfall Zone 4: 85th percentile, 24-hr storm depth = 0.95 inches
- Drainage Area = 3.5 acres
- Imperviousness = 95%
- HSCs: 0.2 inches total = 31 percent capture
- BMP Storage Volume Provided = 5,400 cu-ft with 72 hour drawdown

Required:

- Compute cumulative capture efficiency of the system described above

Solution:

1) Storage Volume Provided = 5,400 cu-ft (given).
   →Effective design storm depth, d = 5,400 cu-ft × 12 in/ft/[(0.95*0.75+0.15) × 3.5 ac × 43560 sf/ac] = 0.49 inches (See **Appendix III.1.1**)
   →Fraction of DCV = 0.49 inches/0.95 inches = 0.52

28) 72-hr constant drawdown (given)

29) 31 percent (0.2" of HSCs from **Table III.1**). From **Figure III.7**: X_1 = 0.22

30) X_2 = 0.22 + 0.52 = 0.74

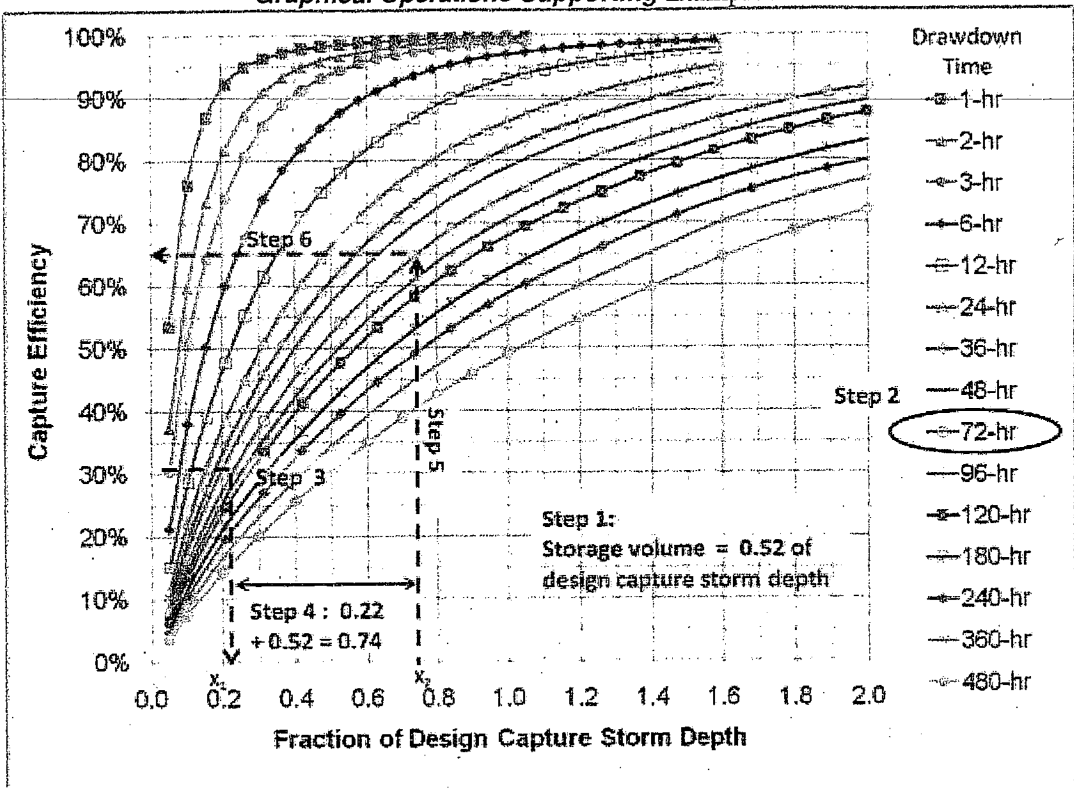
31) X_2 = 0.74 (draw line up to 72 hour drawdown line)

32) From **Figure III.7**, the cumulative capture efficiency achieved by the combination of HSCs and the volumetric BMP is 65%.

Graphical operations supporting solution:

Figure III.7

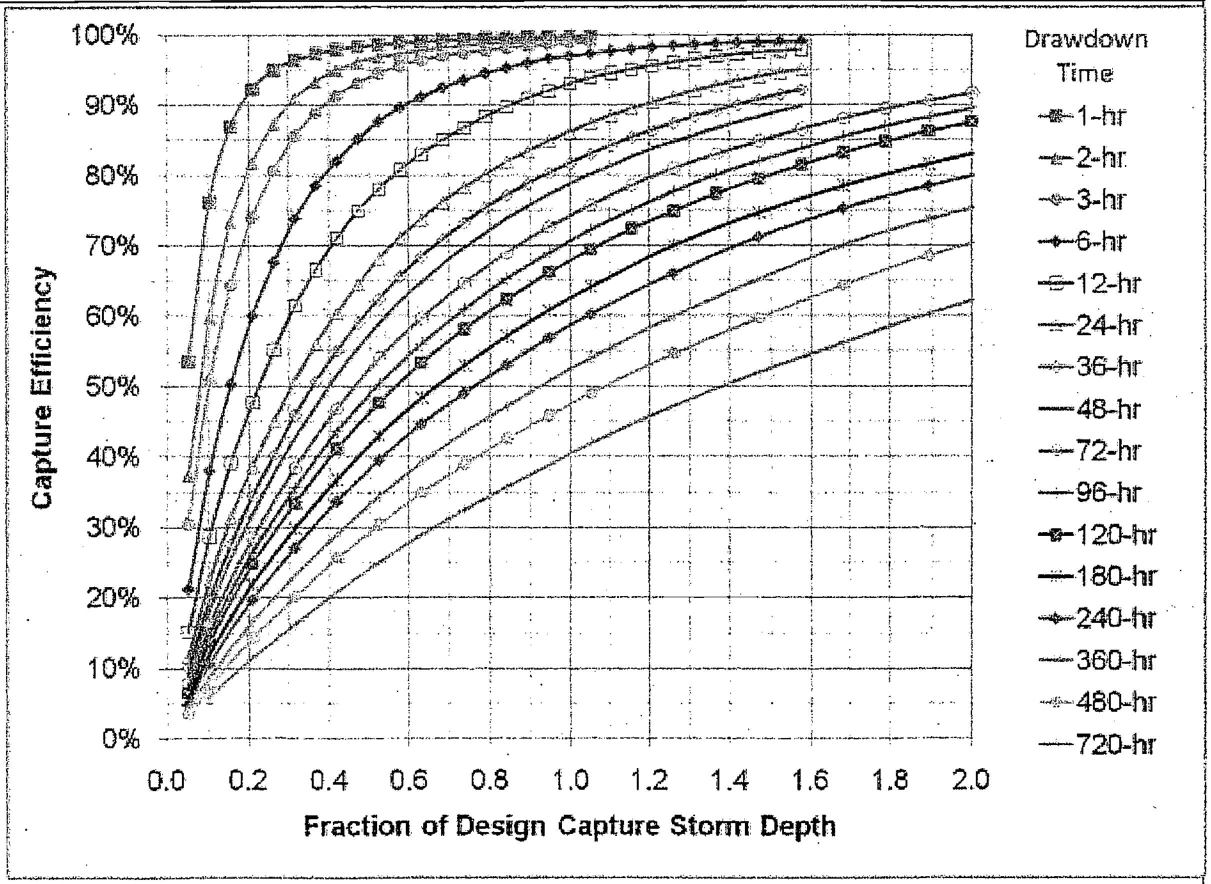
Graphical Operations Supporting Example III.8



Worksheet E: Determining Capture Efficiency of Volume Based, Constant Drawdown BMP based on Design Volume

Step 1: Determine the design capture storm depth used for calculating volume				
1	Enter design capture storm depth from **Figure III.1**, *d* (inches)	d=		inches
2	Enter the storage volume provided in the BMP, *V* (cu-ft)	V=		cu-ft
3	Enter Project area tributary to BMP (s), *A* (acres)	A=		acres
4	Enter Project Imperviousness, *imp* (unitless)	imp=		
5	Calculate runoff coefficient, $C = (0.75 \times imp) + 0.15$	C=		
6	Calculate the effective design storm depth provided (inches), $d_{provided} = (V \times 12)/(C \times A \times 43560)$	$d_{provided}$=		inches
7	Calculate the design storm depth as a fraction of the design capture depth, $X_{fraction} = d_{provided}/d$	$X_{fraction}$=		
Step 2: Calculate the capture efficiency of the BMP system				
1	Determine the drawdown time of the proposed BMP based on equations provided in the applicable BMP Fact Sheet, *T* (hours)	T=		hours
2	Enter the effect of provided HSCs upstream, d_{HSC} (inches) **Worksheet A**	d_{HSC}=		inches
3	Enter capture efficiency corresponding to d_{HSC} from Table 6.7 (regionally based), Y_1 **Worksheet A**	Y_1=		%
4	Using **Figure III.2**, determine the fraction of "design capture storm depth" at which the drawdown time (T) achieves the upstream capture efficiency(Y_1), X_1	X_1=		
5	Determine the fraction of design capture storm depth corresponding to the cumulative capture efficiency, $X_2 = X_1 + X_{fraction}$	X_2=		
6	Using **Figure III.2**, determine the capture efficiency corresponding to total fraction of design storm depth (X_2) for drawdown time (T), Y_2	Y_2=		%

Worksheet E: Determining Capture Efficiency of Volume Based, Constant Drawdown BMP based on Design Volume

Supporting Calculations
Describe system:
Provide drawdown calculations per equations in applicable BMP Fact Sheet:
Graphical Operations

Use this graph to provide the supporting graphical operations. See Example III.8.

III.4.2. Computing Average Annual Capture Efficiency of Harvest and Use BMPs with Seasonally-Varying Use Rate (Irrigation Demand) based on System Description

This section describes instructions for computing the capture efficiency for a given harvest and use BMP configuration with seasonally varying use rate (irrigation demand), considering the cumulative effects of upstream controls and is applicable across Orange County.

Stepwise Instructions for Harvest and Use BMP (with seasonally-varying irrigation demand):

1) Determine the storage volume provided in the BMP, and use the equation presented in **Appendix III.1.1** to back-compute the effective design storm depth provided. Divide the provided storm depth by the design capture storm depth so that it is expressed as a fraction of the DCV. For example, if 0.6 inches of storage is provided and the design capture storm depth is 0.9 inches, then the provided volume would be expressed as (0.6/0.9) = 0.67 of the DCV.
2) Estimate the effective irrigation area ratio of the system (*EIATA*):

$$EIATA = LA \times K_L / [IE \times \text{Tributary Impervious Area}]$$

Where:

EIATA = Effective Irrigated Area to Tributary Area ratio (ac/ac)
LA = landscape area irrigated with harvested water, sq-ft
K_L = Area-weighted landscape coefficient (see guidance and references in **Appendix X.2.5.2**)
IE = irrigation efficiency (assume 0.90)

3) Determine the capture efficiency that has already been provided upstream. This will have already been computed in a previous iteration of this method if upstream BMPs are provided. Trace a horizontal line corresponding to this capture efficiency on **Figure III.3**. Locate where this line intersects with the EIATA line (2). Pivot and read down to the horizontal axis. This is X_1.
4) Add the result of (1) to the result of (3). This is X_2.
5) Draw a vertical line at X_2 to intersect with the drawdown line.
6) Pivot and read to the vertical axis. This is the cumulative capture efficiency achieved by the BMP plus the upstream BMPs.

III.4.3. Computing Average Annual Capture Efficiency of Flow-based BMP Based on System Description

This section describes instructions for computing the capture efficiency for a given flow-based BMP configuration, considering the cumulative effects of upstream controls and is applicable across Orange County.

Stepwise Instructions for Flow-based BMPs:

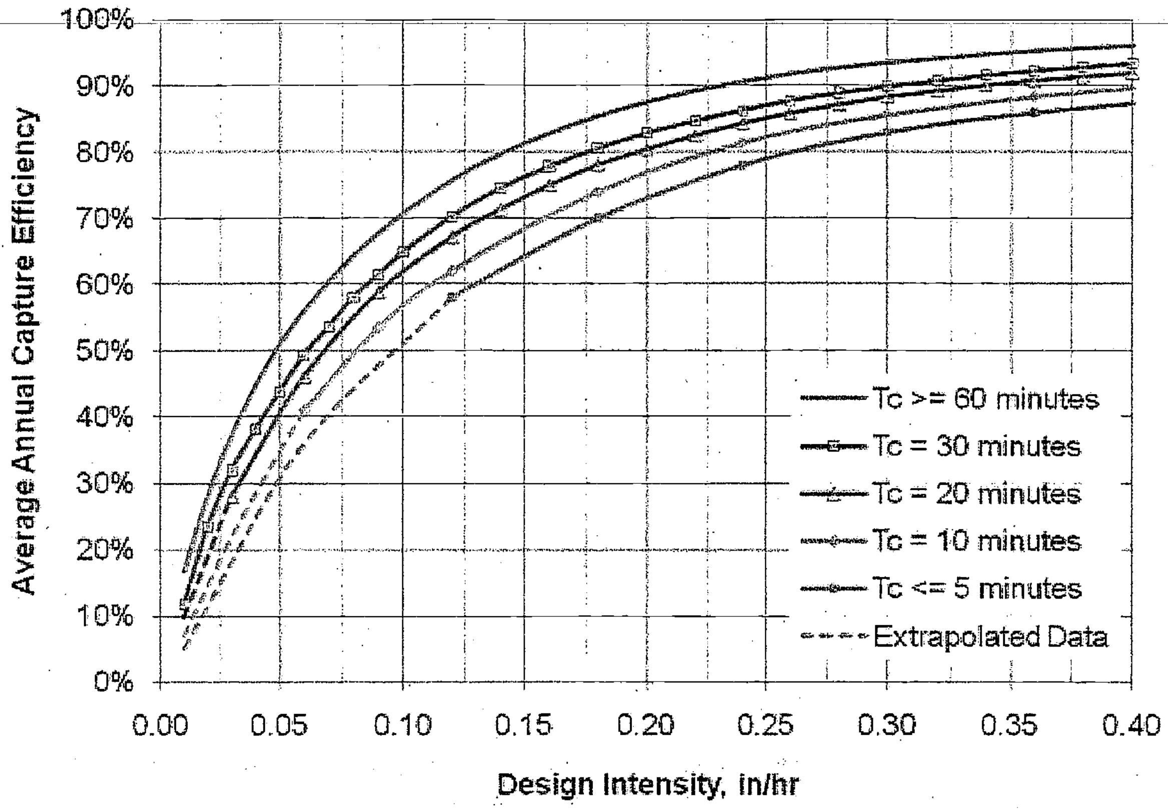
1) Determine the design flowrate of the BMP, and use the equation presented in Section III.1.1 to back-compute the effective design storm intensity provided.
2) Estimate the time of concentration (T_c) of the tributary area per Section IV.2.
3) Determine the capture efficiency that has already been provided upstream. This will have already been computed in a previous iteration of this method if upstream BMPs are provided. Trace a horizontal line corresponding to this capture efficiency on Figure III.4. Locate where this line intersects with the T_c line (2). Pivot and read down to the horizontal axis. This is I_1.
4) Add the result of (1) to the result of (3). This is I_2.
5) Draw a vertical line at I_2 to intersect with the T_c line.
6) Pivot and read to the vertical axis. This is the cumulative capture efficiency achieved by the BMP plus the upstream BMPs.

Worksheet F: Determining Capture Efficiency of a Flow-based BMP based on Treatment Capacity

Step 1: Determine the design intensity used for calculating design flowrate				
1	Determine the design flowrate of the BMP, *Q* (cfs)	Q=		cfs
2	Enter Project Imperviousness, *imp* (unitless)	imp=		
3	Calculate runoff coefficient, *C= (0.75 x imp) + 0.15*	C=		
4	Back calculate the equivalent intensity of rainfall treated in the BMP (cfs), $i_{provided}=Q/C$	$i_{provided}=$		in/hr
Step 2: Calculate the capture efficiency of theflow-based BMP				
1	Enter the time of concentration, T_c (min) (Section **IV.2**)	$T_c=$		
2	Enter the effect of provided HSCs upstream, d_{HSC} (inches) **Worksheet A**	$d_{HSC}=$		inches
3	Enter the upstream capture efficiency corresponding to d_{HSC} from Table III.1 (regionally based), Y_1 **Worksheet A**	$Y_1=$		%
4	Using **Figure III.4**, determine the design intensity at which the time of concentration (T_c) achieves the upstream capture efficiency(Y_1), I_1	$I_1=$		in/hr
5	Determine the cumulative design intensity that is provided by upstream and project BMPs, $I_2 = I_{provided} + I_1$	$I_2=$		in/hr
6	Using **Figure III.4**, determine the capture efficiency corresponding to the total intensity captured (I_2) for time of concentration (T_c) for upstream and Project BMPs, Y_2	$Y_2=$		%
Supporting Calculations				
Describe system:				
Provide time of concentration assumptions:				

Worksheet F: Determining Capture Efficiency of a Flow-based BMP based on Treatment Capacity

Graphical Operations



Provide supporting graphical operations.

III.5. Sizing Approaches for Treatment Trains and Hybrid Systems

BMP design to achieve maximum feasible retention and biotreatment for a given set of site constraints may consist of multiple parts (i.e., retention and biotreatment; volume-based and flow-based). For example, retention storage may be provided within the pores of amended soil in a bioretention area without underdrains, and the surface may function as a vegetated swale providing flow-based biotreatment. Or retention storage may be provided in a cistern which overflows to a planter box with underdrains to provide the remaining biotreatment volume.

The methods described in this Appendix can be used in combination to determine the incremental benefit of each component of the system. In most cases, the performance of the retention component would be estimated first using Section **III.4** (depending on the BMP type), and then the biotreatment component would be sized using Section **III.3.2** or **III.3.3**to achieve the remaining capture up to 80 percent capture. This process would be used for the following examples:

- Retention volume provided in bioretention below underdrains, and biotreatment volume added above the underdrains.
- Retention storage provided within the pores of amended soil in a bioretention area without underdrains, and biotreatment provide in vegetated swale on surface of bioretention area.
- Retention storage provided in a cistern which overflows to a planter box with underdrains to provide the remaining biotreatment.
- Retention volume provided in an infiltration trench which overflows to a planter box with underdrains or vegetated swale to provide remaining biotreatment.
- Other similar configurations.

The exception to this process is when biotreatment is provided upstream of a retention BMP as pretreatment. In this case, there is not another opportunity to bio-treat water should it overflow from the retention BMP. Therefore the upstream BMP must treat the entire DCV (i.e., 80 percent capture of average annual runoff) before discharging to the retention BMP. Anything that overflows from the retention BMP would already be biotreated. This process would apply in the following example and similar examples:

- Pretreatment is provided in planter boxes with underdrains that discharge pre-treated water to an infiltration gallery. The planter boxes would be sized to capture 80 percent of average annual runoff and would not bypass untreated flow to the infiltration gallery. Overflow from the infiltration gallery would be considered biotreated provide that it is treated in the planter boxes before overflowing from the infiltration gallery. If overflow occurred prior to being treated in the planter box, the overflow would not be considered biotreated