appendix e

analysis of urban stormwater best management practice options for the st. joseph river watershed

Analysis of Urban Stormwater Best Management Practice Options for the St. Joseph River Watershed

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Introduction

Although predominantly agricultural, the St. Joseph River Watershed has 19 of 217 subwatersheds with over 10% of the land area in urban uses (commercial, residential, industrial, or transportation) according to the 1992 land cover data from the U.S. Geological Survey (USGS) (http://www.stjoeriver.net/wmp/tasks/urban_lc.htm)). Major urban centers include South Bend-Mishawaka (IN), Benton Harbor-St. Joseph (MI), Elkhart (IN), and Goshen (IN). Nonpoint source (NPS) modeling work conducted by KIESER & ASSOCITES (K&A) revealed that in the 19 subwatersheds with over 10% urban areas, urban land uses contributed more than one-third of the total phosphorus (TP) loading from these subwatersheds (K&A, 2003). Therefore, while controling pollutant loadings from agricultural lands in the watershed is central in managing the overall water quality of the watershed, it is critical to reduce stormwater pollutant loadings from urban areas in order to protect and restore water quality in the streams draining urban subwatersheds.

From a regulatory perspective, USEPA's NPDES Phase II Stormwater Program (http://www.stjoeriver.net/wmp/tasks/npdesp2.htm) has put numerous urban communities in the watershed under regulatory obligation to develop stormwater pollution control and monitoring programs. As a result of this regulation and the predicted high pollutant loadings from urban lands, it is essential for watershed management planning efforts to examine stormwater pollutant loadings from urban subwatersheds. Planning must address solutions and associated costs of abating pollution from these urban sources. This report describes the work conducted by K&A to accomplish this.

This study is based on the empirical model used for estimating NPS pollutant loadings from various land cover types, including urban areas, that has been described by K&A in a report prepared for this 319 grant (K&A, 2003). In addition to updating the modeling work with newly available land cover data (2000), this study focused on the major urban centers in the St. Joseph River Watershed to explore: 1) the pollutant removal potential of select urban stormwater best management practices (BMPs); and 2) the costs associated with these BMPs. These efforts are meant to help the Watershed Management Plan being developed for the St. Joseph River to meet the required USEPA Nine Elements.

These analyses do not include pollutant loads from any combined sewer overflows (CSOs). Computations also assume there no current BMPs are in place and that predicted loads are solely associated with urban stormwater runoff. No additional mapping characterizations have been made which might also determine that select urban areas are isolated from surface waters either topographically or via stormsewer infrastructure. Budget and scope constraints precluded detailed deterministic modeling that would have been required for these consideration. Nevertheless, the findings of this report are still highly applicable as urban stormwater treatment and/or reduction will be necessary in these urban areas to realize water quality improvements.

Methods

The overall analysis procedure is represented in the flow chart shown in Figure 1. The 2000 land cover data for the St. Joseph River Watershed was downloaded from the National Oceanic and

Atmospheric Administration (NOAA)'s Coastal Change Analysis Program (http://www.csc.noaa.gov/crs/lca/greatlakes.html).

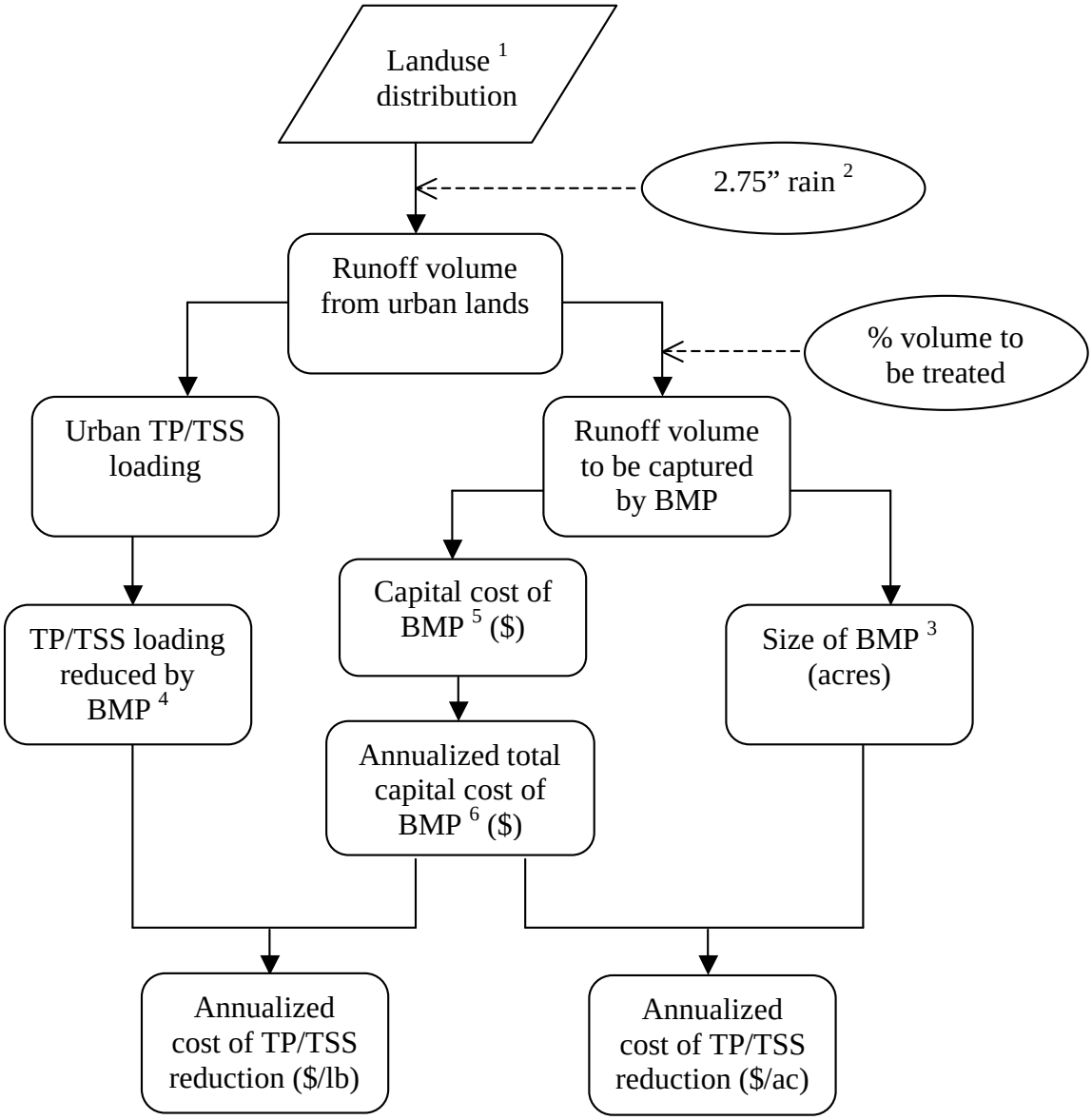

Figure 1. Flow Chart of Urban Stormwater BMP Cost Calculations.

[1] 2000 NOAA data.
[2] Equivalent to a one-hour 100-year or a 24-hour 2-year rain event for the St. Joseph River Watershed.
[3] General assumptions made for the physical dimensions of BMPs.
[4] Load reduction efficiencies of BMPs based on the Michigan Trading Rules and/or literature values.
[5] Cost based on Rouge River Watershed management plans and/or literature values.
[6] 30-year annualization with a 5% discount rate.

In the previous modeling effort (K&A, 2003), 1992 land cover data produced by USGS was used. Although NOAA and USGS use the same type of satellite image data for land cover/landuse classification and the classification process is also similar between the two agencies, they have different purposes for the data and hence different final classifications. NOAA's Coastal Change Analysis Program is interested in coastal habitat change and its land cover classification reflects this by giving more detailed sub-classes for wetlands and coastal lands but less for developed lands and agricultural lands, compared to the 1992 USGS land cover data. For this modeling purpose, however, these differences had minimal influence on data processing as the NPS model groups various land cover classes into five major categories: water and wetland, forest and open space, agricultural land, residential area (low intensity development), and commercial/industrial/transportation uses (high intensity development). Pollutant loading estimations were based on these five categories, and the combination of the latter two categories was considered urban in this study.

After processed and integrated into the St. Joseph River GIS database at K&A, land cover distribution for each of the 217 subwatersheds was tabulated and grouped into the five major categories. The grouping of land cover classes is shown in Table 1.

Table 1. Grouping of land cover classes.

Major Land Cover Groups	NOAA Land Cover Classes (2000)	USGS Land Cover Classes (1992)
Water and wetland	Open water, palustrine forest, palustrine scrub/shrub, palustrine emergent, unconsolidated shore, palustrine aquatic bed	Open water, woody wetlands, emergent herbaceous wetlands
Forest and open space	Deciduous forest, evergreen forest, mixed forest, scrub/shrub	Deciduous forest, evergreen forest, mixed forest, shrubland, grassland/ herbaceous
Agricultural land	Cultivated land, grassland, bare land	Pasture/hay, row crops, small grains
Residential area	Low density development	Low intensity residential, high intensity residential, urban/ recreational grasses
Commerical/industrial/ transportation uses	High density development	Commercial/industrial/transportation

To analyze urban pollutant loadings from the four major urban centers in the watershed, the land cover map was overlaid with the subwatershed delineation map (Figure 2). Subwatersheds containing these urban centers were then chosen for further analysis (Table 2). Because the purpose of this study is to analyze urban stormwater BMP options, it is assumed that only stormwater generated by the low density development and high density development land cover classes in the NOAA 2000 map are treated with the BMPs examined here.

Five widely used urban stormwater BMPs (wet retention ponds, dry detention ponds, vegetated swales, rain gardens, and constructed wetlands) were chosen in this study to evaluate pollution reduction opportunties and their cost-effectiveness in removing TP and TSS from urban stormwater runoff. These BMPs were selected because of their general applicability and the readily available information on their pollutant load reduction efficiencies (MI-ORR, 2002) and construction costs (Rouge River National Wet Weather Demonstration Project, 2001).

The holding capacity or the design volume of a stormwater retention or detention pond is a function of the rainfall depth of the storm event that the pond is designed to treat. As a generally accepted rule, pond volume is designed to fully capture minimally the first inch of the rainfall in a storm event, because runoff from this first inch is believed to carry most of the pollutants from the watershed. To achieve a higher and more consistent pollutant removal, however, ponds with larger holding capacities are necessary. In this study, a 2.75-inch rain depth representing a 24-hour, 2-year or 1-hour, 100-year storm event in the St. Joseph River Watershed (Huff, 1992), was chosen to ensure the TP and TSS removal efficiencies quoted in the Michigan Water Quality Trading Rule (MI-ORR, 2002) and used in this study can be achieved (listed in Table 4). The runoff and pond volume associated with the 2.75-inch rainfall was calculated using the NPS loading model (K&A, 2003) based on the percent of the urban area to be treated by the stormwater facilities. Costs of constructing the ponds were then derived based on pond volume and area (assuming a depth of 5 feet).

For vegetated swales, generally agreed design criteria on the size in relation to treated area could not be found. According to a fact sheet produced by the Center for Watershed Protection (http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Open%20Channel%20Practice/Grassed%20Channel.htm), vegetated swales should generally be used to treat drainage areas less than 5 acres. Optimum size of a swale may be 8 feet (width) by 200 feet (length), based on information available from the Low Impact Development Center (http://www.lowimpactdevelopment.org/epa03/LIDtrans/Ex_Swale.pdf). Using these design benchmarks (i.e., for every 5 acres of drainage, it will require a swale of 8ft ×200ft to reach expected treatment efficiencies), the total size of required swales to treat a certain percentage (e.g., 50%) of the targeted urban area was calculated.

A guidance manual produced by the University of Wisconsin-Extension Services (Bannerman and Considine, 2003) provides some detailed instructions on constructing a rain garden for average home owners. The manual suggests a range of size factors (fraction of the drainage area) for design of rain gardens based on soil types and distance from the downspout. Here, an average value of 0.19 from all the reported values across the entire range was used. In addition, it is assumed here that only runoff from the impervious portion of the urban landuses in a subwatershed is treated with rain gardens. This is a reasonable assumption because rain gardens are mostly used to treat runoff from parking lots, roadways, and rooftops in urban areas. Because of the restrictions on where rain gardens can be built in an urban watershed where private properties dominate, rain gardens can only achieve about 5-15% runoff flow reduction (K&A field data [http://www.kalamazooriver.net/pa319new/docs/handouts/downspout_survey.pdf] and Wade-Trim Detroit Study [http://www.wadetrim.com/resources/pub_conf_downspout.pdf]). Therefore, a maximum treatment coverage of 15% of the impervious area in a watershed was assumed in this study.