Pennsylvania Stormwater Best Management Practices Manual

DRAFT - JANUARY 2005

Section 4
Comprehensive Stormwater Management: Integrating Site Design, Non-Structural, and Structural BMP's

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Section 4 Comprehensive Stormwater Management: Integrating Site Design, Non-Structural, and Structural BMP's

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Section 4 Comprehensive Stormwater Management: Integrating Site Design, Non-Structural, and Structural BMP's

4.1 Recommended Site Design Procedure for Comprehensive Stormwater Management

Sections 5 and 6 set forth multiple Non-Structural and Structural BMP's which can be used to achieve the Recommended Site Control Guidelines for comprehensive stormwater management described in Section 3. Obviously, not all of these BMP's are appropriate for each different land development at each different site. How can BMP's be selected to maximize their performance? What is the optimal blend between Non-Structural and Structural BMP's? How can stormwater management be best integrated into the site planning process?

A Recommended Site Design Procedure for Comprehensive Stormwater Management is set forth in Figure 4-1 (also referenced to the Checklist Summary in Figure 4-2 which is discussed in Section 4.2 below). This Procedure begins with assessment of the site and its natural systems and then proceeds to integrate both Non-Structural and Structural BMP's in the formulation of a comprehensive stormwater management plan. The intent of the planning process is to promote development of stormwater management "solutions" which achieve rigorous quantity and quality standards, as set forth in Section 3, in a cost effective manner. Some aspects of the Procedure will not be fully applicable in all land development cases. For example, Non-Structural BMP's can be expected to be challenging to apply in those cases where higher densities/intensities are proposed on the smallest of sites in already developed areas, and where more highly engineered Structural BMP's may be more dominant in the comprehensive stormwater management plan.

An essential objective of the Recommended Procedure is to maximize stormwater "prevention" through use of Non-Structural BMP's (Section 5). Once prevention has been maximized, some amount of stormwater peaking and volume control likely will remain to be mitigated. These mitigative stormwater management needs should be met with an array of natural-system based Best Management Practices (Vegetated Swales, Vegetated Filter Strips, etc.), with the remaining stormwater management needs met with structural Best Management Practices such as Infiltration Basins, Trenches, Porous Pavement, Wet Basins, Retention Ponds, Constructed Wetlands, and others, all of which are presented in Section 6.

This Procedure, or a process similar to it, is an integral part of comprehensive stormwater management and transcends the bounds of conventional stormwater management which has existed in most Pennsylvania municipalities. Perhaps most importantly, the Procedure involves the total site design process, which is so essential. Conventional stormwater management has so often been relegated to the final stages of the site design and overall land development process, after most other building program issues have been determined and accommodated (and thus the frequent relegation of stormwater management practices to what appears to be the "leftover" areas of the site). To the contrary, the Procedure places stormwater management into the initial stages of site planning process, when the building program is being fitted and tested on the site. In this way, comprehensive stormwater management can be integrated effectively into the site design process.

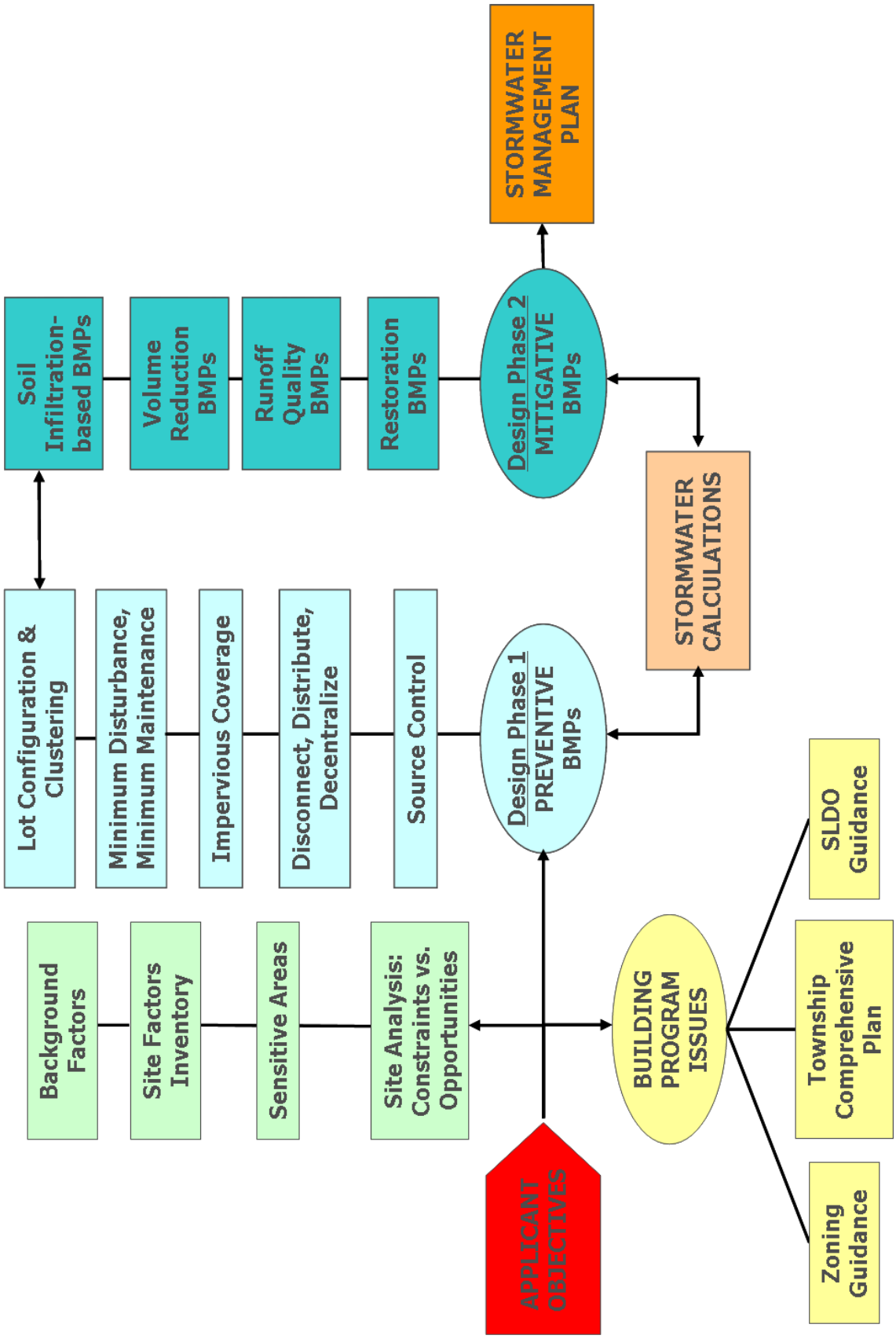

Figure 4-1 Recommended Procedure for Comprehensive Stormwater Management

Although the Procedure may appear to be far-reaching, much of the information relied on in this Procedure is information which already is being required to satisfy other sections of many existing municipal land development ordinances, such as requirements often contained in sedimentation and erosion control planning sections, sewage modules, and the like. The Procedure is intended to more effectively utilize and exploit this already-collected site data and site knowledge in order to generate better stormwater management in the context of a markedly improved site plan. To the extent that this data is not already being collected and assessed, the information needs to be collected as part of the site design process.

4.2 The Site Design Checklist for Comprehensive Stormwater Management

Coordinated with the Recommended Site Design Procedure for Comprehensive Stormwater Management is a series of questions, structured to facilitate and guide an assessment of the site's natural features, together with stormwater management needs (Non-Structural and Structural) of various land development concepts. The Site Design Checklist for Comprehensive Stormwater Management (Figure 4-2) is intended to help implement the Recommended Site Design Procedure. The initial questions in the Checklist focus on Site Analysis, including Background Site Features, a Site Factors Inventory, and Site Factors Analysis: Constraints and Opportunities. This part of the Recommended Procedure relates directly to the first Non-Structural BMP category: Protect Sensitive and Special Value Features, which include:

BMP 5.1 Protect Sensitive/Special Value Features
BMP 5.2 Protect/Conserve/Enhance Riparian Areas
BMP 5.3 Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design

Because these first steps in the Procedure are so important, they are further discussed below in Section 4.3 Importance of Site Assessment.

The Procedure continues with potentially multiple cycles of "testing" and "fitting" preventive Non-Structural BMP's at the site. The Checklist provides questions designed to facilitate the potential application of these additional Non-Structural BMP's. Once Non-Structural BMP's have been "maximized," the Recommend Procedure then continues with the testing/fitting of Structural BMP's, again facilitated by the Checklist questions. This testing/fitting of Non-Structural and Structural BMP's can continue through several cycles. At the completion of the Procedure, a comprehensive stormwater management plan emerges, satisfying appropriate Section 3 Recommended Site Control Guidelines. If these Checklist questions are addressed thoroughly and the Procedure is fully and effectively applied, the critical objective of managing stormwater comprehensively – both quantity and quality – will be achieved in a cost effective manner through this integration of Non-Structural and Structural BMP's. The Procedure, though largely common sense, constitutes a change from conventional engineering practice in many Pennsylvania municipalities.

CHECKLIST SUMMARY FOR COMPREHENSIVE STORMWATER MANAGEMENT
(Use with Site Planning and Design Procedure)

SITE ANALYSIS

1. Background Site Factors

Describe the hydrologic and natural elements

- Chapter 93 stream use designation?
  - Special Protection waters (EV, HQ)?
  - Fishery / Aquatic Life Use (WWF, CWF, TSF)?
- Any Chapter 303d/impaired stream listing classifications?
- Aquatic biota sampling?
- Existing water quality sensitivities downstream (water supply source?)?
- Location of any known downstream flooding?

2. Site Factors Inventory

Describe the size and shape of the site

- Special constraints/opportunities?
- Special site border conditions?

Describe the existing developed features of the site, if any?

- Existing structures/improvements, structures to be preserved?
- Existing cover/uses?
- Existing impervious areas?
- Existing pervious maintained areas?
- Existing public sewer and water?
- Existing storm drainage system?
- Existing wastewater system?

Describe important natural features of site

- Existing hydrology (drainage swales, intermittent, perennial)?
- Existing topography, contours, subbasins?
- Soil series found on site and their Hydrologic Soil Group ratings?
- Areas of vegetation (trees, scrub, shrub)?
- Special Value Areas?
  - Wetlands?
  - Floodplains?
  - High quality woodlands, other woodlands and vegetation?
  - Riparian buffers?
  - Naturally vegetated swales/drainageways?
- Sensitive Areas?
  - Steep slopes?
  - Special geologic conditions (limestone?)?
  - Shallow bedrock?
  - High water table?
- PNDI areas or species?

3. Site Factors Analysis

Characterize the constraint-zones at site

- Avoid development on or near special and sensitive natural features

Characterize the opportunity-zones at site

- Location of well-draining soils
- Location and quality of existing vegetation

BACKGROUND SITE CONSIDERATIONS

Figure 4-2 Checklist Summary for Comprehensive Stormwater Management

BUILDING PROGRAM

Township Comprehensive Plan and Zoning guidance?
- Guidance in Comprehensive Plan?
- Existing Zoning District?
  - Total number of units
  - Type of units
  - Density of units
- Any allowable options?

Township SLDO guidance and options?
- Performance standards for neo-traditional, village, hamlet planning?
- Reduce building setbacks?
- Curbs required?
- Street width, parking requirements, other impervious requirements?
- Cut requirements?
- Grading requirements?

Township SLDO/stormwater requirements?
- Peak rate and design storms?
- Total runoff volume?
- Water quality provisions?
- Methodological requirements?
- Maintenance requirements?

Tailor building program to fit the constraints and opportunities of the natural features?

Is applicant submission complete or fully responsive to municipal zoning/SLDO requirements?

Are municipal zoning/SLDO requirements themselves inadequate?

Is useful interaction at sketch plan or even pre-sketch plan phases occurring?

BACKGROUND SITE CONSIDERATIONS

SITE DESIGN

1. Lot Configuration and Clustering
- ***Reduce individual lot size?***
- ***Concentrate/cluster uses and lots?***
- ***Configure lots to avoid critical natural areas ?***
- ***Configure lots to take advantage of effective mitigative stormwater practices?***
- ***Orient built structures to fit natural topography?***
- ***Minimize site disturbance (excavation / grading) at site?***
- ***Minimize site disturbance (excavation / grading) for each lot?***

2. Impervious Coverage
- ***Reduce road width?***
- ***Utilize cul-de-sacs and turnarounds at reduced road width?***
- ***Reduce driveway length and width?***
- ***Reduce parking ratios?***
- ***Reduce parking sizes?***
- ***Examine potential for shared parking?***
- ***Utilize porous surfaces for applicable parking features (overflow)?***
- ***Design sidewalks for single-side street movement?***
- ***Disconnect stormwater flows from roofleaders?***
- ***Utilize rainbarrels and/or cisterns for lot irrigation?***

3. Minimum Disturbance/Maintenance
- ***Define disturbance zones for site?***
  - Protect maximum total site area from development disturbance
  - Protect naturally sensitive and special areas from disturbance

DESIGN PHASE 1: PREVENTATIVE

Figure 4-2 Checklist Summary for Comprehensive Stormwater Management

Minimize total site compaction?
Maximize zones of open space and greenways?
Consider re-forestation and re-vegetation opportunities?

4. **Preliminary Calculations for SW Management for Mitigation**
   Address management objectives of applicant?
   - runoff volume
   - recharge volume
   - runoff rate
   - non-point source pollutant loading

VEGETATED/NON-STRUCTURAL BMPs

Use of vegetative BMPs for stormwater management
- Swales?
- Filter Strips?
- Raingardens/Recharge Gardens/Bioretention Beds?
- Berms, Level Spreaders, other grading techniques?

Consider short- and long-term maintenance

STRUCTURAL BMPs

Use structural, infiltration BMP's
- Infiltration Basin?
- Infiltration Trench?
- Porous pavement with recharge bed?

Where infiltration is infeasible, use pollution control practices
- Water quality devices?
  - Wet pond/retention basin?
  - Constructed wetland?
  - Extended detention pond?
  - Multi-chamber catch basin and inlets?
  - Sand and sand-peat filter?

Where infiltration is infeasible, use other volume control practices
- Roof garden or vegetated roof?

Consider short- and long-term maintenance

STORMWATER METHODOLOGY AND CALCULATIONS

1. **Iterative process occurring throughout planning and design processes**
   Soil Cover Complex Method (TR-55) is industry standard for calculations
2. **Strive to achieve two basic goals**
   Minimize the pre to post development increase for Curve Numbers
   Maximize predevelopment Time of Concentration
   Assume "conservative" pre-development conditions
   Respect natural sub-areas in the design and engineering calculations
3. **Strive to achieve 4 standards of Comprehensive Stormwater Management**
   No increase in total volume of runoff from pre to post development, for up to the 2-yr storm
   No reduction in total volume of recharge, for up to the 2-yr storm
   No increase in peak rate of runoff
   No increase in pollutant loading

STORMWATER PLAN

DESIGN PHASE 2: MITIGATIVE

STORMWATER CALCULATIONS

Figure 4-2 Checklist Summary for Comprehensive Stormwater Management

4.3 Importance of Site Assessment

Comprehensive stormwater management begins with a thorough assessment of the site and its natural systems. This includes inventorying and evaluating the various natural resource systems which define each site and which pose both problems – as well as opportunities – for site development and stormwater management. Resources include the full range of natural systems – water quantity and quality, floodplains, riparian areas, wetlands, soils, geology, vegetation, and more. Natural systems range in scale from resources of areawide importance on a macro scale, down to more micro- and site-specific scale.

Comprehensive stormwater management, as set forth in the Recommended Site Design Procedure for Comprehensive Stormwater Management (Figures 4-1 and 4-2), sets forth a basic approach to understanding the site in the broader context of its watershed and relevant natural systems context, based on a reasonable inventory and analysis process:

4.3.1. Background Site Factors

Broader system characteristics should be described, including State Chapter 93 stream classifications, presence of Special Protection Waters, stream order (i.e., 1st order, 2nd order, etc.), source water supply designations, 303d/TMDL/Impaired Stream designations, flooding history, and other information which provides an understanding of how a particular site is functioning within its watershed context. More specific questions would include:

Does the site drain to special waterbodies with special water quality needs?
Determine if the site ultimately flows into a reservoir or other type of impoundment where special water quality sensitivities exist, such as use as a water supply source.
Determine if other special fishery issues exist.
Determine if the site is linked to a special habitat system, such as delineated in the Pennsylvania Natural Diversity Inventory. For both water quality and temperature reasons, approaches and practices that achieve a higher order of protection may become especially important.

Are there known downstream flooding problems?
Determine if stream system to which the site discharges is characterized already by flooding problems, especially important where urbanization already has occurred and where hydrology already has been impacted. Unfortunately the existing FEMA mapping and related studies don't adequately assess this issue. County agencies and possibly other sources may be able to indicate anecdotally the extent to which downstream flooding is already a problem or has potential to become a problem if substantial additional development is projected, in which case a cautionary flag should go up. If so, greater care should be taken in both floodplain management as well as stormwater management.

Does the site discharge to 1st, 2nd, 3rd order streams?
Another important question relates to a site's location within its watershed. All else being equal, sites located near the base of watersheds have a lesser degree of potential hydrologic impact in the watershed system (i.e., the longer the route or routing of whatever additional stormwater is generated, the greater the potential problem this stormwater may cause). Sites located farther up in watersheds closer to headwaters are potentially more problematic when additional stormwater is generated. Conversely, and perhaps even more critical, sites located within headwaters must be managed most carefully in terms of stormwater so as to maintain

pre-development infiltration and groundwater recharge rates. In so doing, critical stream base flow will be maintained and the aquatic community supported.

4.3.2. Site Factors Inventory

Site-specific factors that influence comprehensive stormwater management include the following items:

How does site size and shape affect stormwater management?

As site size increases, ability to use different comprehensive stormwater management Non-Structural and Structural BMP's increases. As site size decreases, some aspects of BMP's may become more challenging to implement, although comprehensive stormwater management especially through Non-Structural BMP's can reduce space requirements at a site and therefore offer greater flexibility than the conventional site design approach (examples range from the clustering of dwellings in concentrated areas to elimination of conventional stormwater structural measures such as basins). Oddly shaped sites also usually can be better adapted with BMP's set forth here, given that wide variety of shapes and sizes.

What are the important natural features characterizing the site?

At the heart of the comprehensive stormwater management Procedure is an understanding of the natural areas (systems) characterizing each site. Existing vegetation and soil have tremendous importance and are key in so many different ways to understanding land development impacts on natural systems. Careful accounting of existing vegetation is an important prerequisite for comprehensive stormwater management, followed closely by soils mapping, including classification by permeability rating into Hydrologic Soil Group categories, followed closely by basic site hydrology in order to understand natural predevelopment surface flow patterns. Critical site features, such as wetlands, floodplains, riparian areas, natural drainageways, special habitat areas, special geological formations (e.g., carbonate), steep slopes, shallow depth to water table, shallow depth to bedrock, and other factors must be inventoried and understood. Critical areas include special value areas that are distinguished by special positive functions that can be translated into real economic value or benefit. Elimination of/reduction in these functions through the land development process creates real economic losses. These special value areas—including wetlands and floodplains and riparian areas—must be conserved and protected during land development. Critical natural areas also include sensitive areas, such as steep slopes, shallow bedrock, high water table areas, and other constraining features, where encroachment by land development typically creates increased negative impacts of one sort or another. Both types of impacts should be avoided.

4.3.3. Site Factors Analysis

Given all of the above, what site factors constrain comprehensive stormwater management and in what ways? What site factors can be viewed as opportunities?

How is the site constrained?

Determine where buildings, roads, and other disturbance should be avoided, in terms of natural factors (viz., Primary Conservation Areas, Secondary Conservation Areas a la PADCNR's *Growing Greener 4-Step Design Process*)

Where are the zones of site "opportunity," in terms of stormwater management?
Determine where most infiltration occurs in terms of vegetation, in terms of soils. Both constraints and opportunities are grounded in the natural systems present at the site. Constraints and opportunities are not necessarily simple converses of one another, although these relationships often do hold. For example, certain types of critical natural areas should be viewed as constraints in terms of direct land disturbance and building construction, yet also provide significant opportunity in terms of stormwater management, quantity and quality. Woodlands, which should be protected from direct land development, provide excellent opportunity for stormwater management, provided that the correct approaches and practices are used. Vegetated riparian buffers should not be disturbed by building and road construction, yet can be used carefully with level spreading devices to receive diffuse stormwater runoff. Soils with maximum permeabilities at the site should not be paved over with buildings and roads, but used for stormwater management where feasible. Conversely, buildings and other impervious areas should be located on those portions of a site with least permeable soils, all else being equal. Site opportunities for volume control can typically be defined in terms of vegetation types which minimize runoff, as well as soil types with maximum permeabilities.