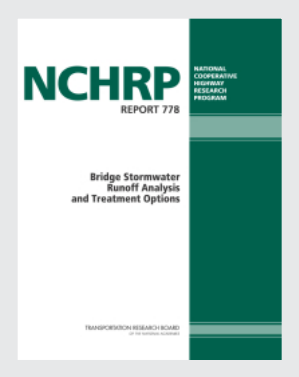

Bridge Stormwater Runoff Analysis and Treatment Options (2014)

DETAILS

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CHAPTER 1

Overview

1.1 Purpose

The purpose of this guide is to assist the practitioner in assessing the need for and identifying the appropriate BMPs for stormwater runoff from bridge decks. The study focuses on bridge structures that cross a waterway and discharge runoff directly to the receiving water, though many of the measures discussed will be applicable to other bridge structures. Runoff from bridge decks is generally transferred directly to the receiving water via deck drains. This is because there is considerable expense to design, construct, and maintain a collection system to convey the runoff to the bridge abutment. The primary purpose to convey bridge deck runoff to the abutment is to facilitate the use of a land-based treatment BMP prior to discharge to the receiving water.

The EPA (1993) in its non-point source control guidance notes that,

> . . . since bridge pavements are extensions of the connecting highway, runoff waters from bridge decks also deliver loadings of heavy metals, hydrocarbons, toxic substances, and deicing chemicals to surface waters as a result of discharge through scupper drains, with no overland buffering.

Much of the EPA guidance focuses on locating bridge crossings away from the most sensitive portions of the receiving water. However, the EPA also recommends consideration of diversion of bridge deck runoff to land for treatment; restricted use of scupper drains on bridges less than 400 feet in length and on bridges crossing very sensitive ecosystems; or a provision for equivalent urban runoff treatment in terms of pollutant load reduction elsewhere on the project or off-project to compensate for the loading discharged off the bridge. EPA indicates that the recommendations,

> . . . have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management [for non-point source control] measure . . .

These recommendations stand in contrast to published research, which has not identified environmental impairment associated solely with either bridge runoff or where bridge runoff was a significant contributor to receiving water impairment. It is apparent that the EPA guidance for managing bridge deck runoff has been offered at a program level. This guide describes some of the available BMPs for bridge deck runoff and the conditions of their application that would both protect the environment and ensure the prudent expenditure of public funds.

The definition of maximum extent practicable, or MEP, is embodied as the basic performance standard in state and federal regulations, including the Federal Endangered Species Act and Sections 402 and 404 of the Federal Clean Water Act. The MEP standard does not necessarily involve the same criteria in each application; it is intended to address projects or actions on an individual basis considering each of their specific circumstances and purpose. The MEP standard for treatment of runoff from bridge decks is necessarily different from treating a standard highway section on land. This is because the cost of conveying bridge deck runoff to the abutment area is relatively high when compared to a standard highway section at grade, right-of-way at the abutment is limited, and the benefit of the BMP may be substantially less.

1.2 Pollution Removal Benefit of the Treatment of Bridge Deck Runoff

Assessment of water quality impacts of bridges generally focus on pollutants conveyed in stormwater runoff. An often overlooked issue is the transport and subsequent deposition of pollutants into receiving waters during dry weather (dry deposition). Dry deposition occurs when particulate matter that has accumulated on the bridge deck is re-suspended by vehicle and wind-induced turbulence and subsequently transferred directly into the receiving water below the bridge. Dry weather deposition occurs on all surfaces in all locations to varying degrees.

The flux of particulates (pollutants) deposited on the bridge surface and subsequently removed by vehicle-induced and natural wind currents is significant since displaced particles will be deposited directly on the receiving water during dry weather conditions. This directly deposited pollutant load is not available for subsequent treatment during a runoff event. This is in contrast to a comparable at-grade highway section where re-suspended particulates are captured in the highway shoulder area or along the adjacent right-of-way and either are sequestered in place or have the potential for treatment in a BMP within the highway conveyance system.

While further research is needed to understand the contribution to total pollutant loadings to receiving waters from vehicular and wind-driven re-suspension of pollutants, as compared with contributions of stormwater runoff, studies have quantified atmospheric deposition (bulk precipitation of particulates for both dry and wet weather) on bridge and highway sites, which provide insight into expected levels of dry deposition loading. Wu et al. (1998) indicates that the percentage of bulk precipitation in runoff for a bridge site (where pervious retention could be ignored) was approximately 20% of total suspended solids (TSS) loadings, 70–90% of nitrogen loadings, and 10-50% of other constituents. Harrison and Wilson (1985) have indicated that rainfall can contribute to 48% of TSS and 78% of major ionic constituents (e.g., Na, Mg, Cl) in highway runoff. Therefore, it is likely that atmospheric deposition, especially on bridges where sequestration is minimal, has a significant influence on the amount of dry deposition loading to receiving waters. More research is needed on the quantification of bulk atmospheric deposition on bridges and adjacent receiving waters and how these relative pollutant loadings should influence stormwater runoff management decisions and the development of appropriate treatability goals for bridge runoff.

If treatment of bridge deck runoff is required, the physical processes that dominate pollutant deposition and re-suspension on roadways should be considered when determining the optimum location to construct treatment BMPs. The effectiveness of collecting and treating deck runoff is likely modest compared to treating runoff from an at-grade highway section with standard shoulders, particularly for bridge decks with narrow shoulders and locations that lack or have low railing walls.

1.3 Runoff Treatment Evaluation Strategy

The primary objective of this guide is to develop a procedure to determine what BMPs should be considered for bridges and when treatment BMPs are effective for bridge deck runoff. All bridge projects should consider source control BMPs that are applicable to the local conditions. This guide provides a discussion (in Chapter 4) of the various practices that should be considered by the designer for new or retrofit bridge construction. Some recommendations may not be suitable for all cases, while others have more universal application.

Two general cases are presented for determining if treatment BMPs for bridge deck runoff are appropriate. The cases are differentiated according to the surrounding general land use, either rural or urbanized, which is consistent with the approach taken by EPA for implementation of the NPDES permit program. The practitioner is provided with a practical analysis method that is both protective of the environment and ensures stewardship of public funds. For the rural case, treatment of bridge deck runoff is generally not recommended since the impacts to the receiving stream are usually shown to be de minimis. The practitioner can verify this conclusion for an individual site using the simple assessment procedure discussed in Chapter 3. For urban areas, treatment of bridge deck runoff should be guided by the DOT Municipal Separate Storm Sewer System (MS4) permit or the states or federal agency Section 401 certification. The decision to apply treatment BMPs for a specific bridge project in an urban area (if required) should be evaluated from the perspective of providing the highest level of treatment for the least cost.

This guide provides a spreadsheet tool to assist the practitioner in documenting the BMP benefit and cost analysis for a bridge crossing in an urban area. The tool facilitates the computation of treatment BMP whole life cost and performance information as well as the whole life cost of a bridge deck drain collection system. This information can be quickly compared by the practitioner, for example, to an alternative land-based in-lieu treatment location to determine the treatment strategy with the least cost and highest benefit.

Figure 1-1 provides an overview of the recommended analysis process for any bridge project crossing waters of the United States.

Step 1: This guide can be used to develop bridge deck runoff mitigation at the environmental documentation stage. The environmental documentation will discuss if the project receiving water is a special classification, which would include outstanding national resource waters (ONRW), a domestic water supply reservoir, receiving water with endangered species or a receiving water with an active total maximum daily load (TMDL). Chapter 3 discusses analysis approaches for these types of receiving waters in more detail. The analysis approaches may be helpful in demonstrating whether the bridge deck will be a source of a pollutant of concern for the receiving water.

Step 2: All bridges should consider applicable stormwater and other source control and operation and maintenance practices, as described in Chapter 4. Source control BMPs include design and operational provisions to ensure that the bridge structure or traffic operations do not contribute

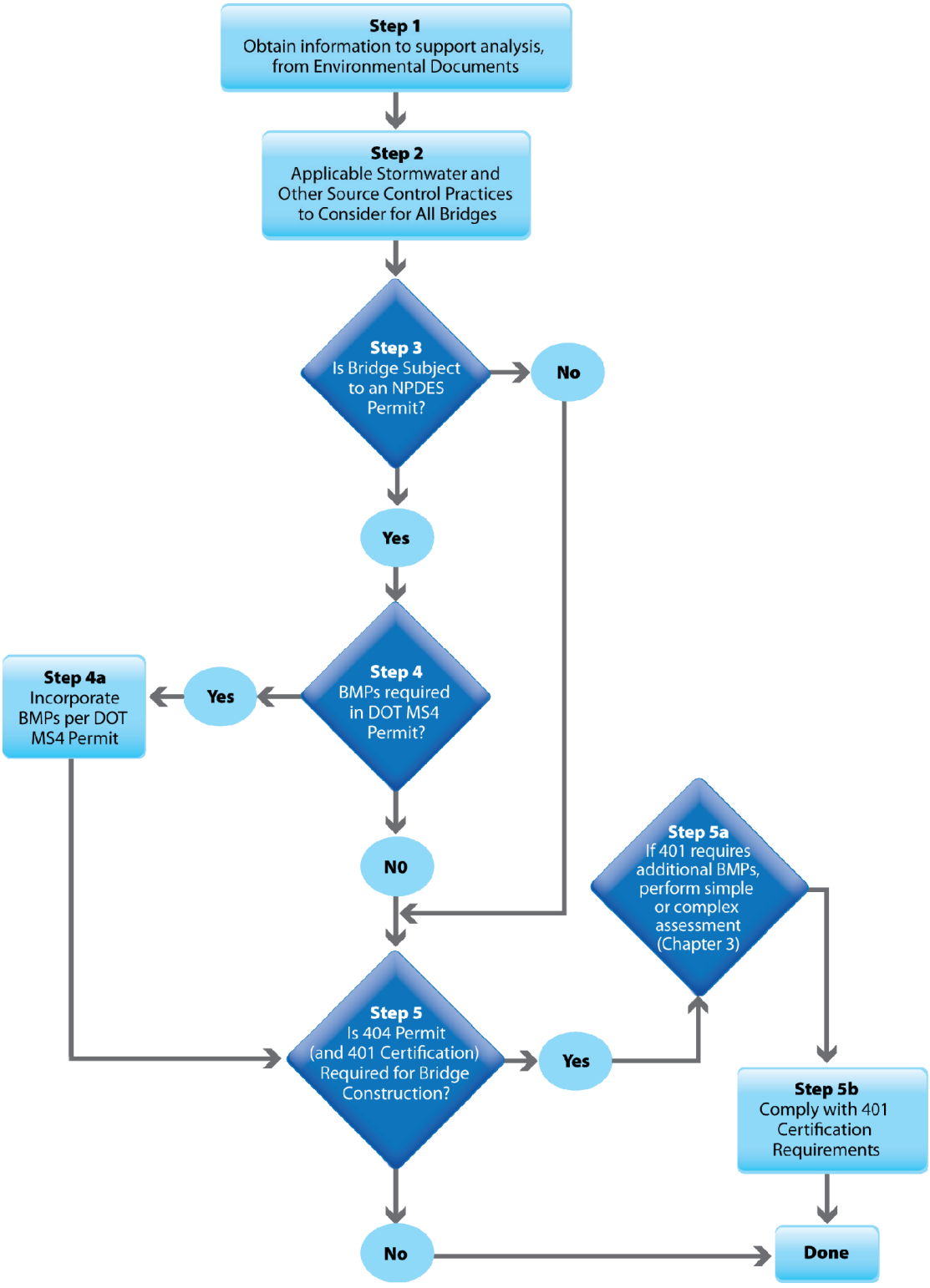

Figure 1-1. BMP flowchart.

pollutants to the receiving water during dry or wet weather to the extent practicable.

Step 3: Determine if the bridge is subject to an NPDES permit. Bridges not subject to an NPDES permit skip to Step 5; otherwise move to Step 4 to determine what BMPs are required by the DOT's MS4 Permit.

Step 4: Treatment requirements in the MS4 permit, if any, should be incorporated into the project. If none are required beyond those already incorporated in Steps 1 and 2, proceed to Step 5. If treatment is required by the DOT's NPDES permit, proceed to Step 4a. The least cost and highest benefit can be achieved by treating a comparable section of roadway (with similar annual average daily traffic [AADT], adjacent land use, and impervious area) rather than the bridge deck runoff. This is because the capital, operation, and maintenance cost of a deck collection and conveyance system is relatively high, and the benefits of treating deck runoff, as discussed in Section 1.2, may be comparatively less. The tool described in Chapter 6 can be used to document the cost basis for treatment at an off-site location. The off-site treatment location should be within the same watershed or upstream of the bridge crossing. The recommended approach follows the basic tenants of MEP to select the location and BMP with the least cost and highest environmental benefit.

Step 5: Determine if a 404 permit is required to construct or rehabilitate the bridge. Bridges that require a 404 permit will also require the companion 401 water quality certification. The 401 certification may contain requirements for treatment of deck runoff. The agency responsible for providing the 401 certification should be consulted early in the project development process to determine if BMPs beyond those described in Chapter 4, the project environmental document, or the DOTs MS4 permit (for crossings in urban areas) will be included in the 401 certification. If the resource agency is requiring BMPs beyond those in Chapter 4 or required as a part of the DOT's MS4 permit, it is recommended that a simple or complex assessment be performed to demonstrate that the bridge will not have impacts on the receiving water [40 CFR 230.10(a)(2)].

Chapter 3 provides assessment procedures the DOT can use to assist regulatory agencies in determining if runoff from a bridge crossing will have a significant impact on the receiving water. The assessment procedures can be used by the practitioner during the development of the project environmental documents, as well as during the project 401 process. They may also be helpful if the DOT MS4 permit is ambiguous regarding the application of BMPs to bridge crossings. The practitioner can apply the procedures to determine the environmental impact of the new or rehabilitated crossing on the receiving water. Two assessment methodologies are provided. The simplified method is appropriate for demonstrating the new or rehabilitated crossing will have a de minimis impact on the receiving water. This is accomplished through a basic computation of dilution, and showing that the change in concentration of pollutants downstream of the crossing will not be significant or measureable.

A more sophisticated analysis may be required for crossings of domestic water supply reservoirs or in the case where endangered species are present. The complex assessment approach, also described in Chapter 3, can provide estimates of the concentration of a specific pollutant in the receiving water before and following project completion. The complex assessment method may be required when numeric values for a pollutant in the receiving water are needed.

1.4 BMP Selection and Evaluation

This guide promotes the use of source control and operation and maintenance BMPs for controlling the quality of bridge deck runoff as the basic measures that should be considered, as applicable, for all crossings. Treatment of an off-site at grade location is recommended in lieu of treating the actual deck runoff for bridges that require treatment in urban areas. If regulatory or receiving water conditions mandate treatment of the deck runoff, then a bridge deck drain collection system may be required to transport runoff to the abutment and the treatment BMP location. Use of a pervious friction course overlay is an on-deck treatment approach that can be considered as an alternative (see Chapter 5) that will not require a conveyance system.

The selection of the type of BMP for treatment of runoff either at the off-site in lieu location or at the bridge abutment is largely at the discretion of the designer. Several NCHRP publications can assist the designer in treatment BMP selection. Recent publications include, *NCHRP Report 565: Evaluation of Best Management Practices for Highway Runoff Contro*l and *NCHRP Report 728: Guidelines for Evaluating and Selecting Modifications to Existing Roadway Drainage Infrastructure to Improve Water Quality in Ultra Urban Areas.* Selection of the type of BMP will be driven largely by physical site constraints, since all of the BMPs described in these publications are targeted at constituents of concern for highways.

The spreadsheet tool (located on the TRB website) includes five treatment BMPs that have been proven effective for a conventional highway and are suitable for bridges. Four of these BMPs are for use at the bridge abutment and one can be used on the bridge deck:

At the abutment:

- Swales
- Dry detention basin
- Bioretention
- Sand filter

On the bridge deck:

- Permeable friction course (PFC)

These BMPs were selected for their performance, generally broad compatibility with physical site constraints and familiarity to and common use by DOTs. The practitioner is not constrained by these choices and other BMPs may be a better fit for site conditions. A separate study, in process at the time this guide was prepared, is "Long-Term Performance and Life-Cycle Costs of Stormwater Best Management Practices," under NCHRP Project 25-40. This report provides an expanded list of BMPs for the practitioner to consider, as well as a tool similar to the one provided with this guide to evaluate BMP performance and whole life cost.

1.5 Organization of the Guide

This guide was developed to assist the practitioner in performing a maximum extent practicable analysis for stormwater treatment for a new or reconstructed bridge project crossing a water of the United States. Technical background and supporting information and examples are included in the Appendices, to reduce complexity and keep the guide focused on the recommended steps to complete the analysis. The remaining chapters of the guide are summarized as follows:

- **Chapter 2: State of the Practice** – This chapter identifies the current state of practice of assessment of the impacts of runoff from bridge decks on the receiving water, and provides an overview of regulatory requirements and current DOT practices. The purpose of this chapter is to orient the practitioner to the current standard of care for bridge deck runoff.
- **Chapter 3: Assessment Procedure** – This chapter provides the practitioner with a stepwise approach to determine if bridge deck runoff will have a significant impact on receiving water quality. Two assessment procedures are described, a "simple" approach and a "complex" approach, depending on the objectives of the analysis to demonstrate a de minimis impact of bridge deck runoff on the receiving water, or to determine expected concentrations of pollutants of concern in the receiving water following bridge construction or reconstruction, respectively.
- **Chapter 4: Stormwater Practices to Consider for All Bridges** – This chapter presents stormwater and other source control BMPs that should be considered for all bridges as appropriate, depending on the physical setting and type of bridge construction. Source control BMPs and maintenance practices to avoid or reduce loading of pollutants to the receiving water are described.
- **Chapter 5: Stormwater Treatment Controls for Bridges** – In some instances in urban areas, or at sensitive receiving waters, treatment controls may be required. Whether constructed off-site to treat a conventional highway section on an in-lieu basis, or constructed at the bridge abutment to treat the deck runoff, this chapter provides an overview of treatment BMP options for the practitioner. An experimental practice developed as a part of NCHRP Project 25-32 is also described to treat runoff directly at the bridge deck drain. This chapter also discusses the probability of a spill on a bridge deck and considerations for spill containment countermeasures.
- **Chapter 6: BMP Evaluation Tool** – This chapter provides a description of the use of the BMP selection evaluation tool. The basic functions of the tool and tool outputs are described. The user will also understand what portions of the tool default input values can be customized to more closely align with local conditions. A worked example with the tool is provided. A comprehensive worked example, following the flow chart (Figure 1-1), for the entire guide, is provided in Appendix B.
- **References** – This section lists references cited in the text.

The Guide also contains a number of appendices with additional reference information and examples to assist the practitioner. The contents of the appendices are:

- **Appendix A: Literature Review** – The literature review provides a summary of previous studies assessing the impact of bridge deck runoff on receiving water quality, as well as BMP applications at bridges. This appendix also contains the results of the DOT survey of nine agencies. The literature review found several applicable and contemporary studies that support the conclusions and recommendations developed in the guide.
- **Appendix B: Simple and Complex Assessment Methods and Worked Example** – This appendix provides worked example calculations to aid the practitioner in completing "simple"; and "complex" assessments to determine the potential impact of bridge deck runoff on the receiving water. It also provides a comprehensive worked example problem using the entire procedure outlined in the guide.
- **Appendix C: Quick Start Guide** – A quick start guide is provided for the practitioner that has completed the process previously and just needs a basic outline of the recommended procedure. The quick start guide is an abridged version of the steps the practitioner should complete to assess the appropriate BMPs for a bridge project.
- **Appendix D: User's Guide for the BMP Evaluation Tool** – This appendix contains a user's manual for the spreadsheet tool.
- **Appendix E: BMP Evaluation Tool Modeling Methodology** – This appendix provides the modeling methodology and underlying data for the spreadsheet tool.