TMDLs to Stormwater Permits Handbook
Abridged Version
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INTRODUCTION

The purpose of the Handbook is to provide information to total maximum daily load (TMDL) practitioners and National Pollutant Discharge Elimination System (NPDES) stormwater permit writers (referred to as *TMDL writers and permit writers* throughout the Handbook) on the following:

- Current methods and other potential options for developing more precise WLAs for stormwater sources (referred to simply as *sources* throughout this Handbook)
- TMDL implementation plans including best management practice (BMP) and other stormwater management strategy recommendations
- Approaches for translating TMDL WLAs and implementation recommendations into NPDES stormwater permit requirements and implementation strategies.

A summary of the content of each chapter of the Handbook is included in Table 1 and in the following sections.

Table 1. Summary of Contents of *TMDLs to Stormwater Permits Handbook* by Chapter

Section	What's Included
Chapter 1: Understanding the Connections between TMDLs and Stormwater Permits	▪ Overview of the TMDL and stormwater programs. ▪ Discussion of the challenges associated with connecting TMDLs and stormwater permit requirements.
Chapter 2: Identifying Opportunities to Coordinate TMDLs and Stormwater Permits	▪ Overview of activities used by various states agencies to promote better coordination and communication among TMDL and permit writers. ▪ Discussion of opportunities to promote better coordination between TMDLs and stormwater permits at different stages of the development process.
Chapter 3: Characterizing Impairments and Stormwater Sources	▪ General description of the types of impairments resulting from stormwater. ▪ Description of the commonly used types of data analyses to understand the impairment being addressed in a TMDL. ▪ Discussion of setting TMDL targets for TMDLs with stormwater sources. ▪ Discussion of identifying potential sources to include in the TMDL analysis. ▪ Description of the types of data generated by stormwater discharges that TMDL writers can use to better understand the relative contribution of stormwater sources to a waterbody impairment.
Chapter 4: Developing TMDLs with Stormwater Sources	▪ Discussion of considerations for selecting an approach for developing TMDLs with stormwater sources. ▪ Description of commonly analytical approaches that can be used for developing stormwater-source TMDLs. ▪ Identification of factors that affect how stormwater sources are addressed in the TMDL analysis. ▪ Discussion of and examples illustrating options for calculating and expressing stormwater WLAs.
Chapter 5: Promoting Effective Stormwater Management	▪ Description of possible stormwater management strategies and techniques for evaluating and selecting appropriate strategies for reducing pollutant loads to achieve WLAs.

Section	What's Included
Chapter 6: Coordinating TMDLs and Stormwater Permit	▪ Discussion of the type of requirements (e.g., water quality controls and effluent limitations, monitoring and adaptive management, reporting) TMDL and permit writers should work together to develop. ▪ Options for connecting requirements through TMDL and stormwater permit language.
Appendix	▪ Excerpts of TMDLs, implementation plans, and stormwater permit requirements to illustrate how states connect permitted stormwater source requirements among programmatic documents.
Bibliography	▪ Comprehensive list of documents, Web sites, and databases that are included in the Resources section of each chapter or cited in the Handbook.
Glossary	▪ Definitions of key terms introduced throughout the Handbook.

CHAPTER ONE: UNDERSTANDING THE CONNECTIONS BETWEEN TMDLS AND STORMWATER PERMITS

Understanding the regulatory, programmatic, and technical issues associated with the TMDL and NPDES Stormwater programs can help TMDL and permit writers improve cross-program connections, leading to better TMDLs and stormwater permits. This chapter of the Handbook briefly summarizes the key statutory and regulatory elements of these two programs, with the goal of informing permit writers about the TMDL program and TMDL writers about the NPDES stormwater program.

This chapter of the Handbook provides a discussion of what every permit writer should know about the basic steps of the TMDL development process, including the following:

- Stakeholder involvement and public participation to engage affected parties and solicit input, feedback and buy-in for a successful TMDL. This process can occur throughout the TMDL development (and implementation) process.
- Watershed characterization to identify the waterbody, watershed, and impairment conditions; TMDL targets; and potential sources.
- Linkage analysis to calculate the loading capacity.
- Allocation analysis to evaluate and assign wasteload allocations (WLAs) to point sources and load allocations (LAs) to nonpoint sources.
- Developing the TMDL report and administrative record for submittal to EPA.
- TMDL implementation to identify management activities to implement WLAs and LAs.

In addition, the Handbook reviews what every TMDL writer should know about the basic elements of the NPDES stormwater program, including the following:

- EPA authorizes states to act as the NPDES permitting authority. Where states do not have this authorization, EPA Regional offices serve as the NPDES permitting authority and administer the NPDES program.
- Permitting authorities can develop and issue general or individual permits to authorize three types of stormwater discharges: (1) municipal separate storm sewer system (MS4) discharges; (2) stormwater discharges associated with industrial activity; and (3) stormwater discharges associated with construction activity.
- The regulatory definition of an MS4 refers to both the type of infrastructure regulated under a stormwater permit and the type of entity. In addition to a system of pipes, MS4s can also include drainage systems for roadways, gutters, and ditches. In addition to municipalities, MS4 permittees can include a variety of entities

that own and operate MS4 infrastructure, such as departments of transportation, military bases, universities, hospitals, and prisons.

- Stormwater permit requirements generally apply to the areas that meet the regulatory definition of an MS4, industrial facility, and construction activity. As a result, a regulated area (e.g., the infrastructure boundary of an MS4) can differ from the jurisdictional boundary of the regulated entity (e.g., a municipality's jurisdictional boundary).
- The Clean Water Act (CWA) requires NPDES permits to contain technology-based effluent limits and water quality-based effluent limits (WQBELs) when the technology-based limits alone do not adequately protect water quality. Permits for MS4s, however, must require controls to reduce the discharge of pollutants to the maximum extent practicable (MEP) to protect water quality. Generally, stormwater permits require implementation of BMPs, identified as narrative effluent limits, deemed by the permitting authority to be appropriate to meet the intent of the CWA.
- Operators of MS4s develop and implement SWMPs that cover a variety of activities discharging to the MS4, while operators of industrial facilities and construction activities must develop and implement facility-specific stormwater pollution prevention plans (SWPPPs).

Improving the ways in which water quality programs work together and relate to one another often presents challenges because of programmatic, regulatory, and technical differences. This chapter of the Handbook presents and discusses key challenges between the TMDL program and the NPDES stormwater program, including the following:

- Addressing differences in organizational structure
- Developing consistent stormwater allocations in TMDLs
- Translating numeric TMDL WLAs into implementation strategies and permit requirements
- Reconciling spatial boundaries of TMDLs with boundaries of NPDES stormwater permits
- Incorporating monitoring, tracking, and adaptive management elements into TMDL WLAs and stormwater permits

CHAPTER TWO: IDENTIFYING OPPORTUNITIES TO COORDINATE TMDLS AND STORMWATER PERMITS

Improving the connection between TMDLs and stormwater permits can start with TMDL and permit writers taking steps to improve communication through programmatic and institutional efforts. This chapter of the Handbook addresses efforts such as (1) coordinating programmatic schedules and activities and (2) developing institutional and organizational communication mechanisms.

TMDL and permit writers can examine each program's schedule to determine the timing for (1) waterbodies and watersheds with ongoing TMDL development activities for impairments with known or suspected stormwater sources; (2) waterbodies and watersheds with planned TMDL development activities for impairments with known or suspected stormwater sources; and (3) general and individual stormwater permits nearing expiration, expired, or administratively continued discharging to impaired waterbodies or within impaired watersheds that have ongoing or planned TMDL development activities.

Organizational structures that affect how easily staff from the two programs can work together also influence TMDL and permit writer coordination and collaboration. Several EPA Regions and state agencies have reorganized to bring the TMDL and NPDES Stormwater programs under a common management unit (e.g., branch, division, group). Some have gone beyond bringing the programs together and have taken steps to ensure further integration either by developing TMDL-stormwater teams or specific positions tasked with promoting stormwater-source TMDL implementation.

This chapter of the Handbook also addresses how improved coordination and communication between TMDL and permit writers can affect stakeholder involvement in developing and implementing TMDLs with stormwater sources. Because stormwater sources have a great deal of the data and information in key permit documents, it is important for these sources to participate throughout the process. Permit writers can help to encourage stormwater sources to participate in the TMDL development process and facilitate information sharing. Although TMDL writers are likely to work with permit writers to obtain permit-related information from stormwater sources, there might be instances when TMDL writers have to go directly to stormwater sources to obtain information and data. Stormwater sources might have an additional level of comfort and willingness to share information knowing their permit writer is involved in the process.

CHAPTER THREE: CHARACTERIZING IMPAIRMENTS AND STORMWATER SOURCES

Chapter Three of the Handbook discusses the process of *watershed characterization* for stormwater-source TMDLs. Watershed characterization provides a thorough understanding of the waterbody and watershed characteristics, available data, causes of impairment, sources, water quality standards, and potential targets. This step provides the necessary background information to support decisions regarding the approach used for calculating the TMDL, the level of detail or focus of the analysis, and ultimately TMDL implementation. This chapter discusses the following elements of watershed characterization:

- Understanding the impairment
- Identifying TMDL targets
- Identifying and assessing potential sources

Understanding the Impairment

Understanding the impairment(s) being addressed by a TMDL is critical to establishing appropriate TMDL targets, identifying potential sources and eventually selecting a technical approach for calculating the loading capacity. The main objective of this step is to identify the nature of the impairment(s) being addressed by the TMDL, including location, timing, and magnitude of impairment. This section first introduces the commonly observed impairments associated with stormwater and discusses how stormwater can affect waterbody conditions. The section then describes the types of data analyses used to characterize the impairments, highlighting the issues unique to developing stormwater-source TMDLs. Types of data analyses discussed include the following:

- **Identifying Pollutants or Other Causes of Impairment.** Impaired waterbodies affected by stormwater sources are often listed as impaired due to such things as *biological impairment* or *habitat alteration* rather than for specific pollutants (e.g., metals, sediment). These listings are typically based on biological assessments or violations of biocriteria. Biological communities can show a response from multiple stressors or from a series of combined stressors such as water column pollutants, flow alterations, channel alterations, and other habitat alterations. Therefore, it might be difficult to identify the pollutant or suite of pollutants affecting the biological community. This section discusses the use of such analyses as Stressor Identification to identify pollutants for which to develop TMDLs for waters impaired by stormwater.
- **Identifying Spatial Patterns.** Analyzing waterbody data to identify spatial variations in waterbody, watershed and impairment conditions can help to identify sources or waterbody or environmental conditions that are contributing to impairment. This section discusses ways of evaluating data to identify spatial patterns, including generally reviewing variations in conditions throughout the watershed, analyzing data collected upstream and downstream of an expected source, and analyzing data representative of spatially variable conditions such as land use. For example, comparing monitoring data from sites representative of heavily developed commercial or industrial areas to data representative of residential or undeveloped areas can help to evaluate the relative significance of the different land use types discharging to an MS4.
- **Identifying Temporal Trends.** Temporal analysis of waterbody and watershed data serves to evaluate the timing of impairment and potential source loading or other conditions contributing to the impairment. Temporal variations in water quality, whether from month to month or year to year, can be the result of trends

in environmental conditions, such as weather and resulting runoff and flows, or from variations in loading because of schedules or variations in source activities. For example, open areas or parks that drain to MS4s can experience increased wildlife activity or dog walking during summer months, potentially increasing pathogen loads. Similarly, increased loads of sediment or chlorides can occur during winter months from use of sand and deicers on roadways during winter weather. This section discusses data analyses for evaluating temporal trends to identify stormwater sources and understand their impacts, including evaluation of short- and long-term variations in waterbody conditions and the evaluation of the temporal variations in and relationship between flow and waterbody conditions.

- **Evaluating Relationships among Parameters.** Analysis of the relationships among multiple parameters or waterbody measures (e.g., pollutant concentration and flow) supports a better understanding of impairment conditions and identification of potential sources. This section discusses using data analyses to understand such relationships as pollutants following similar patterns because they originate with common sources or are associated with other pollutants (e.g., sediment-absorbed nutrients or metals). For example, sediment, chlorides, and litter are often associated with road maintenance for snow and ice removal. Observed impairments by these parameters in the same waterbody segment might indicate snow removal activities as a source of pollutants delivered through an MS4.
- **Identifying Critical Conditions.** Evaluating the critical conditions builds on the previous analyses of spatial and temporal trends and relationships among pollutants and processes and identifies the combination of environmental conditions (physical, chemical, and biological) under which impairment occurs. When addressing stormwater sources, understanding the critical conditions can be crucial when identifying a TMDL target. Especially without an applicable numeric water quality criterion or when dealing with a biological impairment, evaluation of the critical conditions will help determine the causes and conditions associated with the impairment, such as times of elevated pollutant concentrations or high flows. As with all the other analyses discussed, understanding critical conditions can provide clues about the location, timing, and type of sources affecting impairment and guides selection of an appropriate TMDL development approach.

Identifying TMDL Targets

All TMDLs must have a numeric target for which to calculate a loading capacity. Figure 1 illustrates the potential steps or options for developing targets for TMDLs that include stormwater sources. When developing a TMDL for a waterbody listed for a specific pollutant that has an associated numeric criterion, the criterion serves as the target for the TMDL. However, many impaired waterbodies affected by stormwater sources are listed as impaired by pollutants with narrative criteria (e.g., sediment, nutrients) or due to biological impairments (e.g., biological assessments indicate poor benthic communities, increase in *tolerant* species, or decrease in fish populations). This section discusses the options for identifying numeric targets for stormwater-source TMDLs, including the identification of numeric targets for pollutants based on data analysis (e.g., reference conditions, historical conditions) or appropriate site-specific or regional literature values and also the use of surrogate measures (e.g., flow, impervious cover).

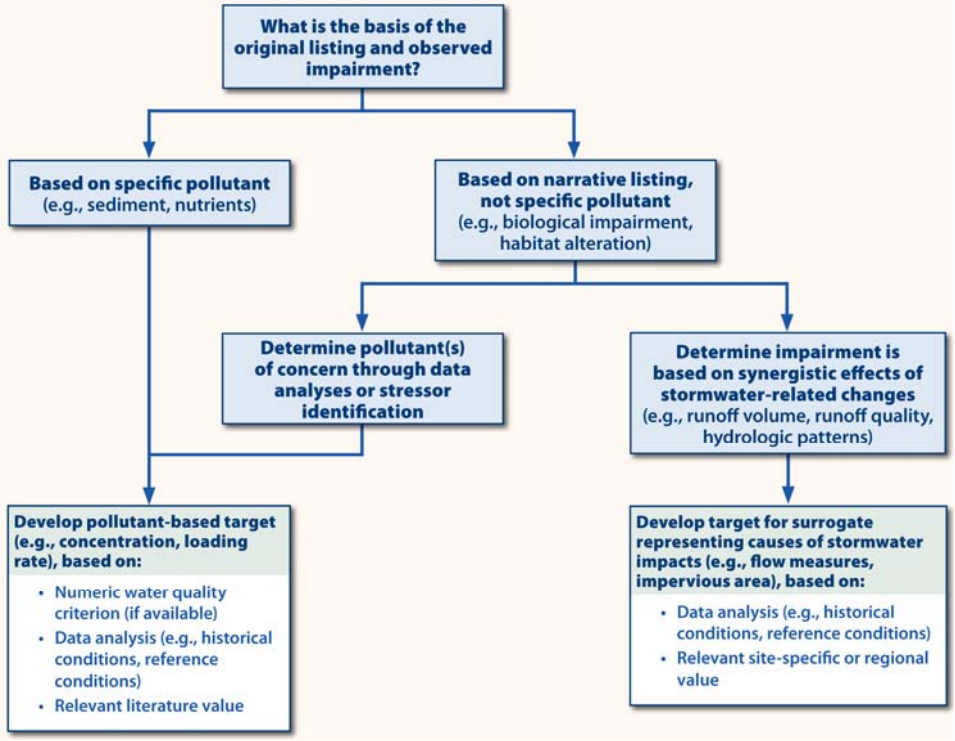

Figure 1. Options for identifying targets for TMDLs that include stormwater sources.

Identifying and Assessing Potential Sources

The step of identifying sources for TMDL development should be an extension of the data analyses conducted to understand the impairment and serves to further characterize the important sources and better define their location, behavior, magnitude, and influence. The source assessment should result in an understanding of what major sources are contributing to impairment and how (e.g., pollutants, delivery pathways). This section discusses the information available to support the following activities to further define and characterize stormwater sources:

- Identify type and general location of stormwater sources
- Delineate drainage area for stormwater sources
- Characterize discharge from stormwater sources

This section discusses the complexities of identifying regulated versus unregulated stormwater sources, as illustrated in Figure 2. This section describes the national and state resources (e.g., Regional and state NPDES coordinators, PCS, eNOI) and types of analyses or activities (e.g., field reconnaissance, evaluation of land use) that can be used to identify stormwater sources. It also identifies the types of information generated by stormwater sources that can support their identification and characterization, as outlined in Table 2.

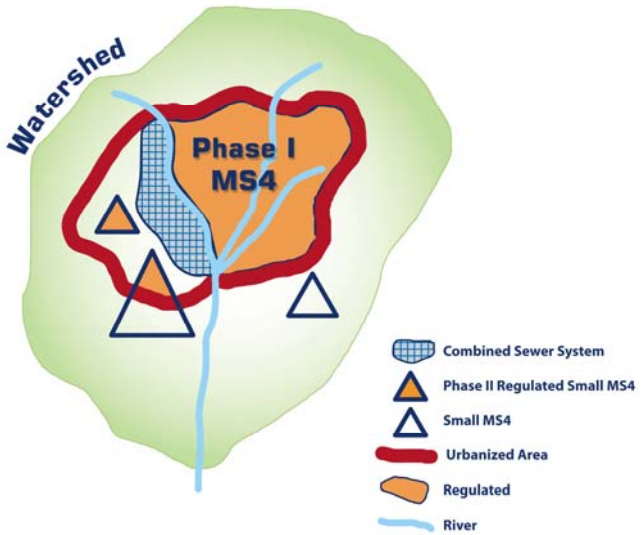

Figure 2. Potential spatial complexities of regulated and unregulated stormwater sources.

Table 2. Data and information generated by stormwater sources through the permitting process

Stormwater permit document or activity	Specific type of data generated by permittee
MS4 discharger generated data	
Phase I MS4 permit application	▪ Description of land use and 10-year growth projections ▪ Outfall characterization sampling data ▪ Receiving waters
Phase II MS4 general permit NOI	▪ MS4 location and boundaries ▪ Receiving waters
Industrial facility inventory and inspections (Phase I MS4s)	▪ Location of industrial facility to determine the watershed ▪ Activities, materials, and physical features of the industrial facility that might be sources of pollutants of concern during dry or wet weather ▪ Prioritization based on location, pollutants of concern, etc. ▪ Compliance history of industrial facility ▪ Location and pollutants of concern from nonregulated industrial (and perhaps commercial) facilities
Construction activities inventory and inspections	▪ Location of construction activity ▪ Size of disturbed area ▪ Receiving water/watershed ▪ Prioritization based on size, location, compliance history, etc. ▪ Compliance history of project ▪ Number and location of nonregulated (less than one acre) construction projects
IDDE and tracking	▪ Outfall map with receiving waters ▪ Dry weather screening ▪ Tracking of citizen complaints, dumping, spills, restaurant inspections, etc.
Post-construction BMP implementation and tracking	▪ Types of BMPs required ▪ Locations of BMPs ▪ Operation and maintenance (O&M) records/agreements ▪ Inspection results
Outfall and ambient water quality monitoring data	▪ Characterization of discharges from particular land use types, subwatersheds, etc. ▪ Ambient data could provide baseline information before installing BMPs ▪ Habitat assessments might be part of monitoring program
Annual reports	▪ Location and type of identified illicit discharges ▪ Location of approved erosion and sediment control plans ▪ Compiled post-construction BMP inspection results ▪ Compiled monitoring results ▪ Planned SWMP changes
Industrial discharger generated data	
Industrial individual permit application	▪ Location of outfalls ▪ Site drainage map ▪ Impervious area calculation ▪ Description of proposed activities, spills and leaks, on-site materials ▪ Sampling data (if available)
Industrial general permit NOI	▪ Location of facility ▪ Receiving water/MS4 ▪ Applicable industrial sector
Industrial SWPPP	▪ Location of industrial facility to determine the receiving water(s) and if the facility is within an MS4 boundary ▪ Activities, materials, and physical features of the industrial facility that might be sources of pollutants of concern during dry or wet weather ▪ Map that shows outfalls into receiving waters
Monitoring data	▪ Loading from facility for benchmark discharge monitoring parameters
Industrial compliance evaluations and inspections	▪ Assess any compliance or BMP implementation issues on-site which may contribute to loading

Stormwater permit document or activity	Specific type of data generated by permittee
Industrial sampling data	▪ Loading from particular facilities ▪ Assess general loading from types of industrial facilities ▪ Assess industrial loading from an MS4
Construction project generated data	
Construction individual permit application	▪ Location of construction activity ▪ Total area and total disturbed area ▪ Proposed BMPs ▪ Runoff coefficient ▪ Imperviousness created ▪ Receiving water
CGP NOI	▪ Location of construction activity ▪ Start/end dates ▪ Total disturbed area ▪ Receiving water
Construction activity SWPPP	▪ Location and size of disturbance as well as a location with associated surface water discharges. ▪ A description of any discharge associated with industrial activity other than construction and the location of that activity on the construction site. ▪ Type and location of any post-construction BMPs to be implemented on-site
Monitoring data	▪ Loading from project

CHAPTER FOUR: DEVELOPING TMDLS WITH STORMWATER SOURCES

This chapter discusses the activities related to calculating the TMDL and its associated allocations, including the unique technical considerations that affect what approaches can be used and how they are applied for stormwater-source TMDL. The chapter first introduces several approaches for developing stormwater-source TMDLs and then discusses the following:

- Selecting an approach for developing the stormwater-source TMDL
- Applying that approach to develop the TMDL
- Expressing stormwater WLAs

The types of TMDL approaches discussed fall into to two major categories—modeling approaches and non-modeling approaches (e.g., load duration curves, mass-balance analyses). Within those categories, the various types of approaches are further characterized according to the type of simulation or calculation they perform—either calculation of land-based loads or of the resulting waterbody loads. Table 3 presents the types of approaches discussed in this section and their respective categories of modeling vs. non-modeling and land-based vs. waterbody-based. The *land-based* approaches calculate loading from land-based runoff processes assuming some measure of precipitation and characteristics representative of the watershed (e.g., soils, imperviousness). The *waterbody-based* approaches calculate the *delivered* load in the waterbody on the basis of in-stream conditions, either using observed monitoring data (i.e., concentration and flow) or assuming some user-defined load inputs and outputs. Many of these approaches are applied in combination to represent both source loading and waterbody response to establish a loading capacity and associated WLAs and LAs to meet water quality standards.

Table 3. Commonly used TMDL approaches

Calculation process	Type of TMDL approach	
	Modeling	**Non-modeling**
Land-based	▪ Watershed models (simple to complex)	▪ Export coefficients ▪ IC method ▪ Simple Method
Waterbody-based	▪ Receiving water models (simple to complex, hydrodynamic and water quality)	▪ Load duration method ▪ Percent reduction method ▪ Mass balance or steady-state analysis

The Handbook provides brief descriptions of these TMDL approaches and then provides more detail on their selection and application for stormwater-source TMDLs.

Selecting an Approach for Developing Stormwater-Source TMDLs

TMDL writers often consider a number of factors when deciding which approach to use to calculate the loading capacity and associated LAs and WLAs for TMDLs. As shown in Figure 3, these can include user needs or requirements, programmatic considerations, and technical needs. While user needs and programmatic considerations often guide the general type of approach (e.g., simple vs. complex, modeling vs. non-modeling), the technical considerations often guide the selection of a specific approach or methodology. The technical considerations define the following three needs for the TMDL analysis:

- Spatial scale/resolution
- Temporal resolution/time scale
- Processes or features that need to be included (e.g., pollutant type, surface runoff, in-stream transport)

The watershed characterization step of TMDL development (Chapter 3) should generate the necessary information to define these needs by providing an understanding of the impaired waterbodies, the surrounding watershed and the associated impairments. Specifically, the major considerations or questions that were addressed during the watershed characterization that can support selection of an appropriate approach for TMDL development include the following:

- What are the applicable water quality criteria?
- What are the sources?
- What are the impairments and associated critical conditions?

Table 4 summarizes the considerations related to each of the three technical needs for these defining topics of water quality standards, impairment, and sources. The answers to the questions outlined in Figure 3 and more specifically in Table 4 will guide approach selection for TMDL development. While these questions and considerations will not be much different for a stormwater-source TMDL than for any other TMDL, this section of the Handbook discusses the potentially unique issues related to stormwater that will affect the selection of an appropriate approach for TMDL development. Issues might include the use of surrogate measures to represent water quality standards, decisions on the level of detail in representing stormwater sources (e.g., isolating loads from regulated boundary, land uses with regulated boundary) and capturing critical processes that might affect stormwater-related impairments (e.g., flow variations).

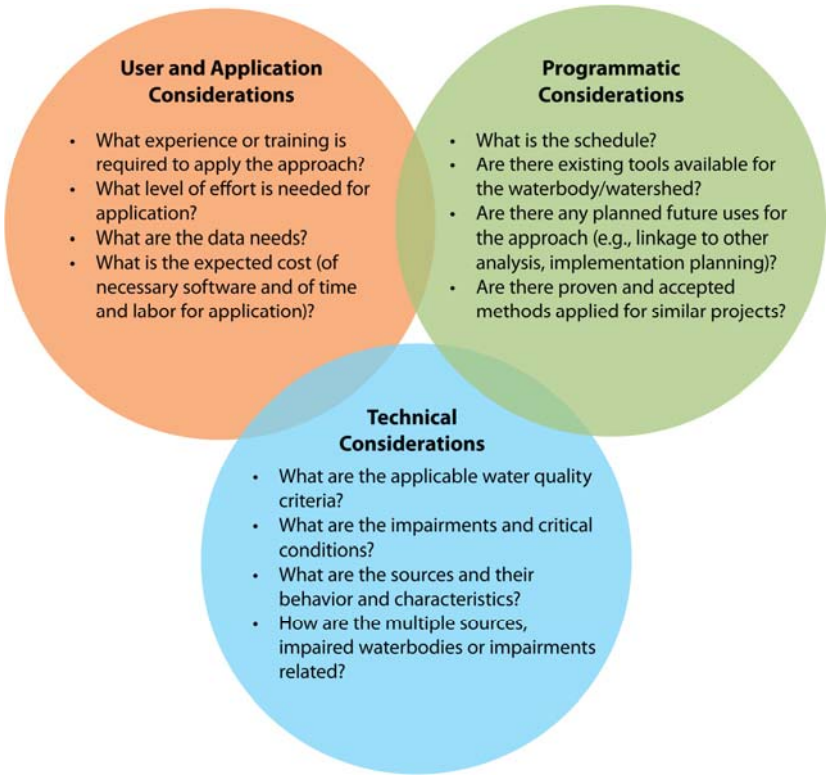

Figure 3. Considerations for selecting a TMDL development approach.

Table 4. Summary of technical considerations for selecting a TMDL development approach

Technical needs of approach	Technical considerations for approach selection		
	Water quality criteria and TMDL targets	**Impairments and critical conditions**	**Sources**
Spatial Needs	▪ Are different criteria or TMDL targets applicable in different locations within the watershed?	▪ How many impaired segments are being addressed? ▪ What are the location and distribution of impaired segments?	▪ What type of sources/land uses exist in the watershed? ▪ What are the location and distribution of sources? ▪ At what level do the sources need to be isolated (e.g., gross loading vs. land use specific loading)?
Time-scale Needs	▪ What are the duration and frequency of applicable criteria or targets?	▪ What is the timing associated with impairment (e.g., instantaneous vs. chronic or cumulative effects)? ▪ Are there any temporal trends to capture (e.g., seasonality in waterbody conditions)?	▪ Are the effects due to cumulative or acute loading conditions? ▪ Are there temporal variations in source loading (e.g., due to weather patterns, seasonal activities)? ▪ At what temporal scale do the sources need to be estimated?

Technical needs of approach	Technical considerations for approach selection		
	Water quality criteria and TMDL targets	**Impairments and critical conditions**	**Sources**
Processes to Include	▪ Is criterion based on pollutant level (e.g., concentration) or a measure of response or condition (e.g., flow, habitat quality, eutrophication)? ▪ What are the pollutants?	▪ Is impairment based on a specific pollutant (e.g., sediment, metals) or based on cumulative effects of stressors (e.g., flow, habitat quality, pollutants)? ▪ Is meeting the target dependent on or affected by multiple waterbody measures (e.g., nutrient levels, temperature, pH)? ▪ What are the waterbody critical conditions for loading response (e.g., dynamic, flow variable vs. steady-state)? ▪ If dealing with multiple pollutants, how are they related?	▪ What is the source loading behavior (e.g., precipitation-driven, direct discharge)? ▪ Do sources impact multiple impaired segments (i.e., need for in-stream routing and transport)? ▪ Does the analysis need to evaluate individual and/or cumulative impact of sources?

Applying Approaches for Stormwater-Source TMDLs

Once an approach is selected for TMDL development, the TMDL writer will apply the approach to calculate the loading capacity and associated allocation for sources. While all sources present challenges in deciding how to accurately represent their inputs and effects, stormwater sources can require some unique considerations when applying a TMDL approach. The two key issues to address when developing TMDLs with stormwater sources are

1. How to represent stormwater source characteristics (e.g., discharge flows and concentrations)
2. How to isolate and estimate the loads transported and discharged through the stormwater system

This section of the Handbook discusses the considerations for developing TMDLs with stormwater sources when using the TMDL approaches introduced previously. Table 5 summarizes the advantages and disadvantages of each method, and the Handbook provides more detail on their application for stormwater-source TMDLs.

Table 5. Summary of commonly used TMDL development approaches

Approach	Can be combined with…	Advantages	Disadvantages
Land-based Approaches			
Watershed Models	▪ Receiving Water Model ▪ Load Duration Curves	▪ Can directly simulate regulated stormwater sources as distinct hydrologic units to facilitate better representation of source inputs. ▪ Enables source-level allocations ▪ Provides flexibility in expression of allocations, from gross to detailed, site-level (if detailed model is used). ▪ Provides time-variable simulation and results to better represent varying conditions for regulated stormwater source inputs and impacts (if dynamic model is used). ▪ Flexibility in how model is set up to represent land units allows for simulation of subareas or land uses within regulated stormwater source boundaries to define spatial inputs and impacts for targeting	▪ Requires significant data and analysis if outlet-level allocation is necessary. ▪ Direct simulation of stormwater sources is dependent on accurate information on drainage areas and runoff. ▪ Moderate or general watershed models (e.g., those with monthly time-steps) have limited capabilities for temporal evaluation or highly variable stormwater sources. ▪ Model accuracy dependent on having sufficient water quality data for calibration. ▪ Requires trained or experienced staff to run the model and understand model assumptions and limitations.

Approach	Can be combined with…	Advantages	Disadvantages
		implementation. ▪ Allows users to simulate potential changes in water quality conditions that might result from implementation activities.	
IC Method	▪ Watershed Models ▪ Load Duration Curves	▪ Because area of impervious surfaces is easily explained and tangible, can be more understandable to the public. ▪ Is translated more easily into management actions.	▪ Requires supplemental analysis and data to support linkage to a load. ▪ Requires sufficient data to support the link between IC and water quality standards. ▪ Is not appropriate for waterbodies affected by a mix of sources other than urban runoff.
Export Coefficients	▪ Percent Reduction ▪ Load Duration Curves	▪ Is simple to apply.	▪ Is usually based on regional or national literature values that might not be representative of local conditions. ▪ Does not provide a direct link to waterbody conditions and use support.
Simple Method	▪ Percent Reduction ▪ Load Duration Curves	▪ Is useful in watersheds lacking flow data. ▪ Is specifically designed to evaluate stormwater pollutant loads from impervious areas.	▪ Assumes all loading originates on impervious surface during storm events, not accounting for runoff from impervious areas or subsurface inputs and baseflow loading. ▪ Because it uses a static runoff concentration, does not account for variability in loading or in-stream levels. ▪ Not appropriate for large watersheds (>1 mi^2) or non-urban areas.
Waterbody-based Approaches			
Receiving Water Models	▪ Watershed Model ▪ Mass Balance	▪ Represents a high level of spatial variability within a waterbody, allowing for detailed outfall-based allocations ▪ Provides time-variable simulation and results to better represent varying conditions for regulated stormwater source inputs and impacts (if dynamic model is used).	▪ When applied independently, is limited to allocations set for specific input points; requires combination with a watershed model for land-based allocation analysis. ▪ Provides limited allocation opportunities when source is not discharging directly to the receiving water (e.g., for construction sites in upland locations). ▪ Provides limited allocation options when applied as a steady-state (non-dynamic) modeling application.
Load Duration	▪ Watershed Models ▪ Simple Method	▪ Is based on observed monitoring data, providing a data-based representation of existing conditions. ▪ Identifies the allowable and existing loads for all flow conditions, providing insight into the critical conditions and accounting for the natural variations in loading and in-stream conditions. ▪ Because it is based on observed in-stream conditions, can capture the effects of unknown sources (e.g., failing septic systems, illicit connections).	▪ Provides limited information regarding the relative magnitude of source loads. ▪ Requires supplemental analysis to distribute loading capacity into source-based allocations. ▪ Requires robust and consistent records of flow and in-stream water quality data. ▪ Is applicable only to non-tidal streams or rivers.

Approach	Can be combined with…	Advantages	Disadvantages
Percent Reduction Method	▪ Simple Method ▪ Export Coefficients	▪ Is simply and quickly applied. ▪ Easy for the public to understand.	▪ Assumes a 1:1 relationship between reductions in pollutant loading and resulting reductions in concentration. ▪ Does not calculate source-based loads, requiring supplementary analysis to identify stormwater WLAs.
Mass Balance or Steady-state Analysis	▪ Receiving Water Models	▪ Relatively simple to apply. ▪ Is based on observed monitoring data, providing a data-based representation of existing conditions.	▪ Typically focuses on a single critical condition (e.g., critical flow) or long-term average conditions (e.g., monthly loading and concentration), not allowing for evaluation of variability in pollutant loading or waterbody conditions. ▪ Simple representative of pollutant fate and transport.

Categorizing WLAs for Stormwater Sources

This section of the Handbook describes the various ways that TMDL writers can categorize and assign WLAs to permitted stormwater sources. The manner in which TMDL writers choose to calculate the WLAs for permitted stormwater sources can vary depending on data availability and quality, stormwater source characteristics, and permit implementation considerations. Four basic options for categorizing stormwater source WLAs are discussed and include the following:

- Aggregated for all stormwater sources (i.e., one overall WLA that represents total allocation to all MS4s, construction activities, and industrial facilities)
- Aggregated by each type of stormwater source (i.e., one WLA for all permitted MS4s; one WLA for all permitted construction activities; one WLA for all permitted industrial facilities)
- Individual by each stormwater source
- Individual by each outfall

These four categories represent the basic options for presenting allocations within the TMDL, not all possibilities. TMDL writers can use one or a combination of these options and can further refine these basic options using spatial and temporal considerations to make the allocations more meaningful to stormwater sources. For example, a TMDL writer could present individual or aggregated WLAs for sources by subwatershed or by land cover category. If the WLA has temporal variations, a TMDL writer could further refine the WLAs by flow conditions (i.e., wet versus dry), months, or seasons.

The Handbook details of each of the four basic options for categorizing and assigning WLAs to stormwater sources, and Table 6 summarizes advantages and disadvantages associated with each option.

Table 6. Options for assigning WLAs to stormwater sources

Option	Advantages	Disadvantages
Single Aggregated WLA for All Permitted Stormwater Sources *Example: Lake Champlain (Vermont) Phosphorus TMDL (2002)*	▪ Requires less permitted stormwater source characterization data to calculate ▪ Requires less resources to calculate ▪ Allows use of less complex WLA development approaches ▪ Allows permitted stormwater sources to determine at the local level how to	▪ Difficult to implement through permits; does not result in equitable and easy-to-understand (i.e., implementable) WLAs for permitted stormwater sources or permit writers ▪ Requires permit writers or sources to conduct further analyses and negotiations to disaggregate the overall WLA and assign equitable portions to individual sources

Option	Advantages	Disadvantages
	further subdivide the overall allocation without specific commitments that could translate into permit requirements ▪ Results in potentially less contentious TMDL WLAs because individual sources are not explicitly identified	▪ Potentially overlooks pollutant load contributions from all types of permitted stormwater sources throughout the watershed ▪ Does not promote individual permitted stormwater source accountability for pollutant load reductions to achieve the overall WLA ▪ More potential to capture unpermitted stormwater sources (i.e., urban nonpoint source runoff) in the aggregated WLA
Separate Aggregated WLA for Types of Permitted Stormwater Sources *Examples:* ▪ *Potomac Direct Drain (West Virginia) Sediment TMDL* ▪ *Charles River (Massachusetts) Pathogen TMDL* ▪ *Shingle Creek (Minnesota) Chloride TMDL* ▪ *Columbia Slough (Oregon) TMDLs*	▪ Requires less permitted stormwater source characterization data to calculate but allows for specificity within each category of permitted stormwater sources ▪ Requires less resources to calculate ▪ Allows use of less complex WLA development approaches ▪ Allows permitted stormwater sources within a specific category to determine at the local level how to further subdivide the overall allocation without specific commitments that could translate into stormwater permit requirements ▪ Results in potentially less contentious TMDL WLAs because individual sources are not explicitly identified	▪ Does not result in equitable and easy-to-understand (i.e., implementable) WLAs for permit writers or stormwater sources ▪ Requires permit writers or stormwater sources to conduct further analyses and negotiations to determine which source will conduct specific implementation strategies to achieve the WLA ▪ Does not promote individual permitted stormwater source accountability for pollutant load reductions to achieve the overall WLA ▪ Potential for double-counting pollutant load reductions where categories of stormwater sources might overlap (e.g., MS4s with permitted construction activities that a TMDL writer could assign under the aggregated MS4 WLA or under the aggregated construction WLA
WLAs to Each Individual Stormwater Source *Examples:* ▪ *Columbia Slough (Oregon) Lead TMDLs* ▪ *Wissahickon Creek (Pennsylvania) Siltation TMDL* ▪ *Swamp Creek (Washington) Pathogen TMDL* ▪ *Potomac Direct Drain (West Virginia) Sediment TMDL*	▪ Promotes transparency and accountability in TMDL implementation ▪ Provides permit writers enough information to include reasonable provisions in relevant permit(s) ▪ Allows permitted stormwater source to understand specific pollutant load reduction responsibility and take steps to analyze overall SWMP or SWPPP to achieve reduction ▪ Promotes following regulatory boundaries (e.g., regulated MS4 boundary) that are familiar to permitted stormwater sources and used to develop and implement SWMPs and SWPPPs	▪ Has the potential to add time to the overall TMDL development process if each permitted stormwater source has issues or concerns related to the separate WLA assigned to its respective regulated MS4, industrial facility, or construction site ▪ Requires data and information specific to each permitted stormwater source, depending on the WLA development approach selected by TMDL writers (e.g., specific regulatory boundaries for each permitted stormwater source)
Individual WLAs on an Outfall Basis *Example: Middle Rio Grande (New Mexico) Fecal Coliform TMDL (2002)*	▪ Provides permit writers with detailed information to develop tailored permit provisions, particularly for individual permits ▪ Allows stormwater sources to target implementation efforts to address a specific area represented by a stormwater discharge from a specific outfall	▪ Requires data and information pertinent to each outfall addressed by the TMDL analysis ▪ Requires comprehensive spatial understanding of a permitted stormwater source area, including a detailed system map with location of all outfalls, and surrounding land uses ▪ Does not seem feasible in watersheds with a large number of permitted stormwater sources, particularly permitted MS4s that might have a large number of outfalls draining the system ▪ Does not align with how most permitted stormwater sources approach SWMP and SWPPP implementation (i.e., focus on systemwide approach as opposed to an outfall-by-outfall approach)

CHAPTER FIVE: PROMOTING EFFECTIVE STORMWATER MANAGEMENT

Implementing TMDLs through stormwater permits will involve planning and coordination. Implementation planning activities might involve TMDL and permit writers or draw on the skills of other agency staff dedicated to implementation related activities. In some instances, implementation planning activities might only involve permittees. For purposes of the Handbook, those engaged in implementation planning activities are referred to as *stormwater planners*.

The role of stormwater planners in implementation planning will vary. Potential roles and activities for stormwater planners can include the following:

- Evaluating and interpreting the WLAs assigned to stormwater sources.
- Developing a recommended list of structural and nonstructural BMPs to include in TMDLs or permits.
- Identifying specific structural and nonstructural BMPs when no BMP recommendations or requirements are provided in the TMDL or permits.
- Developing BMP performance standards to include in the TMDL or permit.

Chapter Five of the Handbook presents and discusses a series of six key questions that stormwater planners can use to promote effective BMP implementation through an adaptive management framework. The adaptive management framework consists of planning, implementing, evaluating and learning, and adjusting. The six key questions are as follows:

1. What is the current pollutant loading from the stormwater source's discharge to the impaired waterbody accounting for existing BMPs?
2. What additional loading reduction is necessary to implement the WLA?
3. What additional BMPs might provide the remaining pollutant load reductions necessary to implement the assigned WLA on the basis of the expected performance of these BMPs?
4. How should permittees measure BMP performance as implementation proceeds?
5. Are measured pollutant load reductions adequate to make progress toward the assigned WLA over time?
6. What modifications to the overall implementation strategy are necessary to make further progress toward implementing the WLA?

CHAPTER SIX: COORDINATING TMDLS AND STORMWATER PERMITS

Stormwater permit writers often consider TMDL-related information as they develop permit requirements. The two primary types of stormwater permits—individual and general permits—can affect options and approaches for coordinating TMDL language with the permit. Chapter Six presents and discusses the permit elements that permit writers can use to address TMDL implementation, including the following:

- **Determining applicability.** Permit writers can include requirements that help permittees determine if they must comply with TMDL implementation related permit conditions. Requirements can help permittees determine if there is a discharge to an impaired waterbody with an approved TMDL. One option for determining applicability requirements could be for a state that the source should make a determination on the basis of the knowledge of their location and discharges, and provide infomration on how to determine if a discharge goes to an impaired waterbody, such as a link to a Web site that provides lists of impaired waterbodies. Another option could be to provide more detailed information to sources to help them determine if they contribute to one or more impairments, where to go for more information on a specific TMDL, or to even include the applicable TMDL data and information in an appendix to the permit.

  Another aspect of determining applicability involves identifying the pollutant of concern addressed in the approved TMDL in the stormwater discharge. A source might have a discharge to an impaired waterbody,

but if the discharge does not contribute to the impairment(s) (e.g., does not contain the pollutant of concern) the additional controls related to the impaired waterbody might not apply. One option for permit writers could be to require sources to conduct discharge monitoring for a pollutant of concern or flow monitoring (or both) over a specified period of time to determine applicability. If the source can demonstrate that the discharge does not contribute to the impairment(s), the permit could then exempt the source from some or all additional TMDL implementation requirements.

- **Implementing stormwater controls through SWMPs and SWPPPs.** SWMPs and SWPPPs are the primary mechanism selecting and implementing stormwater controls to implement stormwater WLAs. Permit writers, in conjunction with information provided by TMDL writers, can consider a variety of approaches that involve either recommending BMPs or relying on sources to do the evaluation and selection on their own. Options that permit writers can consider include the following:
  - ✓ Requiring implementation of specific BMPs in the permit. Under this option, permit writers could develop a proposed list of BMPs that a source could implement to reduce pollutant loadings to implement the WLA. Permit writers could consider this approach when stormwater planners have conducted an internal analysis of possible BMPs. Given the resource-intensive nature of this option, this approach might be suitable for geographic areas that need certain types of BMPs (e.g., developing areas versus built-out areas of an MS4), or discreet sources (e.g., the only MS4 or construction site discharging to the impaired waterbody).
  - ✓ Providing a recommended menu of potential BMPs in the TMDL, implementation plan, or the permit for sources to evaluate and select. This option is similar to the option described above in that TMDL and permit writers could develop a recommended list of BMPs. The difference between these options, however, is that this BMP list serves more as a menu of potential BMPs. Under this option, permit writers could provide some technical information related to each BMP to help sources evaluate and select appropriate BMPs. Sources would need to conduct a thorough analysis to select the appropriate suite of BMPs from the list to achieve progress toward implementing the WLA.
  - ✓ Referencing BMP performance standards in the TMDL, implementation plan, or the permit. Under this option, TMDL and permit writers could recommend or reference performance standards for specific pollutants and allow sources to determine which BMPs will best meet the performance standard. One example might be a construction site must achieve a specific percent reduction in TSS, giving the source flexibility in the types of BMPs used to meet the standard. The TMDL and permit writer could provide recommendations on how sources could demonstrate that the selected BMPs can meet the required performance standards (e.g., using a combination of modeling and monitoring).
  - ✓ Recommending the selection of BMPs and developing benchmark values or performance measures. This option has similarities to the option described above in that it focuses on the use of performance standards. However, under this option, permit writers could develop permit requirements that give sources the responsibility for developing the performance standards, often referred to in this context as benchmark values or performance measures. Permit requirements can focus on selecting BMPs to achieve progress toward implementing the WLA and developing performance measures that indicate the expected level of BMP performance. Beyond BMP performance, requirements can focus on developing quantifiable benchmarks that track the overall success of SWMPs and SWPPPs in reducing pollutant loads. If permit writers choose this option, it is important to note that sources might have concerns about compliance implications associated with benchmark values and performance measures. As a result, permit writers might want to consider developing permit language that specifies the intended use of performance measures and benchmark values—not as numeric effluent limits but as guideline values to facilitate adaptive management.
  - ✓ Requiring the review of existing BMPs and selecting additional BMPs to achieve progress toward addressing the WLA. Under this option, permit writers could require sources to conduct an analysis of existing BMPs to determine the need for additional pollutant load reductions through improved BMP implementation or additional BMPs. Sources receive little technical guidance through the requirements, allowing them flexibility in conducting the analysis and justifying the selection of specific BMPs. Permit

writers could consider including in the requirements a list of supporting documentation (e.g., calculations, assumptions, studies) that would provide the rationale for the proposed strategy to achieve progress toward addressing the WLA. This option is particularly effective when the the TMDL writer develops a WLA that permit writers can use as the basis for developing a performance standard. This approach provides permittees with flexibility in finding the optimal combination of existing and new BMPs to implement the WLA.

- ✓ Consider numeric effluent limitations. Permit writers might determine that BMPs are not an appropriate way to express effluent limitations and might choose to develop numeric effluent limitations as a feasible and appropriate way to incorporate the TMDL provisions into the permit.

There are no guidelines for determining which approach is most appropriate to use. It is likely that a variety of factors, including type of source, type of permit, and availability of resources, will influence which approach makes the most sense.

- **Monitoring requirements.** Many existing stormwater permits do not specifically require monitoring. However, monitoring might be warranted for permits that contain requirements to implement stormwater WLAs as a mechanism for assessing TMDL implementation. Options for monitoring requirements include BMP performance monitoring, stormwater discharge outfall monitoring, and ambient in-stream water quality monitoring.
- **Reporting requirements.** Many existing stormwater permits contain requirements related to assessing and reporting on stormwater controls and overall SWMPs and SWPPPs. For example, MS4 permits contain requirements for developing an annual report that reviews the activities of the past year and addresses necessary modifications to improve stormwater management. These types of requirements are an example of the existing adaptive management approach in stormwater permits that permit writers can use to facilitate assessment of TMDL implementation.
- **Compliance considerations.** One key issue relates to establishing an appropriate compliance schedule for sources to implement a WLA (e.g., within a 5-year permit term or beyond). Permit writers can consider using interim limits or a phased implementation approach. Interim limits are a way for permit writers to schedule incremental progress toward implementing the WLA over time. One option is for the TMDL to reference, or for the permit to specify, the interim limits by providing a schedule with the required interim numeric targets in a specific timeframe. Another option to consider relates to the benchmarking approach (discussed earlier in this chapter) in which a source determines how much progress is feasible, over a specified time frame, to implement the WLA. The source could then submit the proposed benchmarks and associated schedule to the permit writer for review and approval.

TMDL and permit writers can not only work together to consider the appropriate types of conditions that could be developed to implement stormwater source TMDLs, but also can collaborate to decide how the associated programmatic documents, such as the TMDL report and the stormwater permit, can help articulate this information. The goal is to help ensure that no matter what document a permitted stormwater source refers to—the TMDL or the stormwater permit—each document has a clear and consistent connection to the information contained in the other. Options for connecting programmatic documents include:

- **Permit refers to the language in the WLA.** One option is to describe and reference all relevant permit requirements for implementing the WLA within the TMDL report. Under this approach, stormwater permits could state that sources should comply with the numeric WLA and the associated elements included in the TMDL document. This approach basically incorporates the WLA and associated implementation information into the permit by reference.
- **Permit copies the language in the WLA.** Another option is to have stormwater permits directly incorporate the TMDL WLA information so that each programmatic document contains the same element using identical language, as opposed to just referencing the other document as is suggested above.

- **Permit and WLA refer to the language in an implementation plan.** One option for using implementation plans to connect stormwater source WLAs with stormwater permits is to have the implementation plan serve as the primary vehicle for referencing and conveying information relating to implementation of the stormwater source WLAs (e.g., supplemental BMPs, SWMP and SWPPP assessment and modification, monitoring plan development and implementation, adaptive management measures). The TMDL could include these elements by reference and the associated stormwater permits could then incorporate the implementation plan information by reference.

This chapter of the Handbook also briefly mentions other situations where permit writers, watershed organizations, or municipalities could encounter previously developed TMDLs and implementation plans are more difficult to implement in permits, including the following:

- **No separate WLA for stormwater sources.** Permit writers might be working with older TMDLs that were approved prior to EPA's guidance, Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs (Wayland, R.H., and J.A. Hanlon, 2002), or that include allocations for stormwater discharges that were considered to be nonpoint sources at the time the TMDL was approved, but that currently are subject to NPDES permitting. For example, an older TMDL could group both urban nonpoint source and point source runoff into one overall category under an aggregated load allocation, or the older TMDL could include runoff from MS4's under the load allocation that are now covered under the Phase II NDPES requirments. Because permit effluent limits have to meet water quality standards under 122.44(d)(1)(vii)(A), the permit writer will need to account for the current regulated stormwater discharges identified in the TMDL regardless of how they were labeled in the older TMDL document, and should explain how they are being accounted for in the permit. The permit writer might be able to get additional information from TMDL writers to help implement these wasteload allocations into permits.
- **Impaired waterbody with no approved TMDL.** Another scenario that TMDL and permit writers might encounter is an impaired waterbody that does not yet have an approved TMDL. Clearly, it is important to ensure that stormwater discharges do not further cause or contribute to exceedances of water quality standards. However, without a specific WLA, TMDL and permit writers might have questions about the appropriate implementation activities to recommend or, in the case of a permit, require until a TMDL is developed and approved. To provide some level of control on pollutants of concern associated with the impairment, TMDL and permit writers could work together to identify interim early action BMPs or performance standards that sources could implement until an approved TMDL becomes available. In such cases, it might be valuable to identify monitoring programs to evaluate contributions from stormwater sources to the impairment for use in future TMDL development.