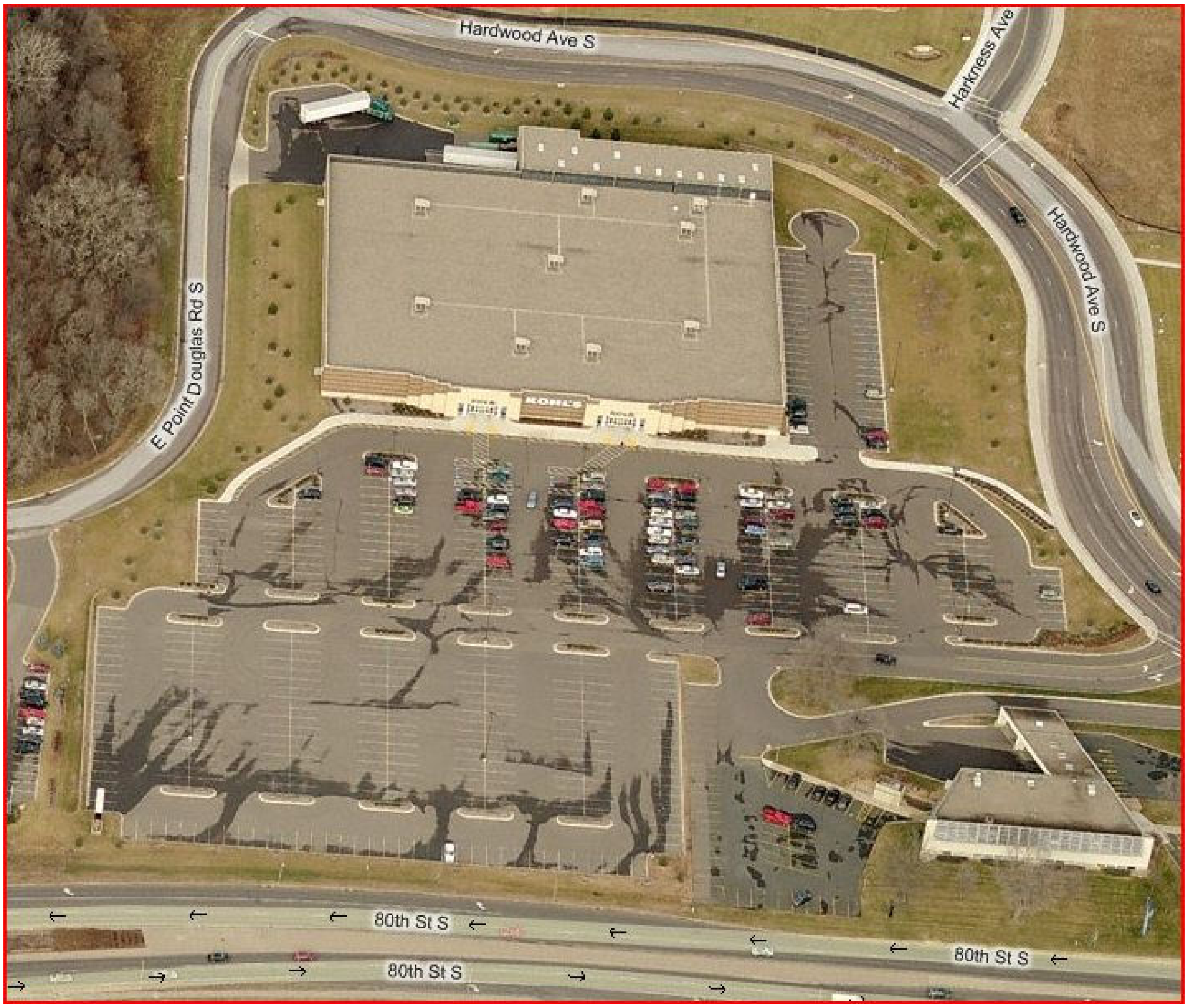
# Highway 61 Corridor Subwatershed: Stormwater Retrofit Assessment




*Prepared by:*

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*With assistance from:*

*THE METRO CONSERVATION DISTRICTS*

*for the*

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# Executive Summary

This report details a subwatershed stormwater retrofit assessment resulting in recommended catchments for placement of Best Management Practice (BMP) retrofits that address the goals of the Local Governing Unit (LGU) and stakeholder partners. This document should be considered as *one part* of an overall watershed restoration plan including educational outreach, stream repair, riparian zone management, discharge prevention, upland native plant community restoration, and pollutant source control.

The assessment's background information is discussed followed by a summary of the assessment's results; the methods used and catchment profile sheets of selected sites for retrofit consideration. Lastly, the retrofit ranking criteria and results are discussed and source references are provided.

Results of this assessment are based on the development of catchment-specific *conceptual* stormwater treatment best management practices that either supplement existing stormwater infrastructure or provide quality and volume treatment where none currently exists. Relative comparisons are then made between catchments to determine where best to initialize final retrofit design efforts. Finally, site-specific design sets (driven by existing limitations of the landscape and its effect on design element selections) will need to be developed to determine a more refined estimate of the reported pollutant removal amounts reported here-in. This typically occurs after the procurement of committed partnerships relative to each specific target parcel slated for the placement of BMPs.

## Background

In 2009, the SWWD identified Highway 61 corridor commercial parcels as high priority stormwater retrofit areas given their dominant impervious land cover and for their high public outreach potential. An initial protocol for assessing commercial sites within the SWWD was developed, refined and pilot-tested by the Washington Conservation District (WCD) and Metro Conservation Districts (MCD). The protocol initially followed a series of steps using a process of elimination to determine where the greatest treatment gains are located versus overall costs, design time and project difficulty as well as other variables. The protocol was developed though a combination of professional experience of BMP retrofitting and design and with tools developed from the Center for Watershed Protection's Urban Subwatershed Restoration Manual Series (specifically, Manual 3, *Urban Stormwater Retrofit Practices*; hereafter referred to as Manual 3). It was then tested and refined (in-field) and adjusted accordingly. In the summer of 2009, the pilot project was initiated assessing several dozen commercial sites that resulted in the identification of 13 high-ranking properties recommended for stormwater retrofits (for further details on this pilot's process and results, refer to Appendix 1: *South Washington Commercial Sites Stormwater Best Management Practice Assessment Update, April 6, 2009*).

In March of 2010, this protocol was expanded to match the current stormwater retrofit assessment protocol developed by the Landscape Restoration Program, the service-oriented branch of the MCD. This expanded assessment approach is summarized in Methods. The initial Highway 61 corridor assessment identified 13 commercial sites were run through the appropriate steps of this expanded protocol with the resulting summary presented herein.

## Summary of Findings

The following table summarizes the assessment results. Treatment levels (percent removal rates) for retrofit projects that resulted in a prohibitive BMP size, or number, or where too expensive to justify installation are not included. Reported treatment levels are dependent upon optimal siting and sizing. The reported treatment levels for each site were selected using the SWWD's goal of 0.22 lb/ac/yr of site effluent runoff.

| Catch. ID | Retrofit Type | Qty of BMPs | TP Reduction (%) | TP Reduction (lb/yr) | Volume Reduction (ac/ft/yr) | Est. Design/Install Cost ($) | O&M Term (years) | Annual O&M Cost ($/ft$^2$) | Total Est. Term Cost/lb-TP/yr |
|---|---|---|---|---|---|---|---|---|---|
| **R001** | B, PS | 7 | 90 | 9.9 | 8.1 | $77,220 | 30 | $0.75 | $695 |
| **R002** | B, PM | 4 | 90 | 9.7 | 7.9 | $74,007 | 30 | $0.75 | $680 |
| **R003** | B, PS | 4 | 90 | 0.45 | 0.37 | $3,510 | 30 | $0.75 | $730 |
| **R004** | B | 2 | 90 | 1.7 | 1.4 | $11,079 | 30 | $0.75 | $658 |
| **R005** | B | 1 | 90 | 0.45 | 0.37 | $3,443 | 30 | $0.75 | $717 |
| **R006** | B | 4 | 90 | 5.2 | 4.2 | $33,453 | 30 | $0.75 | $643 |
| **R007** | B | 1 | 90 | 1.9 | 1.5 | $12,077 | 30 | $0.75 | $641 |
| **R009** | B, PS | 4 | 90 | 3.1 | 2.5 | $30,176 | 30 | $0.75 | $886 |
| **R010** | B, PS | 2 | 90 | 0.7 | 0.6 | $6,010 | 30 | $0.75 | $878 |
| **R011** | B | 5 | 90 | 5.4 | 4.3 | $44,963 | 30 | $0.75 | $831 |
| **R012** | B | 4 | 90 | 5.9 | 4.8 | $58752 | 30 | $0.75 | $888 |
| **R013** | B | 10 | 90 | 11.0 | 8.8 | $108,810 | 30 | $0.75 | $881 |

*B = Bioretention* (infiltration and/or filtration)
*IR = Impervious [cover] Reduction*
*PM = Pond Modification* (increased area/depth, additional cells, forebay, and/or outlet modification)
*PS = Permeable Surface* (infiltration and/or filtration)
*VS = Vegetated Swale* (wet or dry)
*WD = New [wet] Detention or Wetland creation*

# About this Document

## Document Overview

This Subwatershed Stormwater Retrofit Assessment is a watershed management tool to help prioritize stormwater retrofit projects by performance and cost effectiveness. This process helps maximize the value of each dollar spent.

This document is organized into four major sections that describe the general methods used, individual catchment profiles, a resulting retrofit ranking for the subwatershed and references used in this assessment protocol. In some cases, and Appendices section provides additional information relevant to the assessment.

Under each section and subsection, project-specific information relevant to that portion of the assessment is provided with an ***Italicized Heading***.

### Methods

The methods section outlines general procedures used when assessing the subwatershed. It overviews the processes of retrofit scoping, desktop analysis, retrofit reconnaissance investigation, cost/treatment analysis and project ranking. Project-specific details of each process are defined if different from the general, standard procedures.

NOTE: the financial, technical, current landscape/stormwater system, and timeframe limits and needs are highly variable from subwatershed to subwatershed. This assessment uses some, or all, of the methods described herein.

### Retrofit Profiles

When applicable, each retrofit profile is labeled with a unique ID to coincide with the subwatershed name (e.g., SC-001 for Sand Creek catchment 001). This ID is referenced when comparing projects across the subwatershed. Information found in each catchment profile is described below.

#### *Catchment Summary/Description*

Within the catchment profiles is a table that summarizes basic catchment information including acres, land cover, parcels, and estimated annual pollutant load (and other pollutants and volumes as specified by the LGU). Also, a table of the principal modeling parameters and values is reported. A brief description of the land cover, stormwater infrastructure and any other important general information is also described here.

#### *Retrofit Recommendation*

The recommendation section describes the conceptual BMP retrofit(s) selected for the catchment area and provides a description of why the specific retrofit(s) was chosen.

#### *Cost/Treatment Analysis*

A summary table provides for the direct comparison of the expected amount of treatment, within a catchment, that can be expected per invested dollar. In addition, the results of each catchment can be cross-referenced to optimize available capitol budgets vs. load reduction goals.

### *Site Selection*

A rendered aerial photograph highlights properties/areas suitable for retrofit projects. Additional field inspections will be required to verify project feasibility, but the most ideal locations for retrofits are identified here.

## Retrofit Ranking

Retrofit ranking takes into account all of the information gathered during the assessment process to create a prioritized project list. The list is sorted by cost per pound of phosphorus treated for each project for the duration of one maintenance term (conservative estimate of BMP effective life). The final cost per pound treatment value includes installation and maintenance costs. There are many possible ways to prioritize projects, and the list provided is merely a starting point. Final project ranking for installation may include:

- Non-target pollutant reductions
- Project visibility
- Availability of funding
- Total project costs
- Educational value
- Others

## References

This section identifies various sources of information synthesized to produce the assessment protocol utilized in this analysis.

## Appendices

This section provides supplemental information and/or data used at various points along the assessment protocol.

# Methods

## Selection of Subwatershed

Before the subwatershed stormwater assessment begins, a process of identifying a high priority water body as a target takes place. Many factors are considered when choosing which subwatershed to assess for stormwater retrofits. Water quality monitoring data, non-degradation report modeling, and TMDL studies are just a few of the resources available to help determine which water bodies are a priority. Assessments supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the assessment also rank highly.

In areas without clearly defined studies, such as TMDL or officially listed water bodies of concern, or where little or no monitoring data exist, metrics are used to score subwatersheds against each other. In large subwatersheds (e.g., greater than 2500 acres), a similar metric scoring is used to identify areas of concern, or focus areas, for a more detailed assessment. This methodology was slightly modified from Manual 2 of the *Urban Stormwater Retrofit Practices* series.

### *Selection of the Highway 61 corridor*

The highway 61 corridor was selected for assessment by the South Washington Watershed District due to the region's high percentage of impervious cover and its associated pollutants and the commercial area-dominant land use's visibility/outreach opportunities.

## Subwatershed Assessment Methods

The process used for this assessment is outlined below and was modified from the Center for Watershed Protection's *Urban Stormwater Retrofit Practices,* Manuals 2 and 3 (Schueler, 2005, 2007). Locally relevant design considerations were also included into the process (*Minnesota Stormwater Manual, v2*).

### Step 1: Retrofit Scoping

Retrofit scoping includes determining the objectives of the retrofits (volume reduction, target pollutant etc) and the level of treatment desired. It involves meeting with local stormwater managers, city staff and watershed district staff to determine the issues in the subwatershed. This step also helps to define preferred retrofit treatment options and retrofit performance criteria. In order to create a manageable area to assess in large subwatersheds, a focus area may be determined.

### *Highway 61 Scoping*

Pollutants of concern for this subwatershed were identified as TP, TSS, Metals and Thermal. Total volume of runoff was also listed as a priority. Additionally, the WD wanted to prioritize areas close to the major traffic confluences of the highway and major crossroads, focusing on sites highly visible to the public. A one-inch storm event was chosen for a design storm event in BMP sizing as a starting point. Final designs, rather, will use more detailed, rigorous treatment quality-based models for sizing.

### Step 2: Desktop Retrofit Analysis

The desktop analysis involves computer-based scanning of the subwatershed for potential retrofit catchments and/or specific sites. This step also identifies areas that don't need to be assessed because of existing stormwater infrastructure. Accurate GIS data are extremely valuable in conducting the desktop retrofit analysis. Some of the most important GIS layers include: 2-foot or finer topography, hydrology, soils, watershed/subwatershed boundaries, parcel boundaries, high-resolution aerial photography and the storm drainage infrastructure (with invert elevations). The following table highlights some important features to look for and the associated potential retrofit project.

| Subwatershed Metrics and Potential Retrofit Project Site/Catchment | |
|---|---|
| **Screening Metric** | **Potential Retrofit Project** |
| Existing Ponds | Add storage and/or improve water quality by excavating pond bottom, modifying riser, raising embankment, and/or modifying flow routing. |
| Open Space | New regional treatment (pond, bioretention). |
| Roadway Culverts | Add wetland or extended detention water quality treatment upstream. |
| Outfalls | Split flows or add storage below outfalls if open space is available. |
| Conveyance system | Add or improve performance of existing swales, ditches and non-perennial streams. |
| Large Impervious Areas (campuses, commercial, parking) | Stormwater treatment on site or in nearby open spaces. |
| Neighborhoods | Utilize right of way, roadside ditches or curb-cut raingardens or filtering systems to treat stormwater before it enters storm drain network. |

### *Highway 61 Desktop Analysis*

Commercial areas (parcels) within 1 block from highway 61 and major road corridor intersections were selected for initial review of potential sites for retrofitting stormwater BMPs. All other properties were eliminated from further review. Those sites with parking lots greater than 2-acres or part of major lot complexes with high traffic and visibility were selected for a field assessment (Step 3). Industrial or other small business areas not meeting these criteria were eliminated from further assessment.

## Step 3: Retrofit Reconnaissance Investigation

After identifying potential retrofit sites through this desktop search, a field investigation was conducted to evaluate each site. During the investigation, the drainage area and stormwater infrastructure mapping data were verified. Site constraints were assessed to determine the most feasible retrofit options as well as eliminate sites from consideration. The field investigation may have also revealed additional retrofit opportunities that could have gone unnoticed during the desktop search.

### *Highway 61 RRI*

Hundreds of parcels were evaluated in GIS to determine likely candidates for further filed investigation. Sites were remotely eliminated if they did not meet the criteria of:

1. Being within ¼-mile of a major road
2. Being a commercial site with substantial visibility
3. No obvious form of stormwater treatment on-site, or with rate control structures and/or quality control structures easily modifiable to provide greater quality treatment.

Each site that was identified as a possible retrofit location was visited in the field to verify GIS data and for appropriateness for stormwater retrofitting. Site constraints were noted. The pollutant, volume and public outreach goals identified in the Scoping process were then used, along with several other metrics, to score and rank each site for relative comparison and subsequent ranking. Those sites with the highest scores were then considered for one or more treatment options (see Catchment Profiles). Each treatment option concept was assigned design elements that either improved or limited pollutant removal performance based on existing site limitations. Estimated existing pollutant loadings could then be run through several concept BMP(s) types for relative performance comparison. BMPs that reduced volume and had the highest runoff volume reductions were prioritized (*see* Appendix 1).

The following stormwater BMPs were considered for each catchment/site:

| Stormwater Treated Options for Retrofitting | | |
|---|---|---|
| **Area Treated** | **Best Management Practice** | **Potential Retrofit Project** |
| 5-500 acres | Extended Detention | **12-24 hr detention of stormwater with portions drying out between events (preferred over Wet Ponds). May include multiple cell design, infiltration benches, sand/peat/iron filter outlets and modified choker outlet features.** |
| | Wet Ponds | **Permanent pool of standing water with new water displacing pooled water from previous event.** |
| | Wetlands | **Depression less than 1-meter deep and designed to emulate wetland ecological functions. Residence times of several days to weeks. Best constructed off-line with low-flow bypass.** |
| 0.1-5 acres | Bioretention | **Use of native sol, soil microbe and plant processes to treat, evapotranspirate, and/or infiltrate stormwater runoff. Facilities can either be fully infiltrating, fully filtering or a combination thereof** |
| | Filtering | **Filter runoff through engineered media and passing it through an under-drain. May consist of a combination of sand, soil, compost, peat, compost and iron.** |
| | Infiltration | **A trench or sump that is rock-filled with no outlet that receives runoff. Stormwater is passed through a conveyance and pretreatment system before entering infiltration area.** |
| | Swales | **A series of vegetated, open channel practices that can be designed to filter and/or infiltrate runoff.** |
| | **Other** | **On-site, source-disconnect practices such as rain-leader raingardens, rain barrels, green roofs, cisterns, stormwater planters, dry wells or permeable pavements.** |

### Step 4: Treatment Analysis/Cost Estimates

#### *Treatment analysis*

Sites most likely to be conducive to addressing the LGU goals and appear to be simple-to-moderate in design/install/maintenance considerations are chosen for a cost/benefit analysis in order to relatively compare catchments/sites. Treatment concepts are developed taking into account site constraints and the subwatershed treatment objectives. Projects involving complex stormwater treatment interactions or pose a risk for upstream flooding require the assistance of a certified engineer. Conceptual designs, at this phase of the design process, include a cost estimate and estimate of pollution reduction. Reported treatment levels are dependent upon optimal site selection and sizing.

Modeling of the site is done by one or more methods such as with P8, WINSLAMM or simple spreadsheet methods using the Rational Method. Event mean concentrations or sediment loading files (depending on data availability and model selection) are used for each catchment/site to estimate relative pollution loading of the existing conditions. The site's conceptual BMP design is modeled to then estimate varying levels of treatment by sizing and design element. This treatment model can also be used to properly size BMPs to meet LGU restoration objectives.

| General P8 Model Inputs | |
|---|---|
| **Parameter** | **Method for Determining Value** |
| **Total Area** | **Source/Criteria** |
| **Pervious Area Curve Number** | **Values from the USDA Urban Hydrology for Small Watersheds TR-55 (1986). A composite curve number was found based on proportion of hydrologic soil group and associated curve numbers for open space in fair condition (grass cover 50%-75%).** |
| **Directly Connected Impervious Fraction** | **Calculated using GIS to measure the amount of rooftop, driveway and street area directly connected to the storm system. Estimates calculated from one area can be used in other areas with similar land cover.** |
| **Indirectly Connected Impervious Fraction** | **Wisconsin urban watershed data (Panuska, 1998) provided in the P8 manual is used as a basis for this number. It is adjusted slightly based on the difference between the table value and calculated value of the directly connected impervious fraction.** |
| **Precipitation/Temperature Data** | **Rainfall and temperature recordings from 1959 were used as a representation of an average year.** |
| **Hydraulic Conductivity** | **A composite hydraulic conductivity rate is developed for each catchment area based on the average conductivity rate of the low and high bulk density rates by USDA soil texture class (Rawls et. al, 1998). Wet soils where practices will not be installed are omitted from composite calculations.** |
| **Particle/Pollutant** | **The default NURP50 particle file was used.** |
| **Sweeping Efficiency** | **Unless otherwise noted, street sweeping was not accounted for.** |

| General Rational Method/EMC Spreadsheet Model Inputs | | |
|---|---|---|
| **Parameter** | **Method for Determining Value** | |
| **Total Area** | **Source/Criteria** | |
| **Pervious Area Curve Number** | **As for P8** | |
| **Directly Connected Impervious Fraction** | **As for P8** | |
| **Indirectly Connected Impervious Fraction** | **As for P8** | |
| **Precipitation/Temperature Data** | **Target design water volumes were used based on goals identified in *Scoping*. No temperature data was used. Runoff using Rational Method.** | |
| **Hydraulic Conductivity** | **No direct modeling of infiltration is used in this method. Rather, simple BMP sizing rules-of-thumb based on infiltration by soil type are used (modified form MANUAL 3):** | |
| | **BMP** | **Treatment Area as % of Contributing Watershed** |
| | Dry Extended Detention | **3** |
| | Pond Wet Pond | **3** |
| | Wetland | **5** |
| | Bioretention (type A soils) | **5** |
| | Bioretention (type B soils) | **7** |
| | Bioretention (type C soils) | **10** |
| | Bioretention (type D soils) | **15** |
| | Sand Filter (type A-B soils) | **2** |
| | Sand Filter (type C-D soils) | **5** |
| | Infiltration (type A soils) | **2** |
| | Infiltration (type B soils) | **5** |
| | Filter Swale/Strip (type A soils) | **5** |
| | Filter Swale/Strip (type B soils) | **10** |
| | Filter Swale/Strip (type C-D soils) | **15** |
| **Particle/Pollutant** | **No particle attributes are used. Event mean Concentration values are selected by land-cover (or use) of catchment or by individual source on-site (e.g., lawn areas, parking lot, roof tops, etc.) as provided by MANUAL 3 and the MN Stormwater Manual.** | |
| **Sweeping Efficiency** | **No street sweeping is accounted for.** | |

### *Highway 61 Treatment Analysis*

For the Highway 61 treatment analysis, each site was first assessed for BMP "family" type applicability given specific site constraints and soil types. Pedestrian and car traffic flow, parking needs, snow storage areas, obvious utility locations, existing landscaping, surface water runoff flow, project visibility, "cues of care" in relation to existing landscape maintenance, available space and several other factors dictated the selection of one or more potential BMPs for each site.

Conceptual treatment for each was then estimated by using the general rational method for runoff volume estimation and the BMP spreadsheet method for direct comparison of the relative pollutant efficiency of 1 or more BMPs. Each conceptual BMPs design elements were chosen given the site characteristics identified earlier (*see* Appendix 1 for more details). After the field investigation, P8 was used in conjunction with GIS remote data to run annual expected loading and treatment values for each site and selected BMP(s). Treatment levels were driven by a percent TP-removal sizing criteria ranging from 30% to 95% and reported in each Catchment Profile.

Treatment levels of various BMPs are determined by their specific design parameters. For the sake of this analysis, we assumed the following design parameters by BMP given complete capture of a 1 to 1.25-inch event:

**Infiltration Efficiency (permeable asphalt and fully infiltrating raingardens)**

Infiltration concept design included the following assumed elements that enhance performance of pollutant removal:

1. Treatment exceeds $WQ_v$ by 25%
2. Infiltration rates between 1-4 inches per hour
3. Catchment drainage area is nearly, or all, 100% impervious

The resulting efficiency of the above concept is approximately:

- 95% (of 95% max possible) for TP
- 95% (of 95% max possible) for TSS

**Bioretention Efficiency (partially filtering raingardens)**

Bioretention concept design included the following assumed elements that enhance performance of pollutant removal:

1. Tested filter media coil P-index <30
2. Filter bed $\geq$ inches
3. Two-cell design (first cell being a pre-treatment chamber)
4. Permeable soils $\geq$ 0.5-in/hr
5. Up-flow pipe on underdrain (or suspended pipe)

Bioretention concept design included the following assumed elements that inhibit performance of pollutant removal:

1. Bioretention cell(s) surface area is less than 5% the catchment drainage area (until final approval for plans is given, it was assumed that no parking space reductions will be allowed and that only a portion of the existing green space will be available for retrofitting purposes)

The resulting efficiency of the above concept is approximately:

- 40% (of 60% max possible) for TP
- 72% (of 85% max possible) for TSS

### *Cost Estimates*

Each resulting BMP (by percent TP-removal dictated sizing) was then assigned estimated design, installation and first-year establishment-related maintenance costs given it's $ft^3$ of treatment. In cases where live storage was 1-ft, this number roughly related to $ft^2$ of coverage. An annual cost/TP-removed for each treatment level was then calculated for the life-cycle of said BMP which included promotional, administrative and life-cycle operations and maintenance costs. The following table provides the BMP cost estimates used to assist in cost-analysis:

| Average BMP Cost Estimates | | | | | | |
|---|---|---|---|---|---|---|
| **BMP** | **Median Inst. Cost ($/ft²)** | **Marginal Annual Maintenance Cost (contracted)** | **O & M Term** | **Design Cost ($70/hr)** | **Installation Oversight Cost ($70/hr)** | **Total Installation Cost (Includes design & 1-yr maintenance)** |
| **Pond Retrofits** | $3.00 | $500/acre | 30 | [1]40% above construction | $210 (3 visits) | **$4.21/sq ft** |
| **Extended Detention** | $5.00 | $1000/acre | 30 | [3]$2800/acre | $210 (3 visits) | **$5.09/sq ft** |
| **Wet Pond** | $5.00 | $1000/acre | 30 | [3]$2800/acre | $210 (3 visits) | **$5.09/sq ft** |
| **Stormwater Wetland** | $5.00 | $1000/acre | 30 | [3]$2800/acre | $210 (3 visits) | **$5.09/sq ft** |
| **Water Quality Swale**[6] | $12.00 | $250/100 ln ft | 30 | $1120/100 ln ft | $210 (3 visits) | **$12.91/sq ft** |
| **Cisterns** | $15.00 | [5]$100 | 30 | NA | $210 (3 visits) | **$15.00/sq ft** |
| **French Drain/Dry Well** | $12.00 | [5]$100 | 30 | 20% above construction | $210 (3 visits) | **$14.40/sq ft** |
| **Infiltration Basin** | $15.00 | $500/acre | 30 | $1120/acre | $210 (3 visits) | **$15.04/sq ft** |
| **Rain Barrels** | $25.00 | [5]$25 | 30 | NA | $210 (3 visits) | **$25.00/sq ft** |
| **Structural Sand Filter (including peat, compost, iron amendments, or similar)** [6] | $20.00 | $250/25 ln ft | 30 | $300/25 ln ft | $210 (3 visits) | **$21.47/sq ft** |
| **Impervious Cover Conversion** | $20.00 | $500/acre | 30 | $1120/acre | $210 (3 visits) | **$20.04/sq ft** |
| **Stormwater Planter** | $27.00 | $50/100 ft² | 30 | 20% above construction | $210 (3 visits) | **$32.90/sq ft** |
| **Rain Leader Disconnect Raingardens** | $4.00 | [2]$25/150 ft² | 30 | $280/100 ft² | $210 (3 visits) | **$6.97/sq ft** |
| **Simple Bioretention (no engineered soils or under-drains, but w/curb cuts and forebays)** | $10.00 | $0.75/ft² | 30 | $840/1000 ft² | $210 (3 visits) | **$11.34/sq ft** |

| Average BMP Cost Estimates | | | | | | |
|---|---|---|---|---|---|---|
| BMP | Median Inst. Cost ($/ft²) | Marginal Annual Maintenance Cost (contracted) | O & M Term | Design Cost ($70/hr) | Installation Oversight Cost ($70/hr) | Total Installation Cost (Includes design & 1-yr maintenance) |
| Moderately Complex Bioretention (incl. engineered soils, under-drains, curb cuts, forebays but no retaining walls) | $12 | $0.75/ft² | 30 | $1120/1000 ft² | $210 (3 visits) | **$13.12/sq ft** |
| Highly Complex Bioretention (incl. engineered soils, under-drains, curb cuts, forebays, retaining walls) | $16.00 | $0.75/ft² | 30 | [4]$1400/1000ft² | $210 (3 visits) | **$17.90/sq ft** |
| Underground Sand Filter | $65.00 | $0.75/ft² | 30 | [1]40% above construction | $210 (3 visits) | **$91.75/sq ft** |
| Stormwater Tree Pits | $70.00 | $0.75/ft² | 30 | [1]40% above construction | $210 (3 visits) | **$98.75/sq ft** |
| Grass/Gravel Permeable Pavement (sand base) | $12.00 | $0.75/ft² | 30 | [1]40% above construction | $210 (3 visits) | **$17.55/sq ft** |
| Permeable Asphalt (granite base) | $10.00 | $0.75/ft² | 30 | [1]40% above construction | $210 (3 visits) | **$14.00/sq ft** |
| Permeable Concrete (granite base) | $12.00 | $0.75/ft² | 30 | [1]40% above construction | $210 (3 visits) | **$17.55/sq ft** |
| Permeable Pavers (granite base) | $25.00 | $0.75/ft² | 30 | [1]40% above construction | $210 (3 visits) | **$35.75/sq ft** |
| Extensive Green Roof | $225.00 | $500/1000 ft² | 30 | [1]40% above construction | $210 (3 visits) | **$315.50/sq ft** |
| Intensive Green Roof | $360.00 | $750/1000 ft² | 30 | [1]40% above construction | $210 (3 visits) | **$504.75/sq ft** |

[1]Likely going to require a licensed, contacted engineer.
[2]Assumed landowner, not contractor, will maintain.
[3]LRP would only design off-line systems not requiring an engineer. For all projects requiring an engineer, assume engineering costs to be 40% above construction costs.
[4]If multiple projects are slated, such as in a neighborhood retrofit, a design packet with templates and standard layouts, element elevations and components, planting plans and cross sections can be generalized, design costs can be reduced.
[5]Not included in total installation cost (minimal).

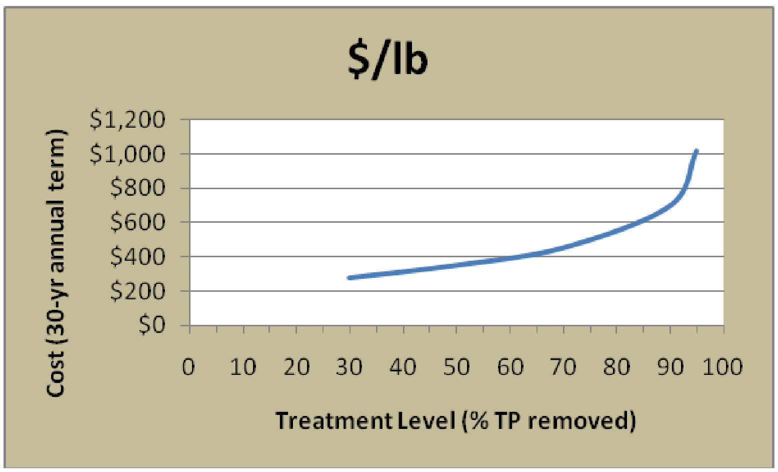
[5]Assumed to be 15 feet in width.

### *Highway 61 Cost Analysis*

For the Highway 61 cost analysis, promotion and administration for each commercial/public property was assumed to not exceed $500, or the rough equivalent of five 2-hr meetings. Annual O & M referred to the $ft^2$ estimates provided in the preceding table. In cases were multiple BMP types were prescribed for an individual site, both the estimated installation and maintenance-weighted means by $ft^2$ of BMP were used to produce cost/benefit estimates.

## Step 5: Evaluation and Ranking

The results of each site were analyzed for cost/treatment to prescribe the most cost-efficient level of treatment.




### *Highway 61 Evaluation and Ranking*

In the Highway 61 evaluation and ranking, the recommended level of treatment for each catchment, as reported in the Executive Summary table, was chosen using the South Washington WD's 0.22 lb/ac/yr site goal. The level reaching or just surpassing this goal for each site is reported in the ranking table (also highlighted within each catchment profile's cost/benefit table). This roughly equaled the 90% reduction level in all cases.

# Catchment Profiles

The following pages provide catchment-specific information that was analyzed for stormwater BMP retrofit treatment at various levels. The recommended level of treatment reported in the Ranking Table is determined by weighing the cost-efficiency vs. site specific limitations about what is truly practical in terms of likelihood of being granted access to optimal BMP site locations and crew mobilization in relation to proximal additional new BMPs.

## *Highway 61 Catchment Profiles*

For development of the Highway 61 catchment profile section, the sites that received a score of 19 (out of 33) or better were further analyzed for retrofit potential. The result was 13 sites that were then ranked in order of importance relative to the metric system described earlier (defined by the SWWD goals in Methods and Appendix 1).

| | METRIC | | | | | | |
|---|---|---|---|---|---|---|---|
| **Catchment ID** | **% I.S. Treated** | **WQ Target** | **Planning** | **Access** | **Visibility** | **Parking Lot Condition** | **TOTAL** |
| | *5* | *5* | *5* | *5* | *10* | *3* | *33* |
| R003 | 3 | 5 | 5 | 5 | 10 | 3 | 31 |
| R009 | 5 | 3 | 5 | 5 | 10 | 3 | 31 |
| R010 | 5 | 3 | 5 | 5 | 10 | 3 | 31 |
| R002 | 5 | 4.5 | 3 | 5 | 10 | 3 | 30.5 |
| R005 | 3 | 4.5 | 5 | 5 | 10 | 3 | 30.5 |
| R011 | 3 | 4.5 | 5 | 5 | 10 | 3 | 30.5 |
| R004 | 3 | 4 | 5 | 5 | 10 | 3 | 30 |
| R007 | 3 | 4 | 5 | 5 | 10 | 3 | 30 |
| R008 | 3 | 4 | 5 | 5 | 10 | 3 | 30 |
| R013 | 3 | 4 | 5 | 5 | 10 | 3 | 30 |
| R012 | 5 | 4.5 | 5 | 5 | 6 | 3 | 28.5 |
| R006 | 5 | 4.5 | 3 | 5 | 10 | 0 | 27.5 |
| R001 | 5 | 4 | 3 | 5 | 2 | 0 | 19 |

## R001 KOHLS

| Catchment Summary | |
|---|---|
| Acres | 5.5 |
| Dominant Land Cover | Commercial |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 9.3 |
| TP (lb/yr) | 11.0 |
| TSS (lb/yr) | 3453.8 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 49 |
| Indirectly Connected Impervious Fraction | 0.00 |
| Directly Connected Impervious Fraction | 0.82 |
| Hydraulic Conductivity (in/hr) | 3.39 |

**DESCRIPTION**

The Kohl's property is predominantly comprised of mid-life parking lot and small landscaped areas, some of which drain onto the asphalt (north-eastern portion of lot). The majority of the site's catch basins are located along the curb line of the lot's landscaped islands. At least three catch basins are located within the driving lane (north-eastern and eastern side of lot). Snow appears to be stored along the eastern side of the lot in winter. The amount of parking area is quite substantial given what would be expected, with the southern portion of parking lot likely rarely coming into service throughout the year.

Most of the stormwater runoff from the site drains south through the extended parking lot. On the way, the northern portion of the lot is captured by catch basins along the islands that define the driving lane that divides the two lots. Runoff from the southern portion of the lot drains to catch basins along the property's southern boundary. There is no immediately apparent on-site water quality or volume treatment.

**RETROFIT RECEOMMENDATION**

Given the site's dominantly impervious make-up, lack of available green space, absent stormwater pond and sandy soils (USDA lists the soil types as predominantly A soils: Mahtomedi loamy sand and Urban land Zimmerman Complex) two stormwater BMPs were selected for potential retrofits: fully infiltrating bioretention cells and permeable asphalt. With low P-index organic soil amendments, these soils will lend the site well to infiltration BMPs.

Permeable asphalt could be placed around the in-lot catch basin areas while existing landscaped islands can be converted to bioretention cells with existing catch basins being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (moderate bioretention).

Moderate Bioretention: $13.12/ft$^2$

Permeable Asphalt: $14.00/ft$^2$


Proposed Bioretention Areas   Proposed Permeable Asphalt Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 10.42 | 9.9 | 7.7 | 5.5 | 3.3 |
| | TSS Reduction (lb/yr) | 3427.82 | 3338.9 | 2,874 | 2,343 | 1,718 |
| | TSS Reduction (%) | 99% | 97% | 83% | 68% | 50% |
| | Volume Reduction (acre-feet/yr) | 8.8 | 8.1 | 6.3 | 4.8 | 3.1 |
| | Volume Reduction (%) | 94% | 87% | 68% | 52% | 33% |
| | Live Storage Volume (cu feet) | 8820 | 5720 | 2,870 | 1,580 | 740 |
| Costs | Materials/Labor/Design | $119,070 | $77,220 | $38,745 | $21,330 | $9,990 |
| | Promotion & Admin Costs | $500 | $500 | $500 | $500 | $500 |
| | Total Project Cost | $119,570 | $77,720 | $39,245 | $21,830 | $10,490 |
| | Annual O&M | $6,615 | $4,290 | $2,153 | $1,185 | $555 |
| | Term Cost/lb/yr (30 yr) | $1,017 | $695 | $449 | $348 | $274 |

## R002 RAINBOW FOODS

| Catchment Summary | |
|---|---|
| Acres | 4.1 |
| Dominant Land Cover | Commercial |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 9.1 |
| TP (lb/yr) | 10.7 |
| TSS (lb/yr) | 3384.0 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 49 |
| Indirectly Connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 1 |
| Hydraulic Conductivity (in/hr) | 3.39 |

**DESCRIPTION**

The Rainbow Foods property is predominantly comprised of a parking lot with small landscaped island areas, some of which drain to the existing on-site retention pond. There are four catch basins on site located along the middle of the driving lane within the parking lot and along the northwestern curb. At least three catch basins are located along the southwestern edge of the parking lot behind the building. The amount of parking lot area does not appear to be excessive.

Most of the stormwater runoff from the site drains towards the north retention pond at the end of the parking lot. The on-site water quality or volume treatment is treated within the retention pond, which has a buffer of plant material around the perimeter.

**RETROFIT RECEOMMENDATION**

Given the site's dominantly impervious makeup, lack of available green space (USDA lists the soil types as predominantly A Soils: Zimmerman Loamy fine sand Urban Land Complex) two stormwater BMPs were selected for potential retrofits: three fully infiltrating bioretention cells and a proposed pond modification. *Note: Modeling for Bioretention effects only. It is recommended that the watershed district's engineer first model for simple pond modifications (i.e., outlet modification) for treatment and cost analysis before committing to bioretention. With low P-index organic soil amendments, these soils will lend the site well to infiltration BMPs.

Existing landscaped islands can be converted to bioretention cells with existing catch basins being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (moderate bioretention).

Moderate Bioretention: $13.12/ft$^2$

Pond Modification: $4.21/ft$^2$


Proposed Bioretention Areas    Proposed Pond Modification

| | Cost/Benefit Analysis | Percent TP Reduction Level (Bioretention) | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 10.2 | 9.7 | 7.5 | 5.4 | 3.2 |
| | TSS Reduction (lb/yr) | 3360 | 3270 | 2,820 | 2,300 | 1,689 |
| | TSS Reduction (%) | 99% | 97% | 83% | 68% | 50% |
| | Volume Reduction (acre-feet/yr) | 8.6 | 7.9 | 6.2 | 4.6 | 3.0 |
| | Volume Reduction (%) | 95% | 87% | 68% | 51% | 33% |
| | Live Storage Volume (cubic feet) | 8550 | 5482 | 2,770 | 1,540 | 730 |
| Costs | Materials/Labor/Design | $115,425 | $74,007 | $37,395 | $20,790 | $9,855 |
| | Promotion & Admin Costs | $500 | $500 | $500 | $500 | $500 |
| | Total Project Cost | $115,925 | $74,507 | $37,895 | $21,290 | $10,355 |
| | Annual O&M | $6,413 | $4,112 | $2,078 | $1,155 | $548 |
| | Term Cost/lb/yr (30 yr) | $1,008 | $680 | $445 | $345 | $279 |

*Note: Modeling for Bioretention effects only. It is recommended that the watershed district's engineer first model for simple pond modifications (i.e., outlet modification) for treatment and cost analysis before committing to bioretention.

## R003 STARBUCKS

| Catchment Summary | |
|---|---|
| Acres | 0.5 |
| Dominant Land Cover | Commercial |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 0.40 |
| TP (lb/yr) | 0.50 |
| TSS (lb/yr) | 160 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 49 |
| Indirectly Connected Impervious Fraction | 0.00 |
| Directly Connected Impervious Fraction | 0.45 |
| Hydraulic Conductivity (in/hr) | 3.39 |

### DESCRIPTION

The Starbucks property is predominantly comprised of impervious parking lot and small landscaped islands, some of which drain onto the asphalt (north and eastern portion of lot). The site's catch basins are located at the corners of the site. At least three catch basins are located within the drive-thru lane. There are five inlets on site and one curb cut area which flows north onto grass. The amount of parking area is small, however the whole property is surrounded by parking lots for surrounding businesses.

Most of the stormwater runoff from the site appears to drain evenly to all four corners of the property. Runoff from the southern portion of the lot drains to catch basins along the property's southern boundary, which is to the east of Hollywood Video. There is no immediately apparent on-site water quality or volume treatment.

### RETROFIT RECOMMENDATION

Given the site's dominantly impervious make-up, lack of available green space (USDA lists the soil types as predominantly A soils in the south half of the site: Zimmerman loamy fine sand Complex. In the north half of the site there are predominantly A soils: Mahtomedi loamy sand Complex) two stormwater BMPs were selected for potential retrofits: three fully infiltrating bioretention cells and one permeable asphalt area. With low P-index organic soil amendments, these soils will lend the site well to infiltration BMPs.

Moderate Bioretention: $13.12/ft$^2$

Permeable Asphalt: $14.00/ft$^2$


Proposed Bioretention Areas    Proposed Permeable Asphalt Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 0.48 | 0.45 | NA | NA | NA |
| | TSS Reduction (lb/yr) | 160 | 155 | NA | NA | NA |
| | TSS Reduction (%) | 100% | 97% | NA | NA | NA |
| | Volume Reduction (acre-feet/yr) | 0.4 | 0.37 | NA | NA | NA |
| | Volume Reduction (%) | 93% | 86% | NA | NA | NA |
| | Live Storage Volume (cubic feet) | 405 | 260 | NA | NA | NA |
| Costs | Materials/Labor/Design | $5,468 | $3,510 | NA | NA | NA |
| | Promotion & Admin Costs | $500 | $500 | NA | NA | NA |
| | Total Project Cost | $5,968 | $4,010 | NA | NA | NA |
| | Annual O&M | $304 | $195 | NA | NA | NA |
| | Term Cost/lb/yr (30 yr) | $1,047 | $730 | NA | NA | NA |

NA = sizing of BMPs too small to effectively treat runoff or justify construction.

## R004 HOLLYWOOD VIDEO

| Catchment Summary | |
|---|---|
| Acres | 1.3 |
| Dominant Land Cover | Commercial |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 1.6 |
| TP (lb/yr) | 1.9 |
| TSS (lb/yr) | 600.0 |

| Model Inputs | |
|---|---|
| Parameter | Input |
| Pervious Curve Number | 43 |
| Indirectly connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 1 |
| Hydraulic Conductivity (in/hr) | 3.39 |

**DESCRIPTION**

The Hollywood Video property is predominantly parking lot with one half of the building sitting on a turf island. The property is also a corner lot and has a steep turf slope draining onto the parking lot.

The site has three catch basins, which are located along the south side of the property. The stormwater runoff from the site drains south towards the three catch basins. There is no immediately apparent on-site water quality or volume treatment.

**RETROFIT RECOMMENDATION**

Given the site's dominantly impervious make-up, lack of available green space (USDA lists the soil types as predominantly A soils in the south half of the site: Zimmerman loamy fine sand Complex. In the northeast corner the A soils are Mahtomedi loamy sand complex.), the stormwater BMP selected for potential retrofits is two fully infiltrating bioretention cells. With low P-index organic soil amendments, these soils will lend the site well to the infiltration BMPs.

Simple Bioretention: \$11.34/ft$^2$

Proposed Bioretention Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 1.8 | 1.7 | 1.3 | NA | NA |
| | TSS Reduction (lb/yr) | 595 | 580 | 500 | NA | NA |
| | TSS Reduction (%) | 99% | 97% | 83% | NA | NA |
| | Volume Reduction (acre-feet/yr) | 1.5 | 1.4 | 1.1 | NA | NA |
| | Volume Reduction (%) | 94% | 88% | 69% | NA | NA |
| | Live Storage Volume (cubic feet) | 1500 | 977 | 490 | NA | NA |
| Costs | Materials/Labor/Design | $17,010 | $11,079 | $5,557 | NA | NA |
| | Promotion & Admin Costs | $500 | $500 | $500 | NA | NA |
| | Total Project Cost | $17,510 | $11,579 | $6,057 | NA | NA |
| | Annual O&M | $1,125 | $733 | $368 | NA | NA |
| | Term Cost/lb/yr (30 yr) | $949 | $658 | $438 | NA | NA |

NA = sizing of BMPs too small to effectively treat runoff or justify construction.

## R005 MAINSTREET BANK

| Catchment Summary | |
|---|---|
| Acres | 0.3 |
| Dominant Land Cover | Commercial |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 0.4 |
| TP (lb/yr) | 0.5 |
| TSS (lb/yr) | 157.0 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 49 |
| Indirectly connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 0.62 |
| Hydraulic Conductivity (in/hr) | 3.39 |

**DESCRIPTION**

Surrounding the Mainstreet Bank property is predominantly comprised of open lawn area with minimal parking. The property is a corner lot and within the property boundary line the site is dominantly impervious surface and there is minimal turf area. There are no catch basins on the property.

Most of the stormwater runoff from the site drains south through the extended parking lot towards Rainbow's overflow parking lot. There is no immediately apparent on-site water quality or volume treatment.

**RETROFIT RECOMMENDATION**

Given the site's dominantly impervious make-up, lack of available green space within the property line, (USDA lists the soil types as predominantly A soils: Zimmerman loamy fine sand Complex) one stormwater BMPs was selected for a potential retrofit: one fully infiltrating bioretention cell. With low P-index organic soil amendments, these soils will lend the site well to the infiltration BMPs.

Existing landscaped island can be converted to a bioretention cell with existing catch basins being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (moderate bioretention).

Moderate Bioretention: $13.12/ft$^2$


Proposed Bioretention Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 0.47 | 0.45 | NA | NA | NA |
| | TSS Reduction (lb/yr) | 156 | 152 | NA | NA | NA |
| | TSS Reduction (%) | 99% | 97% | NA | NA | NA |
| | Volume Reduction (acre-feet/yr) | 0.4 | 0.37 | NA | NA | NA |
| | Volume Reduction (%) | 95% | 88% | NA | NA | NA |
| | Live Storage Volume (cubic feet) | 400 | 255 | NA | NA | NA |
| Costs | Materials/Labor/Design | $5,400 | $3,443 | NA | NA | NA |
| | Promotion & Admin Costs | $500 | $500 | NA | NA | NA |
| | Total Project Cost | $5,900 | $3,943 | NA | NA | NA |
| | Annual O&M | $300 | $191 | NA | NA | NA |
| | Term Cost/lb/yr (30 yr) | $1,057 | $717 | NA | NA | NA |

NA = sizing of BMPs too small to effectively treat runoff or justify construction.

# R006 DISTRICT SERVICE CENTER

| Catchment Summary | |
|---|---|
| Acres | 2.9 |
| Dominant Land Cover | Commerical |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 4.9 |
| TP (lb/yr) | 5.8 |
| TSS (lb/yr) | 1820.0 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 49 |
| Indirectly connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 0.81 |
| Hydraulic Conductivity (in/hr) | 3.39 |

**DESCRIPTION**

The District Service Center property is predominantly comprised of mid-life parking lot and small landscaped areas, some of which drain onto the asphalt (south-western portion of lot). There are three catch basins on site located along the northeastern half behind the building. One catch basin is located within the middle of the open parking lot. And there is a curb cut on the northwestern edge of the parking lot that drains to open turf. The amount of parking area is quite substantial given what would be expected, with the southern portion of parking lot likely rarely coming into service throughout the year.

Most of the stormwater runoff from the site drains south towards three inlets behind the building and one inlet in the front parking lot. There is no immediately apparent on-site water quality or volume treatment.

**RETROFIT RECOMMENDATION**

Given the site's dominantly impervious make-up, lack of available green space, absent stormwater pond and sandy soils (USDA lists the soil types as predominantly A soils: Zimmerman loamy fine sand Complex) one stormwater BMP was selected for potential retrofits: four fully infiltrating bioretention cells. With low P-index organic soil amendments, these soils will lend the site well to infiltration BMPs.

Existing landscaped islands can be converted to bioretention cells with existing catch basins being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (moderate bioretention).

Moderate Bioretention: $13.12/ft$^2$


Proposed Bioretention Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 5.5 | 5.2 | 4.1 | 2.9 | 1.7 |
| | TSS Reduction (lb/yr) | 1810 | 1760 | 1,490 | 1,240 | 912 |
| | TSS Reduction (%) | 99% | 97% | 82% | 68% | 50% |
| | Volume Reduction (acre-feet/yr) | 4.6 | 4.2 | 3.3 | 2.5 | 1.6 |
| | Volume Reduction (%) | 94% | 86% | 67% | 51% | 33% |
| | Live Storage Volume (cubic feet) | 4630 | 2950 | 1,520 | 830 | 400 |
| Costs | Materials/Labor/Design | $52,504 | $33,453 | $17,237 | $9,412 | $4,536 |
| | Promotion & Admin Costs | $500 | $500 | $500 | $500 | $500 |
| | Total Project Cost | $53,004 | $33,953 | $17,737 | $9,912 | $5,036 |
| | Annual O&M | $3,473 | $2,213 | $1,140 | $623 | $300 |
| | Term Cost/lb/yr (30 yr) | $953 | $643 | $422 | $329 | $270 |

## R007 WALGREENS

| Catchment Summary | |
|---|---|
| Acres | 0.9 |
| Dominant Land Cover | Commerical |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 1.8 |
| TP (lb/yr) | 2.1 |
| TSS (lb/yr) | 652.0 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 49 |
| Indirectly connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 1 |
| Hydraulic Conductivity (in/hr) | 3.39 |

**DESCRIPTION**

Walgreens property is on a corner lot and is predominantly comprised of the building, surrounding parking lot and small landscaped areas, some of which drain onto the asphalt (north-eastern portion of lot). Half the property has a steep turf hill sloped towards the Walgreens parking lot. The majority of the site's catch basins are located along the curb line of the lot's landscaped property edge. At least three catch basins are located within the driving lane (southeastern side of lot). The amount of parking area does not appear to be excessive.

Most of the stormwater runoff from the site drains east towards three curb inlets. There is no immediately apparent on-site water quality or volume treatment.

**RETROFIT RECEOMMENDATION**

Given the site's dominantly impervious make-up, lack of available green space, absent stormwater pond and sandy soils (USDA lists the soil types as predominantly A soils: Zimmerman loamy fine sand Complex) one stormwater BMPs was selected for potential retrofits: two fully infiltrating bioretention cells. With low P-index organic soil amendments, these soils will lend the site well to the infiltration BMPs.

The base of the sloped landscaped can be converted to bioretention cells with existing catch basins being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (simple bioretention).

Simple Bioretention: $11.34/ft$^2$

Proposed Bioretention Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 2 | 1.9 | 1.4 | 1.0 | NA |
| | TSS Reduction (lb/yr) | 648 | 630 | 540 | 445 | NA |
| | TSS Reduction (%) | 99% | 97% | 83% | 68% | NA |
| | Volume Reduction (acre-feet/yr) | 1.7 | 1.5 | 1.2 | 0.9 | NA |
| | Volume Reduction (%) | 94% | 83% | 67% | 50% | NA |
| | Live Storage Volume (cubic feet) | 1670 | 1065 | 535 | 300 | NA |
| Costs | Materials/Labor/Design | $18,938 | $12,077 | $6,067 | $3,402 | NA |
| | Promotion & Admin Costs | $500 | $500 | $500 | $500 | NA |
| | Total Project Cost | $19,438 | $12,577 | $6,567 | $3,902 | NA |
| | Annual O&M | $1,253 | $799 | $401 | $225 | NA |
| | Term Cost/lb/yr (30 yr) | $950 | $641 | $443 | $355 | NA |

NA = sizing of BMPs too small to effectively treat runoff or justify construction.

## R009 BURGER KING

| Catchment Summary | |
|---|---|
| Acres | 1.8 |
| Dominant Land Cover | Commercial |
| Parcels | 2.0 |
| Volume (acre-feet/yr) | 3.0 |
| TP (lb/yr) | 3.5 |
| TSS (lb/yr) | 1100.0 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 69 |
| Indirectly connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 0.79 |
| Hydraulic Conductivity (in/hr) | 1.63 |

**DESCRIPTION**

The Burger King property is a corner lot and predominantly comprised of mid-life parking lot and small landscaped areas, some of which drain onto the asphalt (north-eastern portion of lot). There is one catch basin located along the drive-thru lane and one catch basin in the center of the parking lot. The amount of parking area does not appear to be excessive.

Most of the stormwater runoff from the site drains north through the parking lot to the two inlets. There is a sloped turf hill from Jamaica Ave draining towards Burger King property. There is no immediately apparent on-site water quality or volume treatment.

**RETROFIT RECEOMMENDATION**

Given the site's dominantly impervious make-up, lack of available green space, absent stormwater pond and sandy soils (USDA lists the soil types as predominantly A soils: Sparta loamy sand Complex) two stormwater BMPs were selected for potential retrofits: three fully infiltrating bioretention cells and one permeable asphalt area. With low P-index organic soil amendments, these soils will lend the site well to infiltration BMPs.

Permeable asphalt could be paced around the in-lot catch basin areas while existing landscaped islands can be converted to bioretention cells with existing catch basins being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (moderate bioretention).

Equivalent of Moderate Bioretention: $13.12/ft$^2$


Proposed Bioretention Areas    Proposed Permeable Asphalt Areas

| | *Cost/Benefit Analysis* | *Percent TP Reduction Level* | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| *Treatment* | TP Reduction (lb/yr) | 3.3 | 3.1 | 2.4 | 1.7 | NA |
| | TSS Reduction (lb/yr) | 1090 | 1065 | 922 | 760 | NA |
| | TSS Reduction (%) | 99% | 97% | 84% | 69% | NA |
| | Volume Reduction (acre-feet/yr) | 2.8 | 2.5 | 1.9 | 1.4 | NA |
| | Volume Reduction (%) | 93% | 83% | 63% | 47% | NA |
| | Live Storage Volume (cubic feet) | 4080 | 2300 | 1,140 | 630 | NA |
| *Costs* | Materials/Labor/Design | $53,530 | $30,176 | $14,957 | $7,144 | NA |
| | Promotion & Admin Costs | $500 | $500 | $500 | $500 | NA |
| | Total Project Cost | $54,030 | $30,676 | $15,457 | $7,644 | NA |
| | Annual O&M | $3,060 | $1,725 | $855 | $473 | NA |
| | Term Cost/lb/yr (30 yr) | $1,473 | $886 | $571 | $428 | NA |

NA = sizing of BMPs too small to effectively treat runoff or justify construction.

# R010 KENTUCKY FRIED CHICKEN

| Catchment Summary | |
|---|---|
| Acres | 0.3 |
| Dominant Land Cover | Commercial |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 0.7 |
| TP (lb/yr) | 0.8 |
| TSS (lb/yr) | 253.0 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 69 |
| Indirectly connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 1 |
| Hydraulic Conductivity (in/hr) | 1.63 |

**DESCRIPTION**

The Kentucky Fried Chicken property is predominantly comprised of minimal parking lot and surrounding landscaped areas, some of which drain onto the asphalt (northeastern and northwestern portion of lot). There is one catch basin on site, located along the curb line of the lot's landscaped islands. The amount of parking area is minimal and the property appears to be designed mainly for drive-thru customers.

Most of the stormwater runoff from the site drains east through the drive lane towards Burger King. Runoff from the southern portion of the lot drains to catch basins along the property's southern boundary. There is no immediately apparent on-site water quality or volume treatment.

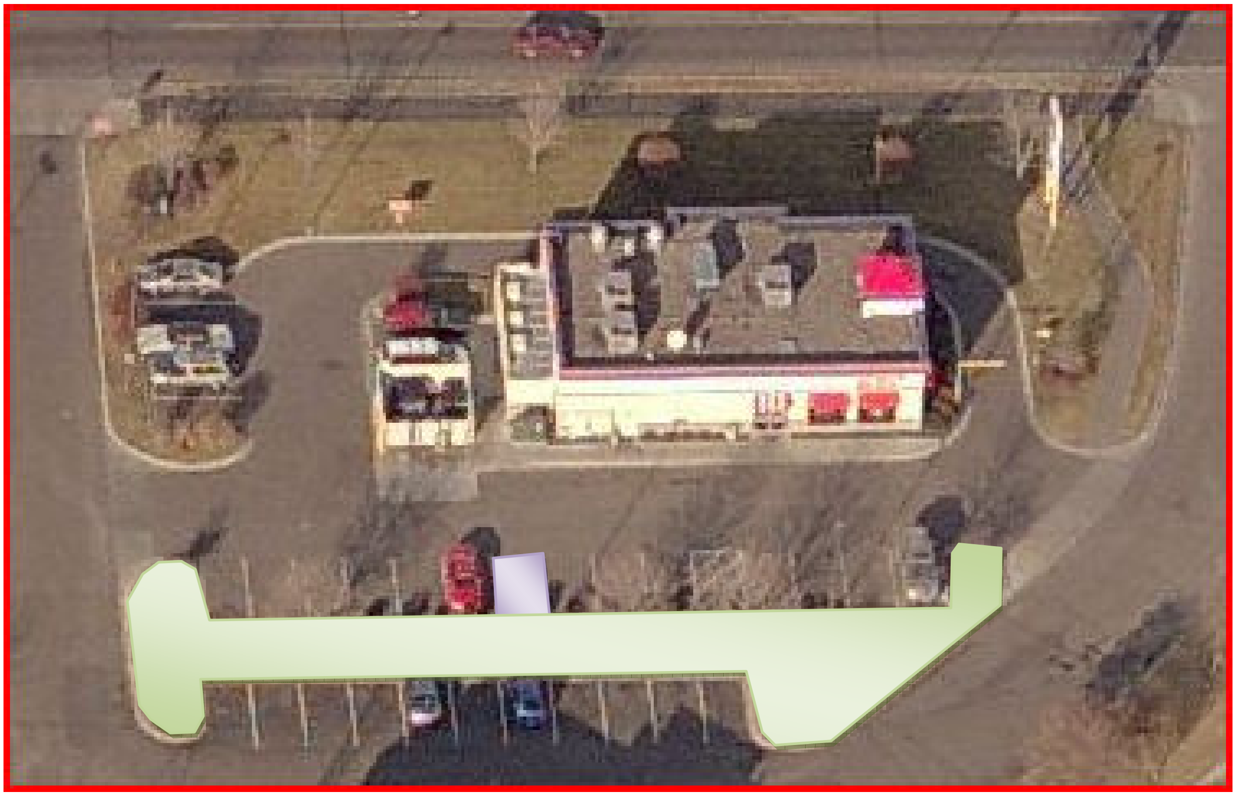
**RETROFIT RECEOMMENDATION**

Given the site's dominantly impervious make-up, minimal available green space, absent stormwater pond and sandy soils (USDA lists the soil types as predominantly A soils: Sparta loamy sand complex) two stormwater BMPs were selected for potential retrofits: one fully infiltrating bioretention cell and one permeable asphalt area. With low P-index organic soil amendments, these soils will lend the site well to the infiltrate on BMPs.

Permeable asphalt could be paced around the in-lot catch basin area, one car stall width, while an existing landscaped island can be converted to a bioretention cells with the existing catch basin being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (moderate bioretention).

Simple Bioretention: $11.34/ft$^2$

Permeable Asphalt: $14.00/ft$^2$



Proposed Bioretention Areas    Proposed Permeable Asphalt Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 0.8 | 0.7 | 0.6 | 0.4 | 0.2 |
| | TSS Reduction (lb/yr) | 251 | 245 | 213 | 175 | 120 |
| | TSS Reduction (%) | 99% | 97% | 84% | 69% | 47% |
| | Volume Reduction (acre-feet/yr) | 0.6 | 0.6 | 0.4 | 0.3 | 0.2 |
| | Volume Reduction (%) | 86% | 86% | 57% | 43% | 29% |
| | Live Storage Volume (cubic feet) | 940 | 530 | 262 | 150 | 75 |
| Costs | Materials/Labor/Design | $10,660 | $6,010 | $2,971 | $1,701 | $851 |
| | Promotion & Admin Costs | $500 | $500 | $500 | $500 | $500 |
| | Total Project Cost | $11,160 | $6,510 | $3,471 | $2,201 | $1,351 |
| | Annual O&M | $705 | $398 | $197 | $113 | $56 |
| | Term Cost/lb/yr (30 yr) | $1,346 | $878 | $520 | $465 | $506 |

## R011 DISTRICT PROGRESSIVE LEARNING CENTER

| Catchment Summary | |
|---|---|
| Acres | 2.5 |
| Dominant Land Cover | Commerical |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 5.1 |
| TP (lb/yr) | 6.0 |
| TSS (lb/yr) | 1890.0 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 69 |
| Indirectly connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 1 |
| Hydraulic Conductivity (in/hr) | 1.63 |

**DESCRIPTION**

The District Progressive Learning Center property is predominantly comprised of mid-life parking lot and small landscaped areas, some of which drain onto the asphalt (south-western portion of lot). The majority of the site's catch basins are located along the south half of the open parking lot. At least two catch basins are located within the driving lane (north-western). The amount of parking area is quite substantial given what would be expected, with the northern portion of parking lot likely rarely coming into service throughout the year.

Most of the stormwater runoff from the site drains south towards two inlets. There are two inlets along the northwestern property line that capture runoff from Applebee's parking lot. There is no immediately apparent on-site water quality or volume treatment.

**RETROFIT RECEOMMENDATION**

Given the site's dominantly impervious make-up, lack of available green space, absent stormwater pond and sandy soils (USDA lists the soil types as predominantly A soils: Sparta loamy sand complex with minimal Hubbard loamy sand Complex in the south and Zimmerman loamy fine sand complex in the north) one stormwater BMP type was selected for a potential retrofit: five fully infiltrating bioretention cells. With low P-index organic soil amendments, these soils will lend the site well to infiltration BMPs.

Existing parking lot parking aisles can be converted to bioretention cells with existing catch basins being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (moderate bioretention).

Moderate Bioretention: $13.12/ft$^2$


Proposed Bioretention Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 5.7 | 5.4 | 4.2 | 3.0 | 1.8 |
| | TSS Reduction (lb/yr) | 1874 | 1830 | 1,590 | 1,310 | 985 |
| | TSS Reduction (%) | 99% | 97% | 84% | 69% | 52% |
| | Volume Reduction (acre-feet/yr) | 4.8 | 4.3 | 3.3 | 2.5 | 1.5 |
| | Volume Reduction (%) | 94% | 84% | 65% | 49% | 29% |
| | Live Storage Volume (cubic feet) | 7100 | 3965 | 1,960 | 1,085 | 530 |
| Costs | Materials/Labor/Design | $80,514 | $44,963 | $22,226 | $12,304 | $6,010 |
| | Promotion & Admin Costs | $500 | $500 | $500 | $500 | $500 |
| | Total Project Cost | $81,014 | $45,463 | $22,726 | $12,804 | $6,510 |
| | Annual O&M | $5,325 | $2,974 | $1,470 | $814 | $398 |
| | Term Cost/lb/yr (30 yr) | $1,408 | $831 | $530 | $414 | $341 |

## R012 CUB FOODS

| Catchment Summary | |
|---|---|
| Acres | 2.7 |
| Dominant Land Cover | Commercial |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 5.6 |
| TP (lb/yr) | 6.6 |
| TSS (lb/yr) | 2072.0 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 69 |
| Indirectly connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 1 |
| Hydraulic Conductivity (in/hr) | 1.63 |

**DESCRIPTION**

The Cub Foods property is predominantly comprised of mid-life parking lot and small landscaped areas, some of which drain onto the asphalt (south-eastern portion of lot). Four of the site's catch basins are located along the south parking lot. Two catch basins are located in the delivery loading dock area (northern side of lot). The amount of parking area is quite substantial given what would be expected, with the southern portion of parking lot likely rarely coming into service throughout the year.

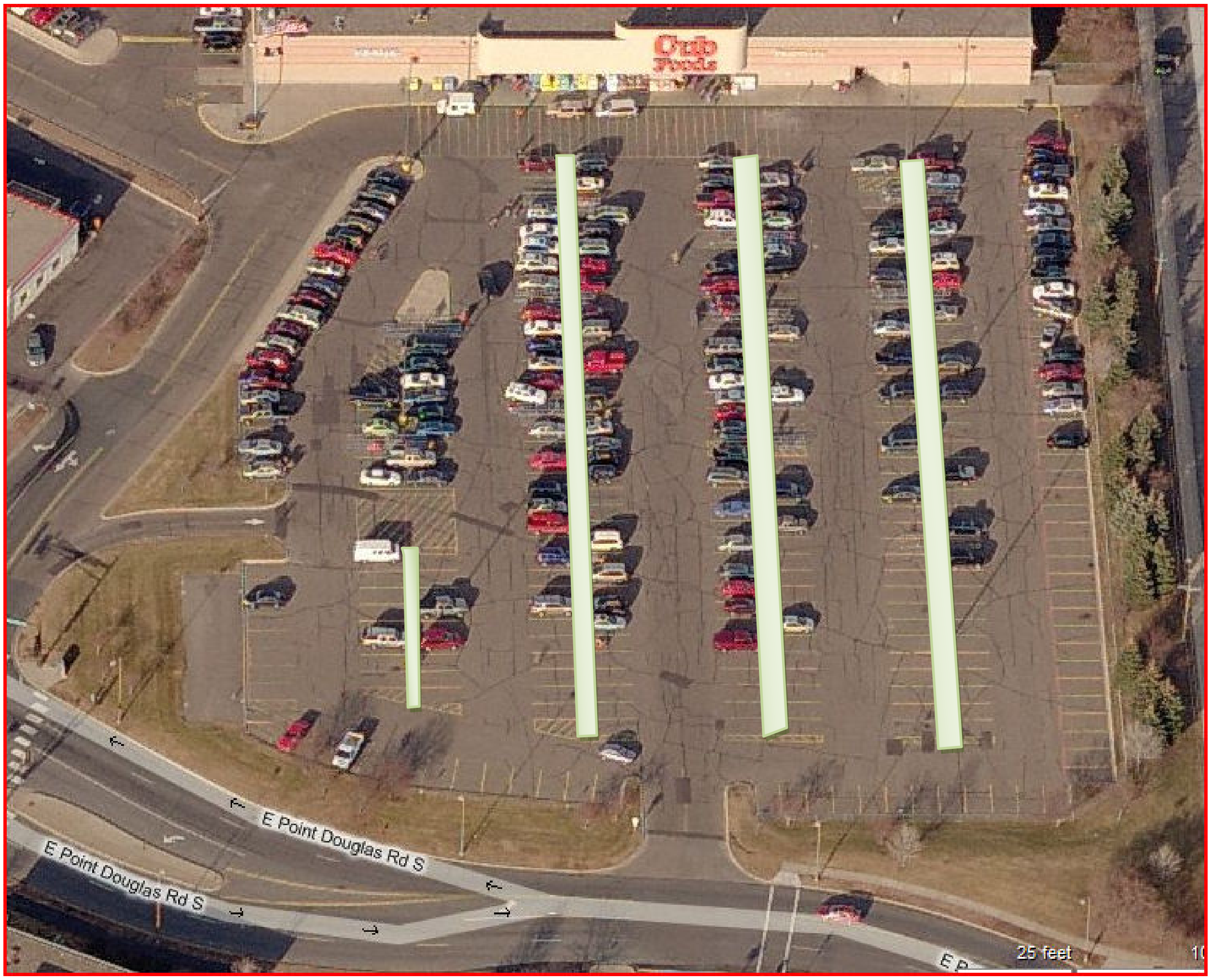
Most of the stormwater runoff from the site drains southeast through the extended parking lot. There is no immediately apparent on-site water quality or volume treatment.

**RETROFIT RECEOMMENDATION**

Given the site's dominantly impervious make-up, lack of available green space, absent stormwater pond and sandy soils (USDA lists the soil types as predominantly A soils: Sparta loamy sand Complex) one stormwater BMP type was selected for potential retrofits: four fully infiltrating bioretention cells. With low P-index organic soil amendments, these soils will lend the site well to the infiltration BMPs.

Existing parking stall aisles can be converted to bioretention cells with existing catch basins being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (moderate bioretention).

Moderate Bioretention: $13.12/ft$^2$




Proposed Bioretention Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 6.2 | 5.9 | 4.6 | 3.3 | 2.0 |
| | TSS Reduction (lb/yr) | 2060 | 2007 | 1,740 | 1,435 | 1,080 |
| | TSS Reduction (%) | 99% | 97% | 84% | 69% | 52% |
| | Volume Reduction (acre-feet/yr) | 5.3 | 4.8 | 3.6 | 2.7 | 1.7 |
| | Volume Reduction (%) | 95% | 86% | 64% | 48% | 30% |
| | Live Storage Volume (cubic feet) | 7700 | 4352 | 2,150 | 1,192 | 580 |
| Costs | Materials/Labor/Design | $103,950 | $58,752 | $29,025 | $16,092 | $7,830 |
| | Promotion & Admin Costs | $500 | $500 | $500 | $500 | $500 |
| | Total Project Cost | $104,450 | $59,252 | $29,525 | $16,592 | $8,330 |
| | Annual O&M | $5,775 | $3,264 | $1,613 | $894 | $435 |
| | Term Cost/lb/yr (30 yr) | $1,493 | $888 | $564 | $439 | $356 |

## R013 TARGET

| Catchment Summary | |
|---|---|
| Acres | 5.0 |
| Dominant Land Cover | Commercial |
| Parcels | 1.0 |
| Volume (acre-feet/yr) | 10.3 |
| TP (lb/yr) | 12.2 |
| TSS (lb/yr) | 3837.0 |

| Model Inputs | |
|---|---|
| **Parameter** | **Input** |
| Pervious Curve Number | 69 |
| Indirectly connected Impervious Fraction | 0 |
| Directly Connected Impervious Fraction | 1 |
| Hydraulic Conductivity (in/hr) | 1.63 |

**DESCRIPTION**

The Target property is predominantly comprised of mid-life parking lot and small landscaped areas, some of which drain onto the asphalt (south-eastern portion of lot). The majority of the site's catch basins are located along the curb line of the lot's landscaped islands. At least ten catch basins are located within the driving lane (north-central and south-central lot in front of building). There are three catch basins behind the building on the south end. The amount of parking area is quite substantial given what would be expected, with the northern portion of parking lot likely rarely coming into service throughout the year.

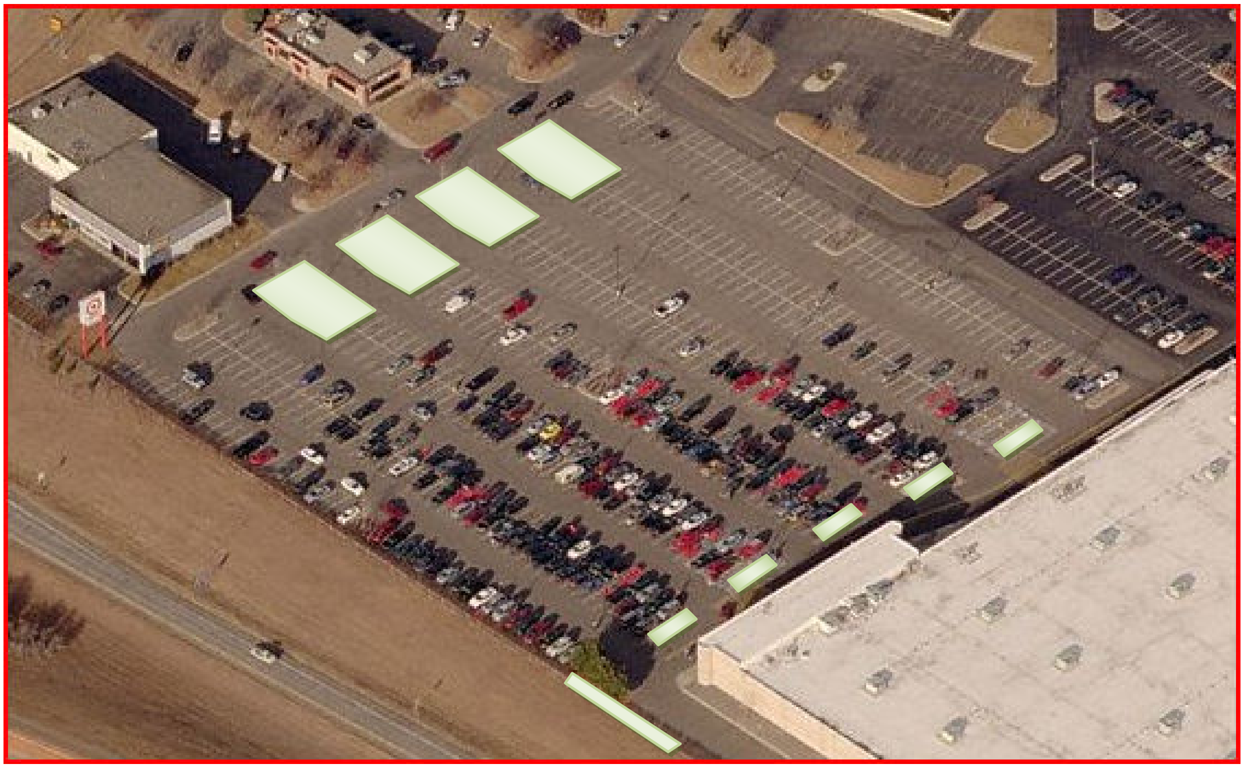
Most of the stormwater runoff from the site drains north through the extended parking lot. On the way, the northern portion of the lot is captured by catch basins along open parking lot lines that define the driving lane that divides the two lots. Runoff from the southern portion of the lot drains to catch basins along the property's southern boundary. There is no immediately apparent on-site water quality or volume treatment.

**RETROFIT RECEOMMENDATION**

Given the site's dominantly impervious make-up, lack of available green space, absent stormwater pond and sandy soils (USDA lists the soil types as predominantly A soils: Sparta loamy sand complex) one stormwater BMP type was selected for potential retrofits: ten fully infiltrating bioretention cells. With low P-index organic soil amendments, these soils will lend the site well to infiltration BMPs.

Existing landscaped islands and open parking lot can be converted to bioretention cells with existing catch basins being utilized for low-flow bypass. Pre-treatment forebays are highly recommended for bioretention cells and it is likely that retaining walls will be used to maximize storage capacity within islands (moderate bioretention).

Moderate Bioretention: $13.12/ft$^2$



Proposed Bioretention Areas

| | Cost/Benefit Analysis | Percent TP Reduction Level | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 90 | 70 | 50 | 30 |
| Treatment | TP Reduction (lb/yr) | 11.6 | 11 | 8.5 | 6.1 | 3.7 |
| | TSS Reduction (lb/yr) | 3810 | 3717 | 3,223 | 2,657 | 2,000 |
| | TSS Reduction (%) | 99% | 97% | 84% | 69% | 52% |
| | Volume Reduction (acre-feet/yr) | 9.8 | 8.8 | 6.7 | 5.0 | 3.1 |
| | Volume Reduction (%) | 95% | 85% | 65% | 49% | 30% |
| | Live Storage Volume (cubic feet) | 14430 | 8060 | 3,978 | 2,207 | 1,080 |
| Costs | Materials/Labor/Design | $194,805 | $108,810 | $53,703 | $29,795 | $14,580 |
| | Promotion & Admin Costs | $500 | $500 | $500 | $500 | $500 |
| | Total Project Cost | $195,305 | $109,310 | $54,203 | $30,295 | $15,080 |
| | Annual O&M | $10,823 | $6,045 | $2,984 | $1,655 | $810 |
| | Term Cost/lb/yr (30 yr) | $1,494 | $881 | $564 | $437 | $355 |

# Retrofit Ranking

| Catch. ID | Retrofit Type | Qty of BMPs | TP Reduction (%) | TP Reduction (lb/yr) | Volume Reduction (ac/ft/yr) | Est. Design/Install Cost ($) | O&M Term (years) | Annual O&M Cost ($/ft$^2$) | Total Est. Term Cost/lb-TP/yr |
|---|---|---|---|---|---|---|---|---|---|
| **R001** | B, PS | 7 | 90 | 9.9 | 8.1 | $77,220 | 30 | $0.75 | $695 |
| **R002** | B, PM | 4 | 90 | 9.7 | 7.9 | $74,007 | 30 | $0.75 | $680 |
| **R003** | B, PS | 4 | 90 | 0.45 | 0.37 | $3,510 | 30 | $0.75 | $730 |
| **R004** | B | 2 | 90 | 1.7 | 1.4 | $11,079 | 30 | $0.75 | $658 |
| **R005** | B | 1 | 90 | 0.45 | 0.37 | $3,443 | 30 | $0.75 | $717 |
| **R006** | B | 4 | 90 | 5.2 | 4.2 | $33,453 | 30 | $0.75 | $643 |
| **R007** | B | 1 | 90 | 1.9 | 1.5 | $12,077 | 30 | $0.75 | $641 |
| **R009** | B, PS | 4 | 90 | 3.1 | 2.5 | $30,176 | 30 | $0.75 | $886 |
| **R010** | B, PS | 2 | 90 | 0.7 | 0.6 | $6,010 | 30 | $0.75 | $878 |
| **R011** | B | 5 | 90 | 5.4 | 4.3 | $44,963 | 30 | $0.75 | $831 |
| **R012** | B | 4 | 90 | 5.9 | 4.8 | $58752 | 30 | $0.75 | $888 |
| **R013** | B | 10 | 90 | 11.0 | 8.8 | $108,810 | 30 | $0.75 | $881 |

*B = Bioretention* (infiltration and/or filtration)
*IR = Impervious [cover] Reduction*
*PM = Pond Modification* (increased area/depth, additional cells, forebay, and/or outlet modification)
*PS = Permeable Surface* (infiltration and/or filtration)
*VS = Vegetated Swale* (wet or dry)
*WD = New [wet] Detention or Wetland creation*

# References

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Walker, W.W. 2007. *P8: Urban Catchment Model, V 3.4.* Developed for the USEPA, Minnesota PCA and the Wisconsin DNR.

# Appendices

## Appendix 1—South Washington Commercial Sites Stormwater Best Management Practice Assessment

April 6, 2009

### Overview

A protocol for assessing commercial sites within the South Washington Watershed District (SWWD) was developed, refined and pilot-tested on behalf of the Washington Conservation District (WCD) by Shawn Tracy (Association of Metropolitan Soil and Water Conservation Districts; AMSWCD) and Pete Young (WCD) as part of a greater, watershed-scale project. The protocol follows a series of steps that uses a process of elimination to determine where the greatest treatment gains are located versus overall costs, design time and project difficulty as well as other variables (discussed in greater detail below). The protocol was developed though a combination of professional experience of BMP retrofitting and design and with tools developed from the Center for Watershed Protection's Urban Subwatershed Restoration Manual Series (specifically, Chapter 3, *Urban Stormwater Retrofit Practices*; hereafter referred to as MANUAL 3). It was then tested and refined, in-field, and adjusted accordingly. A pilot project using this protocol was then used for assessing several dozen sites that resulted in identification of 12 high-ranking sites recommended for stormwater retrofits. Other subwatershed locations in the SWWD are slated for assessment and the resulting total assessment will be used for an outreach program for retrofitting stormwater BMPs at these target locations.

### Protocol

A three-stage approach to identifying key commercial sites for stormwater BMP retrofits was developed. A fourth stage of this assessment begins to weigh various BMP options given specific site constraints and BMP performance estimates given specific design details (site constraints vary from site to site and either promote, prohibit or inhibit specific design details that affect BMP performance). For this Pilot Assessment, the Highway 61 corridor running through SWWD was used.

STAGE 1: Desktop Analysis

Geographic information systems software (ArcGIS) was used to identify properties that were possibly commercial, highly visible: within 1/4-mile of highway 61 and cross streets, had little or no apparent stormwater BMPs visible in high resolution photography and were either of 1-acre or larger or part of a conglomerate of commercial properties larger than 1-acre. Those properties fitting that description were grouped and scaled maps for each area were printed off along with acreage information for each. A GIS shapefile of parcel data was created for this stage to be used for database management of the overall SWWD project and its outreach phase.

STAGE 2: Drive-through Window Survey

A Ranking Form was created that identified 6 project goals relative to prioritization of potential projects (see next page). The results of this initial ranking provide an index for the site expressed as a percentage. Those sites with 85% or greater index were considered for STAGE 3; those of lower ranking were not considered for more detailed assessment; an exception was made for Public property sites that ranked only very slightly lower.

The Window-Survey spreadsheet was created with these goals and assigned weightings:

| | RETROFIT RANKING CRITERIA | | POINTS |
|---|---|---|---|
| 1 | **IMPERVIOUS AREA TREATED** | | 3 |
| | | < 0.5 acre | 1 |
| | | 0.5-2.0 acres | 3 |
| | | > 2.0 acres | 5 |
| 2 | **WATER QUALITY TARGET** | | 4 |
| | | **Runoff Depth Treated (inches per impervious** | 3 |
| | | < 0.25 | 1 |
| | | 0.26-0.50 | 2 |
| | | 0.51-1.00 | 3 |
| | | 1.00-1.50 | 4 |
| | | 1.50-2.00 | 5 |
| | | **TP Pollutant Load Re** | 5 |
| | | Less than 20% | 1 |
| | | 21% to 49% | 3 |
| | | 50% or more | 5 |
| 3 | **PLANNING LEVEL TIME COMMITMENT** | | 5 |
| | | Low | 5 |
| | | Medium | 3 |
| | | High | 1 |
| 4 | **ACCESS** | | 5 |
| | | Poor | 1 |
| | | Good | 3 |
| | | Excellent | 5 |
| 5 | **VISIBILITY** | | 5 |
| | | Poor | 1 |
| | | Good | 3 |
| | | Excellent | 5 |
| 6 | **PARKING LOT CONDITION** | | 3 |
| | | Poor (or not dependent on condition) | 3 |
| | | Good | 0 |
| | | Excellent | 0 |
| | | | **30** /33 |
| | | | **91%** |

Water quality index was an average of the two sub-parameters of Depth and TP Load reduction potential as not all BMPs remove TP at the same rates for a given runoff volume

Visibility was weighted by a factor of 2 in the resulting index (below)

For the Water Quality Target parameter, it wasn't always obvious, in the Window Survey level of assessment, if it would be practical/possible to handle actual target loads or volumes. In those cases, the next STAGE was used to assess the level of treatment we could expect for the site. For all sites, if the resulting Index was 85% or higher (with some exceptions), the site was assessed at the next level of assessment.

STAGE 3: Storage Volumes and Pollutant Loading Estimation

Estimates of runoff volumes and the site's estimated available storage volumes were assessed in greater detail using standard, rapid methods as described below (as defined in MANUAL 3). All areas in yellow are editable fields while the resulting estimates for each variable are reported within the line item for that variables heading (in blue). Depending on the local governing unit's, or designer's, goals, volumes can be determined for both water quality events and channel protection events. After looking at the entire property, the aerial photography and the acreage information from STAGE 1, estimates can be made on available space for retrofit storage. In potential design cases where additional storage below grade is chosen, that volume is included in the available storage estimate. For example, if a bioretention cell is chosen as an option but above ground surface area or grades do not allow for complete storage in its ponding area, designed off-line prefabricated parabolic arch storage may be included in total volume stored as well as the 30% voids of an engineered soil; provided percolation rates do not inhibit flow-though to the embedded storage.

| RETROFIT STORAGE VOLUME | | | |
|---|---|---|---|
| ***Runoff Coefficient*** | | 0.95 | |
| Impervious Cover (%) | 100 | | |
| **Water Quality Target Volume** | | 0.11875 | A.F. |
| Target Rainfall Depth (in) | 0.5 | | |
| Drainage area (acres) | 3 | | |
| **Channel Protection Target Volume** | | 0.378 | A.F. |
| Target Rainfall Depth (in) | 2.8 | | |
| Impervious Cover (%) | 90 | | |
| Drainage Area (acres) | 3 | | |

WQTV = (RD/12) * RC * DA

CPTV = (RD/12) * (IC/100) * DA * 0.6

| AVAILABLE RETROFIT STORAGE | | | |
|---|---|---|---|
| **Storage Capacity** | | 0.1147842 | A.F. |
| Facility Surface Area (sq ft) | 5000 | | |
| Est. Max Depth (ft) | 1.5 | | |

SC = 2/3 * ED *(FSA/43560)

Although this assessment first tries to accommodate the 1-inch runoff event, not all sites are easy to visually determine whether they can actually handle expected volumes. In this example case, although originally thought to be a candidate for storing the 1-inch storm event, it was determined that the site could only accommodate a BMP, or combination of BMPs, of 5000 $ft^2$ and 1.5 ponding depth that could accommodate the 0.5-inch runoff event, not the 1-inch event. The Target Rainfall Depth parameter allows the assessor/designer to see what size event the site can actually accommodate.

The next step in the assessment determines an estimate of the pollutant loads for the site given cover type and annual precipitation, as entered by the assessor/designer. Again, editable fields are highlighted in yellow and the resulting estimates for each parameter are provided in blue. Look-up tables for Event Mean Concentrations (EMC) of the "pollutant of concern" are provided by land-cover type (data and equations as per MANUAL 3). Site specific values, if known, can be used in-lieu of these tables and is preferred. In this Pilot Assessment, an annual average precipitation of 30-inches was used and it was assumed that 90% of all storm events caused runoff (as per MANUAL 3 recommendations in lieu of catchment/watershed empirical data). Runoff Coefficient and Drainage Area values are automatically pulled from the "Volumes' spreadsheet.

| ***EXISTING CONDITION POLLUTANT LOADS*** | | |
|---|---|---|
| ***Estimated Pollutant Load Export*** | 2.6163 | lbs |
| Avg Annual Rainfall Depth (in) | 30 | |
| Fraction of Runoff-Producing Events | 0.9 | |
| Runoff Coefficient | 0.95 | |
| Pollutant Event Mean Concentration (Tables 1-2; mg/L) | 0.15 | |
| Drainage Area (acres) | 3 | |

PL = (RD * RPE * RC)/12) * EMC * DA * 2.72

| ***Table 1*: General Pollutant EMCs in Stormwater Runoff (mg/L)** | | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **Residential** | **Commercial** | **Industrial** | **Freeways** | **Open** |
| *TDS* | 72 | 72 | 86 | 77.5 | 125 |
| *TSS* | 49 | 43 | 81 | 99 | 48.5 |
| *BOD* | 9 | 11 | 9 | 8 | 5.4 |
| *COD* | 54.5 | 58 | 58.6 | 100 | 42.1 |
| *FC* | 7000 | 4600 | 2400 | 1700 | 7200 |
| *NO2+NO3* | 6 | 0.6 | 0.69 | 0.28 | 0.59 |
| *TKN* | 1.5 | 1.5 | 1.4 | 2 | 0.74 |
| *TN* | 2.1 | 2.1 | 2.09 | 2.28 | 1.33 |
| *Dissolved P* | 0.18 | 0.11 | 0.1 | 0.2 | 0.13 |
| *TP* | 0.31 | 0.22 | 0.25 | 0.25 | 0.31 |
| *Dissolved Cu* | 0.007 | 0.00757 | 0.008 | 0.0109 | |
| *T-Cu* | 0.012 | 0.017 | 0.0208 | 0.0347 | 0.01 |
| *Dissolved Zn* | 0.0315 | 0.059 | 0.112 | 0.051 | |
| T-Zn | 0.073 | 0.15 | 0.199 | 0.2 | 0.04 |

| ***Table 2*: Hot Spot Pollutant EMCs in Stormwater Runoff (mg/L)** | | | | | | |
|---|---|---|---|---|---|---|
| **Land Use** | **TSS** | **TP** | **TN** | **Fecal Col** | **T-Cu** | **T-Zn** |
| Lawns | 602 | 2.1 | 9.1 | 2400 | 0.017 | 0.05 |
| Landscaping | 37 | | | 9400 | 0.094 | 0.263 |
| Roof | | | | | | |
| Residential | 19 | 0.11 | 1.5 | 26 | 0.2 | 0.312 |
| Commercial | 9 | 0.14 | 2.1 | 110 | 0.007 | 0.256 |
| Industrial | 17 | | | 580 | 0.062 | 1.39 |
| Parking Lot | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Res or | 27 | 0.15 | 1.9 | 180 | 0.051 | 0.139 |
| Industrial | 228 | | | 270 | 0.034 | 0.224 |
| Driveway | 173 | 0.56 | 2.1 | 1700 | 0.017 | 0.107 |
| Streets | | | | | | |
| Residential | 172 | 0.55 | 1.4 | 3700 | 0.025 | 0.173 |
| Commercial | 468 | | | 1200 | 0.073 | 0.45 |
| Gas Station | 31 | | | | 0.088 | 0.29 |
| Auto Recycler | 335 | | | | 0.103 | 0.52 |
| Heavy | 124 | | | | 0.148 | 1.6 |

In this example, the EMC value of 0.15 mg/L is the value assumed, in Table 2, for Total Phosphorous for a commercial parking lot.

It is important for the assessor/designer to understand that although the values provided in each table are often averages derived from literature review by the MANUAL 3 authors, not all values have many published studies. More accurate estimate of pollutant load generation can be achieved with specific watershed, catchment or site-level runoff analyses but no such data were used in this Pilot Assessment.

The resulting pollutant loadings for specific sites are used here, rather, for the next phase of the project – BMP selection. It provides a means of apples-to-apples comparison of appropriate BMP selection given the expected pollutant loadings of the site based on published estimates of pollutant load reduction via 7 different practices. When the assessor/designer assesses a site for retrofitting BMPs, he/she needs to consider not only how the physical limitations of the site select or eliminate certain BMPs, but also their level of target pollutant removal performance, or whether more than one BMP working together, in series, is appropriate.

An expanded table of results for yearly pollutant loads for all pollutants based on entered watershed data is also included in the protocol as shown below.

| Pollutant | Residential | Commercial | Industrial | Freeways | Open Space |
|---|---|---|---|---|---|
| TDS | 1255.82 | 1255.82 | 1500.01 | 1351.76 | 2180.25 |
| TSS | 854.66 | 750.01 | 1412.80 | 1726.76 | 845.94 |
| BOD | 156.98 | 191.86 | 156.98 | 139.54 | 94.19 |
| COD | 950.59 | 1011.64 | 1022.10 | 1744.20 | 734.31 |
| FC | 122094.00 | 80233.20 | 41860.80 | 29651.40 | 125582.40 |
| NO2+NO3 | 104.65 | 10.47 | 12.03 | 4.88 | 10.29 |
| TKN | 26.16 | 26.16 | 24.42 | 34.88 | 12.91 |
| TN | 36.63 | 36.63 | 36.45 | 39.77 | 23.20 |
| Dissolved P | 3.14 | 1.92 | 1.74 | 3.49 | 2.27 |
| TP | 5.41 | 3.84 | 4.36 | 4.36 | 5.41 |
| Dissolved Cu | 0.12 | 0.13 | 0.14 | 0.19 | 0.00 |
| T-Cu | 0.21 | 0.30 | 0.36 | 0.61 | 0.17 |
| Dissolved Zn | 0.55 | 1.03 | 1.95 | 0.89 | 0.00 |
| T-Zn | 1.27 | 2.62 | 3.47 | 3.49 | 0.70 |

| Table 2: Hot Spot Pollutant EMCs in Stormwater Runoff (mg/L) | | | | | | |
|---|---|---|---|---|---|---|
| Land Use | TSS | TP | TN | Fecal Col | T-Cu | T-Zn |
| Lawns | 10500.08 | 36.63 | 158.72 | 41860.80 | 0.30 | 0.87 |
| Landscaping | 645.35 | 0.00 | 0.00 | 163954.80 | 1.64 | 4.59 |
| Roof | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Residential | 331.40 | 1.92 | 26.16 | 453.49 | 3.49 | 5.44 |
| Commercial | 156.98 | 2.44 | 36.63 | 1918.62 | 0.12 | 4.47 |
| Industrial | 296.51 | 0.00 | 0.00 | 10116.36 | 1.08 | 24.24 |
| Parking Lot | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Res or Comm | 470.93 | 2.62 | 33.14 | 3139.56 | 0.89 | 2.42 |
| Industrial | 3976.78 | 0.00 | 0.00 | 4709.34 | 0.59 | 3.91 |
| Driveway | 3017.47 | 9.77 | 36.63 | 29651.40 | 0.30 | 1.87 |
| Streets | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Residential | 3000.02 | 9.59 | 24.42 | 64535.40 | 0.44 | 3.02 |
| Commercial | 8162.86 | 0.00 | 0.00 | 20930.40 | 1.27 | 7.85 |
| Gas Station | 540.70 | 0.00 | 0.00 | 0.00 | 1.53 | 5.06 |
| Auto Recycler | 5843.07 | 0.00 | 0.00 | 0.00 | 1.80 | 9.07 |
| Heavy Industry | 2162.81 | 0.00 | 0.00 | 0.00 | 2.58 | 27.91 |

STAGE 4: BMP Selection

In the last STAGE of assessment, the assessor considers 7 different BMPs and what relevant design parameters will be allowed given the site constraints or goals of the project. A direct comparison of considered BMPs is then made based on the removal efficiency of the chosen pollutant of concern. Again, the results of these removal efficiencies and expected load reductions, in terms of mass, are purely for comparing one BMP to another and to form the beginnings of a very rough estimate on actual pollutant load reductions. If a more precise pollutant loading and reduction estimate is required, a more sophisticated modeling tool must be chosen using empirical data for calibration.

The assessor enters BMP-specific design variables that will either improve or decrease pollutant removal efficiencies. A resulting scaling index is then generated and applied to the BMPs Low, Median and High pollutant removal rates (as reported and described in Manual 3). No net score above a 5 is allowed. The assessor then compares the resulting load reductions as part of the "weighing" of pros and cons for each BMP selection.

| INFILTRATION RETROFITS | | |
|---|---|---|
| Design Factors | Points | Assigned |
| Exceeds target WQv by more than 50% | 3 | |
| Exceeds target WQv by more than 25% | 2 | |
| Tested infiltration rates between 1.0 and 4.0 in/hr | 2 | 2 |
| At least two forms of pretreatment prior to infiltration | 2 | |
| CDA is nearly 100% impervious | 1 | 1 |
| Off-line design w/ cleanout pipe | 1 | 1 |
| Underdrain utilized | 1 | |
| Filter fabric used in trench bottom | 1 | |

| | | |
|---|---|---|
| CDA more than 1-acre | 1 | 1 |
| Soil infiltration rates <1.0 in/hr or >4.0 in/hr | 2 | |
| Pervious areas or construction clearing in CDA | 2 | |
| Does not provide full WQv volume | 2 | 2 |
| **NET DESIGN SCORE (max. of 5 points)** | | 1 |

**ADJUSTED REMOVAL RATES**

| Pollutant | % | lbs (or other) |
|---|---|---|
| TSS | 91 | 2.380833 |
| TP | 71 | 1.857573 |
| SP | 87 | 2.276181 |
| TN | 45 | 1.177335 |
| C | 91 | 2.380833 |
| Zn | 69 | 1.805247 |
| Cu | 86 | 2.250018 |
| Bacteria | 46 | 1.203498 |
| HC | 91 | 2.380833 |
| Chl | 0 | 0 |
| Trash/Debris | 91 | 2.380833 |

The resulting estimated TP removal amount for this particular BMP, given the design element defined above.

NOTE: All other reported pollutant load reductions other than TP for this BMP are to be ignored. To determine another pollutant's reduction, one must go back one step to the Existing Pollutant Loads Estimates table and enter that pollutant's expected EMC.

**SWALE RETROFITS**

| Design Factors | Points | Assigned |
|---|---|---|
| Exceeds target WQv by more than 50% | 3 | |
| Dry or wet swale design | 2 | |
| Exceeds target WQv by more than 25% | 2 | 2 |
| Longitudinal swale slope between 0.5 to 2.0% | 1 | |
| Velocity within swale <1 fps during WQ storm | 1 | |
| Measured soil infiltration rates exceed 1.0 in/hr | 1 | 1 |
| Multiple cells with pretreatment | 1 | |
| Off-line design w/ storm bypass | 1 | 1 |
| Longitudinal swale slope <0.5 or >2.0% | 1 | |
| Measured soil infiltration rates less than 1.0 in/hr | 1 | |
| Swale sideslopes more than 5:1 h:v | 1 | |
| Swale intersects groundwater (except wet swale) | 1 | |
| No pretreatment to swale or channel | 1 | |
| Swale conveys stormflows up to the 10-yr storm | 2 | |
| Does not provide full WQv volume | 2 | |
| Grass channel | 3 | |
| **NET DESIGN SCORE (max. of 5 points)** | | 4 |

**ADJUSTED REMOVAL RATES**

| Pollutant | % | lbs (or other) |
|---|---|---|
| TSS | 88 | 2.302344 |
| TP | 41 | 1.072683 |
| SP | 12 | 0.313956 |

| | | |
|---|---|---|
| TN | 71 | 1.857573 |
| C | 82 | 2.145366 |
| Zn | 78 | 2.040714 |
| Cu | 77 | 2.014551 |
| Bacteria | 15 | 0.392445 |
| HC | 88 | 2.302344 |
| Chl | 0 | 0 |
| Trash/Debris | 40 | 1.04652 |

In the previous example, the assessor determines, given the site constraints and/or goals of the project, that either an infiltration basin (e.g., series of raingardens) or a swale would be preferable on this particular site. He/she enters design variables that are appropriate, checks to be sure the resulting net index is not greater than five and then compares the results for the pollutant of concern whose EMC was entered in the previous step. If the resulting index was greater than 5 the reported pollutant removal rates are false (outside reported high or low removal rates) and he/she would simply remove whatever design criteria is appropriate to bring the index back to 5. For instance, if there was an overall negative number (shown in Red) as 6, one design point needs to removed from the design table to adjust the index back to 5. In this example, the watershed's primary goal may be to reduce TP. Therefore, the infiltration practice is weighted more heavily in the final selection.

NOTE: The assessor can only refer to the results for the pollutant load of concern on these tables as the formulas are pulled from one EMC entry on the previous step. To determine other pollutant of concern's removal amounts for the designed BMP, one must go back and re-enter the new EMC for that pollutant and then read the line-item results on the BMP tables.

### Summary of Protocol

This protocol attempts to provide a sufficient level of detail to rapidly assess sub-watersheds or catchments of variable scales and land-uses. It provides the assessor defined project goals that aid in quickly narrowing down multiple potential sites to a point where he/she can look a little more closely at site-specific driven design options that affect, sometimes dramatically, BMP selection. We feel that the time commitment required for this methodology is appropriate for most initial assessment applications and has worked well thus far for the SWWD Commercial Site Assessment Project.